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# External Shocks and Inflation in Developing Countries Under a Real Exchange Rate Rule

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Abstract

This paper shows that the response of inflation to external shocks is very different when the authorities target the real exchange rate than when they follow a fixed exchange rate or a preannounced crawling peg. Specifically, shocks that would have no effect on the steady-state inflation rate under a fixed exchange rate are either inflationary or deflationary under a real exchange rate rule. Moreover, irrespective of the degree of capital mobility, the authorities will find it difficult to mitigate the destabilizing effects of real shocks on the price level by using monetary policy, except possibly in the very short run.

JEL Classification Numbers:

E52, E61, F31, F41

1/ Oberlin College and International Monetary Fund, respectively. This paper was presented at the Bank of Canada's Conference on Exchange Rates and is to be published in a forthcoming volume of conference proceedings. It draws heavily on two previous papers (Montiel and Ostry (1991, 1992)). We wish to thank Malcolm Knight and conference participants for helpful comments and discussions. Any opinions expressed are those of the authors and not of the institutions with which they are affiliated.

Contents

## I. Introduction

After the collapse of the Bretton Woods system in the early 1970s, the vast majority of developing countries continued to maintain fixed exchange rates for their currencies, typically expressed in terms of the currency of a single major industrial country. In response to both international and domestic instability, however, the intervening years witnessed a major evolution in developing country exchange rate arrangements in the direction of much more active exchange rate management. A recent study by the International Monetary Fund, for example, found that, among the developing country members of the IMF, the share of countries pegged to a single currency dropped from 63 percent in 1976 to 38 percent in 1989, while the share of such countries adopting more flexible arrangements increased from 14 percent to 38 percent over the same period. 1/ In the majority of these countries, the official exchange rate is changed frequently in accordance with some--announced or unannounced--rule. In many such cases, the exchange rate rule explicitly links changes in the official exchange rate to the difference between domestic and foreign rates of inflation in order to keep the real exchange rate from deviating too far from its targeted level. In this context, policymakers undertake to make frequent adjustments to the nominal exchange rate (in some cases on a daily basis) in order to keep the real exchange rate close to some "target" level. 2/

As is well known, however, the equilibrium real exchange rate is a function of a number of fundamental real variables that themselves change over time. The relationship between the equilibrium real exchange rate and its fundamental determinants has been widely explored in the literature, using various analytical approaches. 3/ An important result that emerges from this general line of research is that, depending on the values of various elasticities and the type of exogenous disturbance under consideration, movements in the equilibrium real exchange rate may be substantial. 4/ A direct implication of this result is that policies that alter the nominal exchange rate so as to keep the real exchange rate constant may prevent the establishment of macroeconomic equilibrium when economies are subjected to exogenous real disturbances, and hence be destabilizing.

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1/ See Aghevli et.al. (1991). The remaining countries maintained a peg against a composite of currencies.

2/ Such rules are usually justified on the grounds that they help to keep the real effective exchange rate close to some level that is viewed as consistent with maintenance of a sustainable external payments position.

3/ Examples are Dornbusch (1974), Edwards (1989), Khan and Montiel (1987), and Ostry (1988).

4/ For an attempt to quantify the magnitude of the response of the equilibrium real exchange rate to a variety of disturbances using representative parameter values for the developing countries, see Khan and Ostry (1992).

Given the widespread practice of real exchange rate targeting in developing countries, it is somewhat surprising that there has not been much analytical work on the macroeconomic effects of real exchange rate rules or on the effects of exogenous and policy-induced real shocks (such as fluctuations in world interest rates and the international terms of trade, changes in government spending levels and in commercial policies) in the context of such rules. 1/ Because developing countries frequently experience such disturbances, this would appear to be an important area of research. Moreover, little attention has been devoted to the issue of alternative nominal anchors in the presence of real exchange rate targeting. Since the adoption of a PPP rule for the nominal exchange rate prevents the latter from serving as a nominal anchor, price level stabilization requires that an alternative anchor be found for economies adopting such policies.

This paper attempts to address some of the above issues in the context of a familiar dynamic model in which the authorities pursue an explicit target for the real exchange rate. In the first part of the paper we consider a regime in which there is perfect capital mobility. Two main results emerge from this analysis. First, the attempt to pursue a target for the real exchange rate that is overly depreciated relative to the equilibrium rate, say with a view to improving the external balance, will lead the economy to an equilibrium with a higher steady-state inflation rate than when the nominal exchange rate is fixed. Second, shocks that would have no effect on the economy's steady-state inflation rate in a fixed exchange rate or crawling-peg regime will be inflationary under real exchange rate targeting.

Given these results, it is natural to ask whether supplementing the real exchange rate rule with a monetary policy that targets some financial aggregate can mitigate the inflationary effects of shocks. Because the model presented in the first part of the paper makes the assumption of perfect capital mobility, the authorities are unable to control the money supply by altering domestic credit policy to sterilize capital inflows. In this context, we show that targeting a credit aggregate cannot substitute for the traditional role of the exchange rate as the nominal anchor for the domestic price level.

To examine the implications of money-supply targeting under a real exchange rate rule, the second part of the paper considers the case in which capital controls are imposed, thereby rendering sterilization feasible, and asks whether fixing the money supply can stabilize the price level in response to shocks. The analysis leads naturally to a consideration of the case in which the effectiveness of capital controls is less than perfect, and we examine the implications of money-supply targeting in this case as

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1/ Exceptions are Dornbusch (1982), Adams and Gros (1986), and Lizondo (1991). The macroeconomic effects of alternative shocks under a real exchange rate rule are analyzed in Montiel and Ostry (1991).

well. We find that using money as a nominal anchor is problematic in both cases.

The remainder of this paper proceeds as follows. Section II presents the basic model with real exchange rate targeting under conditions of perfect capital mobility, and illustrates the potential inflationary consequences of real shocks by analyzing the case of terms of trade disturbances, which have been quite prevalent in developing countries in recent years. Section III modifies the model to incorporate perfect capital controls and shows that a terms-of-trade shock continues to be inflationary under such circumstances. The consequences of monetary targeting in this context are analyzed in Section IV. Sections V and VI turn to the case in which capital controls are imperfect. The main conclusions are summarized in Section VII. Throughout the analysis we maintain the assumption of perfect wage and price flexibility. An appendix presents the results for the case of perfect capital mobility under the assumption that wages adjust slowly to pressures in the labor market.

## II. Real Exchange Rate Targeting Under Perfect Capital Mobility

### 1. The model

Consider a small open economy in which competitive firms combine labor (available in fixed supply) and a sector-specific factor to produce home goods and exportables, using a standard concave technology. 1/ All prices are flexible, ensuring that full employment is continuously maintained.

The income generated from production of the two goods is received by consumers, who use it to buy home goods and importables. Consumers have Cobb-Douglas utility, which implies that they allocate a constant fraction of their total expenditures to each of the two goods in every time period. The real value of aggregate consumption is assumed to depend upon the real value of factor income net of taxes, the real interest rate, and real financial wealth. Real factor income, which we denote by y, is the value of output of exportables and home goods, deflated by the consumer price index. As shown in Khan and Montiel (1987), under the assumption that the external trade surplus is zero in the initial steady-state equilibrium, real factor income depends only on the terms of trade (the price of exports relative to imports), denoted by $\rho$, with $y'(\rho) > 0$.

Denoting by c the real value of aggregate consumption, we thus have that:

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1/ The main features of the model draw on the standard two-good dependent economy model popularized by Dornbusch (1974), Rodriguez (1978), and Liviatan (1979). The modelling of asset accumulation is similar to that found in Calvo and Rodriguez (1977) and Khan and Lizondo (1987). For a more extensive exposition of the "reference" model described in this section, see Montiel and Ostry (1991).

(1) $c = c(y-t_p, r, e^{\theta} a_p)$, $0 < c_1 < 1$, $c_2 < 0$, $0 < c_3$

where $t_p$ denotes the real value of taxes, r is the real interest rate, e is the real exchange rate defined as the price of importables relative to nontradables, $\theta$ is the weight of nontradables in the price index (and the utility function), and $a_p$ is private wealth in terms of importables, so that $e^{\theta} a_p$ is real private wealth in terms of the consumption basket. 1/

Real household financial wealth consists of real money balances $m = M/P$, where M is the nominal money stock and P the consumer price index, plus the real value of foreign securities $f_p = sF_p/P$, where s is the nominal exchange rate and $F_p$ is the nominal value of foreign securities, minus the real value of the private sector's liabilities $d_p = D_p/P$ which are taken to consist of the real value of loans extended by the banking system. Thus,

(2) $e^{\theta} a_p = m + f_p - d_p$.

It is assumed that money pays no interest, that the nominal return on foreign assets is $i^*$, and that the domestic cost of borrowing is i. Under the assumptions that domestic and foreign securities are perfect substitutes and that expectations are characterized by perfect foresight, uncovered interest parity implies

(3) $i = i^* + E\hat{s} = i^* + \hat{s}$

where a circumflex above a variable denotes a proportional rate of change, so that $E\hat{s}$ is the expected (equal to actual) rate of depreciation of the domestic currency.

The real exchange rate rule followed by the authorities consists of a continuous adjustment in the nominal exchange rate, s, that keeps the real exchange rate constant at the level that prevailed at the time the authorities began following the rule. 2/ Using the definition of the real exchange rate, e, as the price of importables relative to nontradables and the assumption that the law of one price holds for tradable goods, the real exchange rate rule takes the form: 3/

(4) $\hat{s} = \pi_n - \pi^*$,

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1/ See, for example, Frenkel and Razin (1987) for previous use of a similar consumption function in the context of an analysis of the Mundell-Fleming model.

2/ Alternative types of real exchange rate rules are considered in Lizondo (1991).

3/ There is an alternative definition of the real exchange as the price of exportables relative to nontradables. Both definitions would of course behave identically for constant terms of trade. Complications arising in the presence of terms of trade changes will be taken into account below.

where $\pi_n$ is the rate of inflation of home goods and $\pi^*$ is the rate of inflation of the world price of the importable good. Because the domestic price index is a weighted average of the price of imports and home goods,1/ the domestic rate of inflation $\pi$ will be equal to the rate of inflation of home goods, $\pi_n$, under the real exchange rate rule. Therefore, the rule could equally be written as

$$(4a) \quad \hat{s} = \pi - \pi^*,$$

which involves only the domestic rate of inflation and the rate of inflation of world prices.

Substituting equation (4a) into equation (3) yields a relationship between the domestic interest rate, the foreign interest rate and the inflation differential under the real exchange rate rule:

$$(3a) \quad i = i^* + \pi - \pi^*.$$

Assuming that the demand for real money balances L depends in conventional fashion on the nominal interest rate and real income, we have, using equation (3a), that

$$(5) \quad m = L(i^* + \pi - \pi^*; y) \quad L_1 < 0, \quad L_2 > 0,$$

where $L_1$ and $L_2$ are the partial derivatives of real money demand with respect to i and y, respectively. Finally, defining the domestic real interest rate r as the difference between the nominal interest rate i and the rate of domestic inflation $\pi$, and the foreign real interest rate $r^*$ as the difference between $i^*$ and $\pi^*$, and applying equation (3a), it is clear that domestic and foreign real interest rates will be equalized under these circumstances, i.e., $r = r^*$.

Private sector saving is the difference between disposable income and expenditure. Disposable income in turn is equal to the sum of factor income and income from asset holdings less tax payments to the government. Expressing all variables in terms of units of the numeraire, one obtains after some manipulation that the real value of private saving, denoted $s_p$, may be written as

$$(6) \quad s_p = e^{-\theta}\{y(\rho)-t_p-c[y(\rho)-t_p;r^*;e^{\theta}a_p]\} + (r^*+\pi)(a_p-e^{-\theta}L[r^*+\pi;y(\rho)]$$
$$+ e^{-\theta}(\pi^*-\pi)f_p.$$

Using equation (6), the change in the real value of private asset holdings, $\dot{a}_p$, will be given by:

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1/ Recall that exportables are not consumed domestically.

$$(7)\quad \dot{a}_p = s_p + e^{-\theta}(\pi-\pi^*)f_p - \pi a_p$$
$$= e^{-\theta}\{y(\rho)-t_p-c[y(\rho)-t_p;r^*;e^{\theta}a_p]\}+r^*a_p-(r^*+\pi)e^{-\theta}L[r^*+\pi;y(\rho)].$$

The government in this model consumes the same two goods as the private sector. The real value of its consumption (in terms of the consumption basket) is denoted by g. It finances its expenditures by levying taxes ($t_p$), through the receipt of transfers from the central bank ($t_b$), and by borrowing ($D_g$). Like the private sector, the government also holds foreign securities ($F_g$) which provide it with interest income. 1/ Its net worth at any instant (in terms of the numeraire) is denoted by $a_g = (sF_g - D_g)/P_z$, where $P_z$ is the price of the importable. At any point in time, the government's real budget surplus, $s_g$, will be given by:

$$(8)\quad s_g = e^{-\theta}(t_p+t_b-g) + (r^*+\pi)a_g + e^{-\theta}(\pi^*-\pi)f_g$$
$$= e^{-\theta}(t_p+t_b) + (r^*+\pi)a_g + e^{-\theta}(\pi^*-\pi)f_g - e^{-1}g_n - g_z,$$

where $f_g = sF_g/P$ denotes the real value of foreign securities, and $g_n$, $g_z$ denote government consumption of nontradable and importable goods, respectively.

In addition to its instantaneous budget constraint (equation 8), the government's actions must satisfy the standard intertemporal constraint, which rules out Ponzi-type schemes. 2/ It is straightforward to show that the joint satisfaction of this intertemporal constraint and the analogous constraint for the rest of the world requires that $\dot{a}_g$ must converge to zero. Since $\dot{a}_g = s_g+e^{-\theta}(\pi-\pi^*)f_g - \pi a_g$, this means that $s_g = \pi a_g - e^{-\theta}(\pi-\pi^*)f_g$ and therefore that one of the variables on the right hand side of equation (8) ($t_p$, $g_n$, or $g_z$) must eventually move into a residual role. Unless otherwise indicated, we will take this variable to be $g_z$, so that in the limit, the government's spending and taxation plans must satisfy

$$(8a)\quad g_z = e^{-\theta}(t_p+t_b) + r^*a_g - e^{-1}g_n$$

where the condition $s_g = \pi a_g - e^{-\theta}(\pi-\pi^*)f_g$ has been imposed on (8).

Turning now to the central bank, its balance sheet is given by

$$(9)\quad a_b = e^{-\theta}(f_b + d_p + d_g - m)$$

where $a_b$ represents the central bank's real net worth, and $f_b$, $d_p$, $d_g$, and m represent, respectively, the real value of foreign securities $F_b$ held by the

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1/ If the government were a net external debtor, $F_g$ would simply be negative.

2/ Technically, the requirement is that the government's net worth be nonnegative in the long-run.

central bank ($sF_b/P$), the real value of the stock of credit extended to the private sector ($D_p/P$), to the government ($D_g/P$), and the real money supply ($M/P$). The central bank's operating profits ($s_b$), in turn, are given by

$$(10) \quad s_b = e^{-\theta}[(r^*+\pi)(f_b + d_p + d_g) + (\pi^*-\pi)f_b - t_b].$$

Operating profits thus represent the difference between the real value of interest receipts, on the one hand, and transfers to the government, on the other. Finally, from the central bank's budget constraint

$$(11) \quad \dot{a}_b = s_b + e^{-\theta}(\pi-\pi^*)f_b - \pi a_b$$
$$= e^{-\theta}\{r^*(f_b + d_p + d_g) + \pi L[r^*+\pi, y(\rho)] - t_b\}.$$

We complete the model by specifying the behavior of the current and capital accounts of the balance of payments. The former, denoted ca, is by definition equal to the rate of accumulation of net claims on the rest of world. If we let these claims be denoted by $F = F_p + F_g + F_b$, and use the definitions of the net worth of each of the three sectors, it is straightforward to show that

$$(12) \quad ca \equiv e^{-\theta}s\dot{F}/P = s_p + s_g + s_b.$$

Thus, the current account is equal to national saving (recall that there is no investment in the model).

Turning to the capital account (denoted ka), using the balance of payments identity $ca + ka = e^{-\theta}s\dot{F}_b/P$, and substituting from the time-differentiated version of equation (9), we have

$$(13) \quad ka = e^{-\theta}s\dot{F}_b/P - ca$$
$$= e^{-\theta}[\dot{m} - (\dot{d}_p + \dot{d}_g - \dot{a}_b) + \pi^* f_b] - ca.$$

The first term on the right hand side of equation (13) simply restates the balance of payments as the excess of the (flow) demand for money ($\dot{m}$) over the change in the net domestic assets of the banking system ($\dot{d}_p + \dot{d}_g - \dot{a}_b$), as in the monetary approach to the balance of payments.

## 2. Equilibrium

The first condition that must be satisfied in any equilibrium is that of internal balance, which requires that the domestic markets for labor and nontradable goods clear continuously:

$$(14) \quad y_n(\rho, e) = \theta e^{1-\theta}c[y(\rho)-t_p, r^*, e^{\theta}a_p] + g_n.$$

Equation (14) states that the supply of nontraded goods (given on the left hand side) must equal the sum of demands from the private and public sectors (on the right hand side). 1/

In the fixed nominal exchange rate version of the model, equation (14) determines the real exchange rate e at each instant, conditional on the predetermined variable $a_p$. In the steady state, $a_p$ must reach a constant value. Therefore, private wealth accumulation $\dot{a}_p$ must be equal to zero:

$$(7a)\quad 0 = e^{-\theta}\{y(\rho)-t_p-c[y(\rho)-t_p;r^*;e^{\theta}a_p]\}+r^*a_p-(r^*+\pi)e^{-\theta}L[r^*+\pi;y(\rho)].$$

Equations (14) and (7a) together thus determine the steady state values of e and $a_p$ under fixed exchange rates. Notice that, with e fixed in the steady state, equation (4) with s = 0 implies that domestic inflation must be equal to world inflation. Assuming that the latter is zero, the steady-state domestic price level is stable ($\pi = 0$).

Suppose, for concreteness, that all central bank operating profits are transfered to the government in the fixed exchange rate steady state, i.e., $t_b = r^*(f_b + d_p + d_g)$. From equation (10), we then have $s_b = 0$. Since equation (8a) must also hold, it will be true that $s_g = 0$. With steady state national saving therefore equal to zero, the current account must necessarily be in balance in the fixed exchange rate steady state. Thus, equations (14) and (7a) determine the equilibrium real exchange rate in familiar fashion as the value of e that is compatible with the simultaneous achievement of internal and external balance.

In order to analyze the determination of the equilibrium under a real exchange rate rule, we assume that the target level of the real exchange rate is initially set at the level corresponding to this fixed exchange rate steady state, given the values of the exogenous and policy variables, including the values of $t_b$ and $g_z$ described above. In particular, then, the current account of the balance of payments is equal to zero and the domestic rate of inflation is also zero. The real exchange rate rule holds e constant at its original steady state value, but the nominal exchange rate s becomes an endogenous variable, as does the domestic price of importables, $P_z$. This means, in particular, that private real wealth $a_p$ is no longer predetermined. Instead, it is an endogenous variable inversely related to the domestic price level, which itself must be proportional to $P_z$ by the real exchange rate rule. Thus, equation (14) now determines $a_p$ (through movements in the price level), for given values of e and the other exogenous variables. With $a_p$ determined in this way, the condition, $\dot{a}_p = 0$, must hold continuously, not just in the steady state, in order to ensure continuous

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1/ Equation (14) already incorporates labor market equilibrium since the sectoral supply functions depend on the real wage, which in turn depends on the terms of trade and real exchange rate (see Khan and Montiel (1987)). For notational simplicity, the equilibrium wage function has been suppressed from equation (14).

equilibrium in the market for nontraded goods. In response to any change in the exogenous variables, equation (14) requires that the level of $a_p$ jump discretely to its new steady-state value through an adjustment in the domestic price level. In contrast to the model with a fixed nominal exchange rate (and, therefore, an endogenously determined real exchange rate), there can be no dynamic adjustment of $a_p$ during which the economy converges toward the new steady state. Since equation (7a) must therefore hold continuously, changes in $a_p$ induced by shocks must be offset by adjustments in the domestic inflation rate ($\pi$) which is the only other endogenous variable appearing in this equation.

The economics of the situation are straightforward. Shocks which give rise to changes in the domestic price level (and thus in $a_p$) will tend to alter measured private saving, $s_p$. This increase in saving in response to the initial discrete adjustment in $a_p$ generates an incipient increase in real private wealth. This, in turn, would cause private consumption to increase over time, leading to excess demand for nontraded goods. In order to maintain equilibrium in the home goods market in the face of this incipient demand pressure, domestic prices must rise sufficiently rapidly to maintain $a_p$ continuously at its new equilibrium level. As in Lizondo (1991), the inflation tax must be sufficiently high as to render the private sector willing to hold the stock of real wealth necessary to clear the market for nontraded goods, given the real exchange rate target and the values of the exogenous and policy variables.

The determination of equilibrium is illustrated in Figure 1. The level of the real exchange rate in the base period satisfies equations (14) and (7a), at an initial domestic inflation rate of zero. On the vertical axis, we plot the domestic rate of inflation, $\pi$, while on the horizontal axis we plot the level of real domestic assets, $a_p$. Equation (14) is represented by the NN locus which shows that, given the real exchange rate target, there is only one level of real assets that will clear the market for home goods. The condition for zero real private wealth accumulation (equation 7a) is labelled SS. Its slope is equal to

(15) $d\pi/da_p\cdot_{SS} = (r^*-c_3)/[(r^*+\pi)L_1+L]$. 1/

The numerator of this expression is negative as long as the marginal propensity to consume out of wealth exceeds the world real interest rate, which we assume to be the case. 2/ The sign of the denominator depends on whether the interest elasticity of money demand is greater or less than unity. In what follows, we make the conventional assumption (which would be valid, for example, in any semilog specification) that money demand is interest inelastic at low levels of inflation, but as inflation rises the

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1/ Throughout the analysis, we choose units such that, in the initial steady state, all prices (including e) are equal to unity.

2/ This assumption would hold, for example, in a life-cycle model in which households had finite horizons (see Flavin, 1985).

elasticity eventually rises above unity. This implies that the SS locus has the "C" shape portrayed in Figure 1. As is usual with this sort of money demand function, there are two possible equilibria, corresponding to the two intersection points of the SS curve with the NN line. We assume that the government, upon announcing the real exchange rate target, remains at the low-inflation equilibrium, denoted by point A in Figure 1, that corresponds to a position of long-run equilibrium for the fixed exchange rate version of the model

## 3. Effects of shocks

The question of interest, of course, is how the economy will respond to shocks under the new policy regime. To begin with, we can ask how the equilibrium will be affected if the authorities decide on a real exchange rate target that is overdepreciated relative to the initial long-run level, which we denote $e^*$. That is, what are the effects of choosing the target $\bar{e} > e^*$? It is straightforward to verify, from equation (7a), that an increase in e, at a given value of $\pi$ (in this case, $\pi = 0$), leads to an incipient tendency to dissave on the part of the private sector. To restore saving to its initial level, $a_p$ has to fall. Thus, the SS curve shifts to the left in Figure 2 according to

$$(16)\quad da_p/d\bar{e}._{SS} = -\theta a_p < 0.$$

The new equilibrium value of $a_p$, however, will be that which clears the nontraded goods market. Since a real exchange rate depreciation creates an excess demand for nontraded goods, the domestic price level must rise, and $a_p$ must consequently fall. The locus NN thus shifts to the left in Figure 2. The change in the equilibrium value of $a_p$, and thus the magnitude of the shift, is given by

$$(17)\quad da_p/d\bar{e}._{NN} = -\theta a_p - (1-\theta)c/c_3 + [\partial y_n/\partial e]/\theta c_3 < 0.$$

Although both curves shift to the left, it is straightforward to verify that the NN line shifts by more than the SS curve and, therefore, that at the original (zero) rate of inflation, real private wealth would be increasing ($\dot{a}_p > 0$). 1/ This puts upward pressure on domestic prices, implying that the new point of equilibrium (B in Figure 2) must involve a higher inflation rate. Thus, the choice of a real exchange rate target that is higher than the one dictated by the long-run equilibrium of the fixed exchange rate version of the model, leads to an increase in the domestic rate of inflation. This increase is permanent and is sustained by a permanent inflow of reserves, the counterpart of which is a surplus in the external current account.

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1/ That the NN schedule shifts by more than the SS schedule can be seen from the fact that the first term in equations (16) and (17) are identical but the last two terms in equation (17) are each strictly negative.

Figure 1
Equilibrium Under a Real Exchange Rate Rule

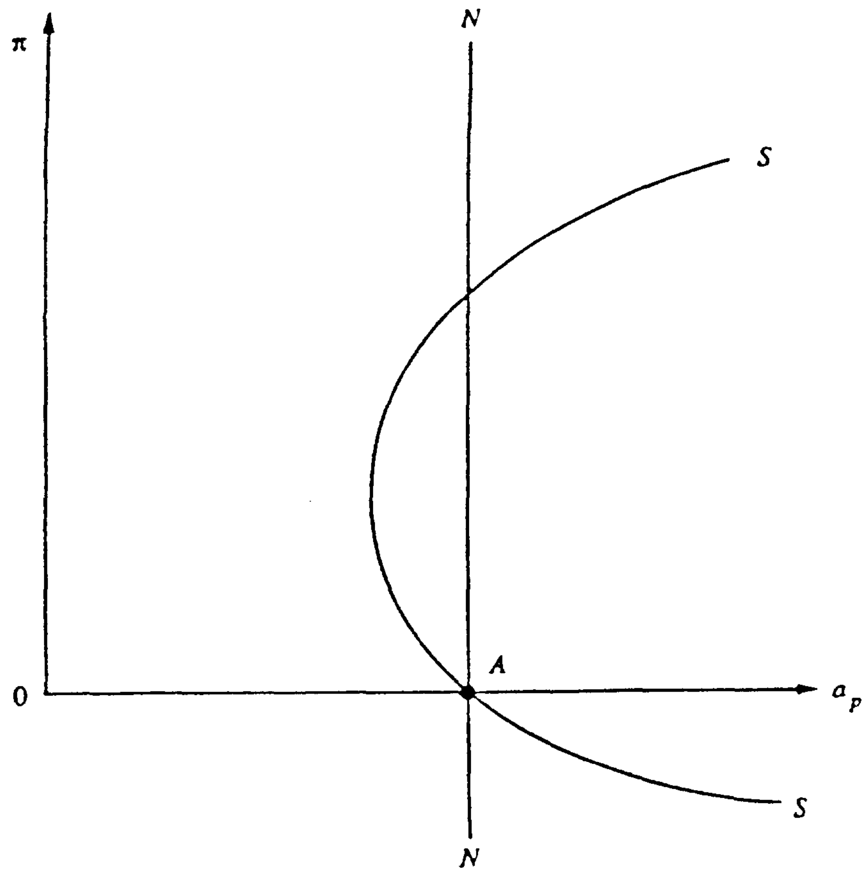
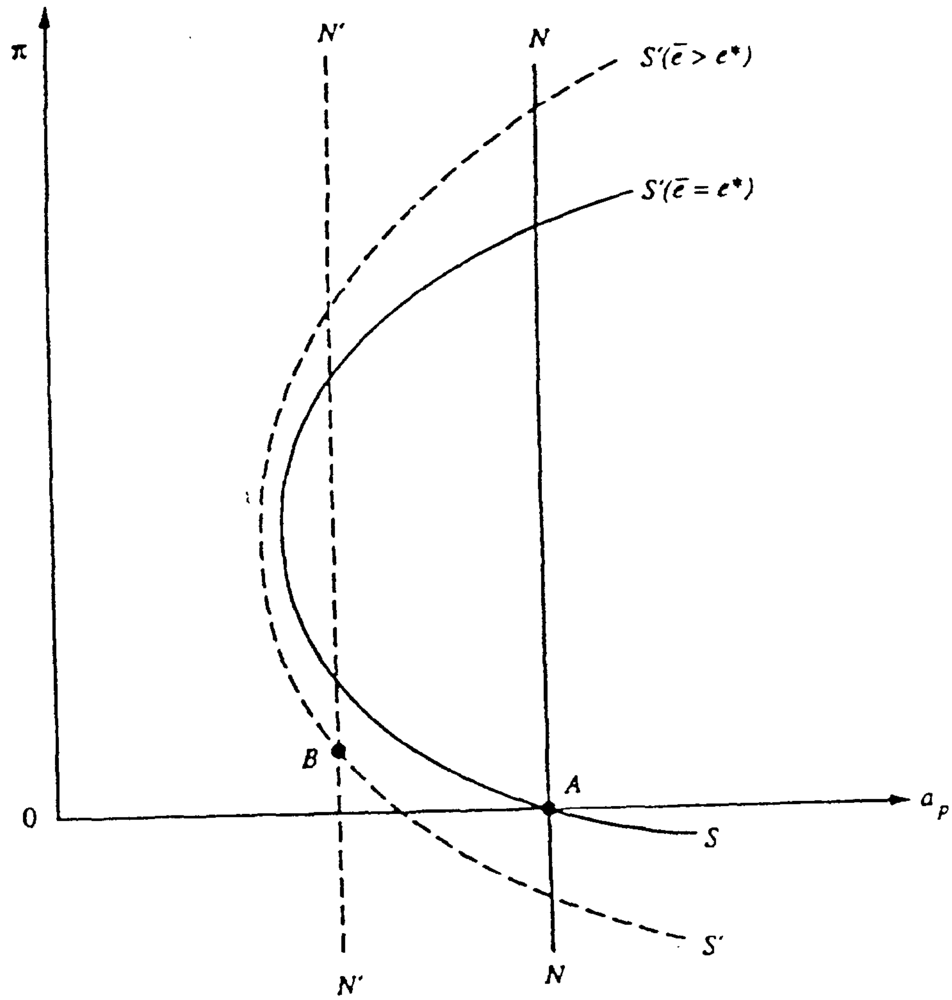


Figure 2
Effect of Choosing an Overdepreciated Real
Exchange Rate Target



It should be noted also that choosing a real exchange rate target that avoids an increase in domestic inflation relative to the fixed exchange rate case (i.e., setting $\bar{e}$ at the level $e^*$), is no easy matter. In particular, detailed knowledge of the entire economic structure (i.e., the values of all the parameters and exogenous variables in the model) is required. It follows that if such knowledge is unavailable and if, in setting a target level for the real exchange rate, one wishes to err on the side of an overdepreciated rather than an insufficiently depreciated target (say, because of external balance considerations), then real exchange rate targeting will be inherently inflationary.

A final point to be made before turning to the effects of real shocks is illustrated in Figure 3. There it is seen that some targets for the real exchange rate are not feasible in the sense that no equilibrium exists for choices of $\bar{e}$ that are sufficiently above $e^*$. In terms of the Figure, since the NN schedule shifts by more than the SS schedule as the real exchange rate target is raised, it follows that for a sufficiently depreciated target, the two curves will no longer intersect and no equilibrium will exist. 1/ The intuition of this type of situation is clear. While successively higher levels of $\bar{e}$ require successively lower levels of $a_p$ to eliminate excess demand for nontradables, substitution away from domestic money and into foreign currency-denominated assets at high rates of inflation implies that there is no level of inflation that is sufficiently high to generate a large enough inflation tax such that equation (7a) can be satisfied. In such a situation, some other policy will need to be altered if such a depreciated real exchange rate target is to be maintained, and the economy is to achieve a steady-state equilibrium.

Consider now the effects of a rise in $\rho$, that is an improvement in the terms of trade. 2/ From equation (6), we know that, for a given rate of inflation $\pi$, an increase in $\rho$ raises saving because it leads to a rise in real factor income, not all of which is consumed. The stabilization of real private wealth therefore requires a rise in $a_p$, which reduces saving by increasing consumption. This is shown by the rightward shift of the SS curve in Figure 4, the magnitude of which is given by:

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1/ Because the extent of the horizontal shifts in the NN and SS loci do not depend on the initial level of inflation, the argument provided in the previous footnote is sufficient to establish that, for sufficiently depreciated real exchange rate targets, the two loci will not intersect, and hence, no equilibrium will exist.

2/ As mentioned previously, there is reason to believe that the effects of targeting the importables or the exportables real exchange rate will differ when there are shocks to the terms of trade. In the first part of this subsection, we assume that the authorities target e (the importables real exchange rate). Before concluding this subsection, however, we briefly consider the consequences of targeting the exportables real exchange rate, $e\rho$.

(18) $da_p/d\rho._{SS} = y'[1-c_1-(r^*+\pi)L_2]/(c_3-r^*) > 0$. 1/

In order to determine the new equilibrium value of $a_p$, we turn to the condition for equilibrium in the market for nontraded goods. An increase in $\rho$ raises the real product wage in the home goods sector, and thereby causes a reduction in the supply of nontradable goods. In addition, the rise in $\rho$ raises real factor income y, which increases the demand for home goods. Thus, both the supply and the demand effects lead to an incipient excess demand in the home goods market, which requires (given that e is fixed by equation 4) a reduction in $a_p$ to restore market clearing. 2/ The magnitude of the reduction in $a_p$, and hence the extent of the leftward shift of the NN schedule in Figure 4, are given by

(19) $da_p/d\rho._{NN} = [\partial y_n/\partial\rho - y'\theta c_1]/\theta c_3 < 0$.

It is clear from Figure 4 that, at the original level of inflation, real private wealth would be increasing. The fact that $\dot{a}_p$ is incipiently positive generates excess demand pressures in the home goods market, thereby putting upward pressure on domestic prices. Equilibrium is therefore only reestablished once inflation and, hence, the inflation tax, have increased to a level that is sufficient to induce the private sector to hold the new equilibrium value of $a_p$ (which is determined in the home goods market, given the new value of $\rho$).

The new equilibrium is given by point B in Figure 4, where $a_p$ is lower and $\pi$ higher than at point A. Totally differentiating equations (7a) and (14), the magnitude of the increase in inflation is given by

(20) $d\pi/d\rho = \{y'[1-c_1-(r^*+\pi)L_2]-(c_3-r^*)(\partial y_n/\partial\rho - y'\theta c_1)/\theta c_3]\}/[(r^*+\pi)L_1+L] > 0$

This equation shows that inflation rises for two reasons. First, as previously indicated, the rise in $\rho$ directly contributes to an increase in saving which, from equation (7a), requires $\pi$ to rise in order to stabilize real wealth. The magnitude of this direct effect is given by the first term in equation (20), $y'[1-c_1-(r^*+\pi)L_2]$. In addition, the fall in $a_p$ that is necessary to clear the home goods market also increases saving, and hence requires an increase in inflation to keep $\dot{a}_p$ from rising above zero. The magnitude of this indirect effect is given by the second term in equation (20), namely $-[(c_3-r^*)\ (\partial y_n/\partial\rho - y'\theta c_1)/\theta c_3]$.

As alluded to previously, the effects of an improvement in the terms of trade under real exchange rate targeting depend on which definition of the

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1/ In signing equation (18), we assume that the marginal propensity to save remains positive even after allowing for the loss of interest income caused by the instantaneous portfolio shift into money that is induced by an increase in household income (see Khan and Montiel, 1987, p. 690).

2/ The reduction in $a_p$ is brought about by a discrete rise in the nominal exchange rate, s.

Figure 3
Effect on Equilibrium of Excessively Depreciated
Real Exchange Rate Targets

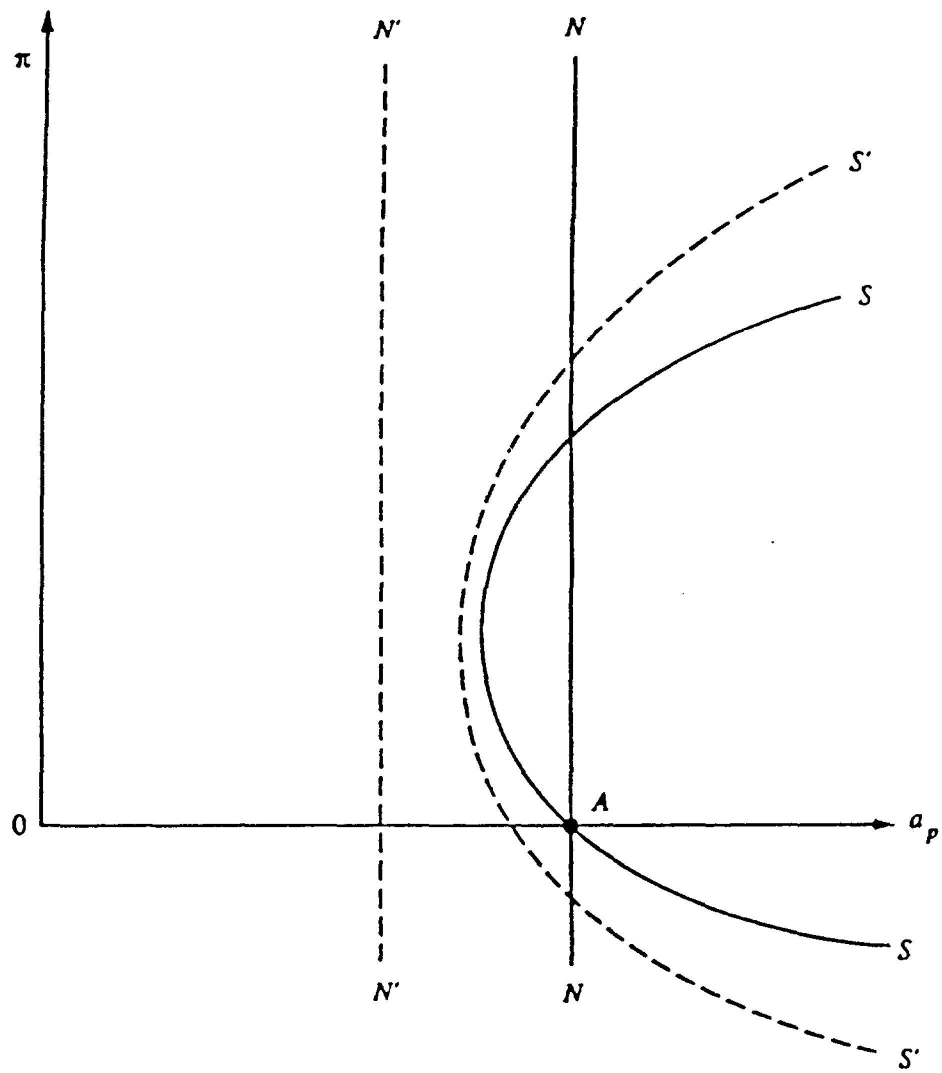
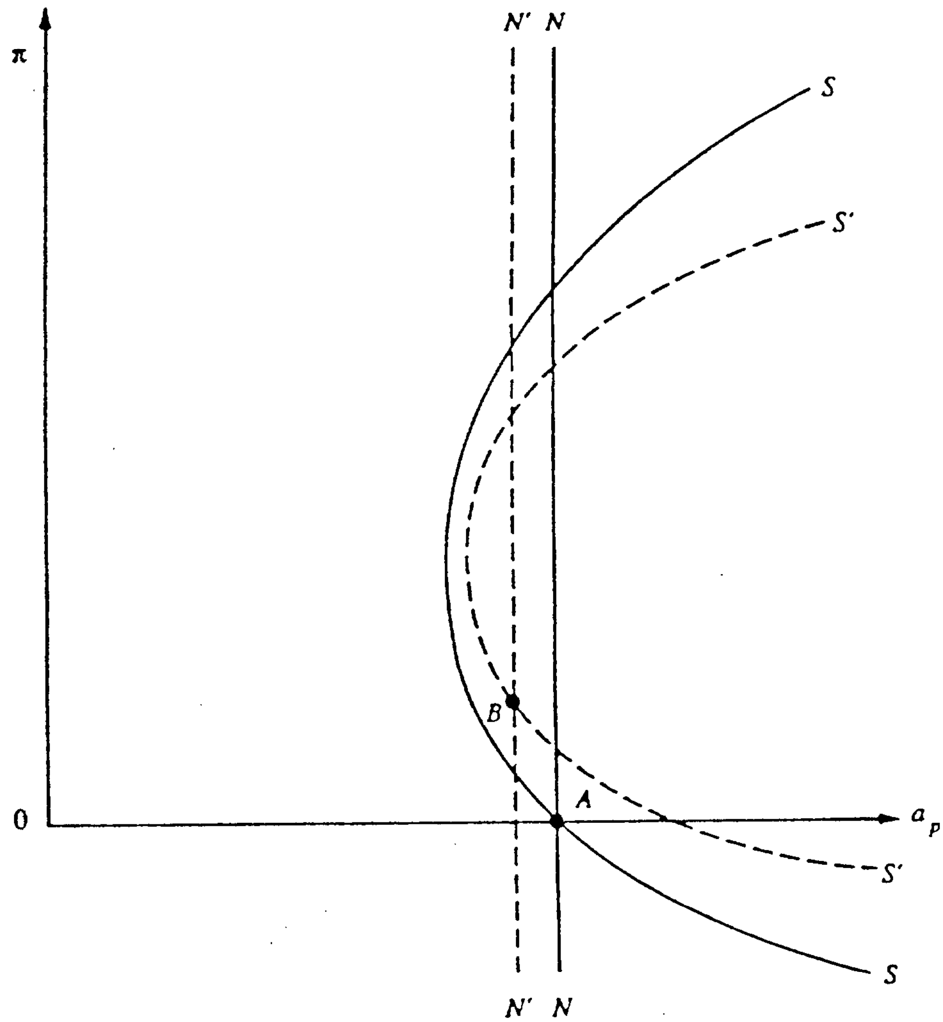


Figure 4
An Improvement in the Terms of Trade



real exchange rate is chosen as the target. Formally, if the authorities decide to target the exportables real exchange rate $e_x = e\rho$, the effects of a rise in $\rho$ will be a combination of those that were analyzed so far in this subsection, together with a reduction in the real exchange rate e. From Figure 2, we know that the qualitative effects of a reduction in e are to lower inflation and raise the level of real wealth, and hence are opposite to the effects of a rise in $\rho$ (which tends to raise $\pi$ and lower $a_p$). In fact, the apparent ambiguity can be established analytically, so that in the presence of a target for the exportables real exchange rate, it is not possible to determine in advance whether a change in the terms of trade will be inflationary or deflationary, and whether it will lead to a rise or a fall in real private sector wealth. This underscores the potential importance of specifying which definition of the real exchange rate is actually to be targeted when an economy is subject to shocks that affect its terms of trade.

While we have assumed that credit policy takes the form of fixing the real stock of credit, it is easy to see that adopting a nominal credit target--e.g., a credit freeze--will not affect the inflation outcome. In other words, the stock of credit cannot provide a nominal anchor for this economy. The price level is determined by the stock of nominal wealth, and credit policy can only alter the composition of private portfolios, without affecting household net worth. The credit freeze cannot provide a nominal anchor because domestic price increases are being driven by private wealth accumulation, a process over which, under perfect capital mobility, changes in the rate of growth of domestic credit have no effect. In spite of the credit freeze, the domestic money supply grows continuously, financed by external inflows through the current and capital accounts of the balance of payments. From equation (11), it can be shown that the increase in the central bank's net worth ($\dot{a}_b$) will equal the inflation tax ($\pi L$), and from (13), it then follows that the credit freeze (which implies that $\dot{d}_p + \dot{d}_g = -\pi(d_p + d_g)$) simply gives rise to a capital inflow equal to $\pi(d_p + d_g)$. If the rate of growth of credit had instead been positive, the capital inflow (and thus the overall balance of payments surplus) would have been commensurately smaller, with no effect on the inflation outcome.

## III. The Model Under Perfect Capital Controls

We now assume that in order to control the domestic money supply, the central bank refrains from engaging in foreign exchange transactions for financial purposes. As a result, a parallel foreign exchange market emerges in which private individuals trade foreign exchange at the market-determined exchange rate, v. The central bank continues to operate an official exchange market, however, for all commercial transactions. Since trade in the official market is limited to commercial transactions, interest earnings on foreign securities are converted into domestic currency at the parallel market exchange rate.

To simplify the analysis, it is assumed that the foreign inflation rate is equal to the nominal interest rate on foreign securities and, therefore, that the foreign real interest rate is zero. This implies that inflows into the parallel market (in the form of interest earnings on the stock of foreign securities) are just sufficient to offset the rate at which the real value of the stock of foreign securities is eroded by foreign inflation, and therefore that the real stock of foreign securities (in terms of traded goods), denoted $f_p$, is constant when capital controls are perfect. 1/

With regard to the composition of the household portfolio, we continue to assume that uncovered interest rate parity holds continuously:

$$(3b) \quad i = i^* + \hat{v},$$

where capital gains on foreign securities now depend on changes in the market-determined exchange rate v. The demand for money can now be written as:

$$(5a) \quad m = L[i^* + \hat{v};\ y(\rho)].$$

As before, assume that the real exchange rate rule is implemented from an initial steady state characterized by a fixed nominal exchange rate (i.e., $\hat{s} = 0$) with no capital restrictions. The resulting equilibrium real exchange rate again represents the base period value for the application of the real exchange rate rule. From (4a), therefore, domestic inflation will be equal to $\pi^*$ in the initial equilibrium. The revisions to the financial sector of the model are completed by using the Fisher equations, $r=i-\pi$ and $r^*=i^*-\pi^*$, together with equations (3b) and (5a), to write the following expression for the domestic real interest rate:

$$(21) \quad r = i^* - \pi^* + \hat{b}$$

$$= \hat{b},$$

where $b = v/s$ represents (one plus) the premium between the financial and commercial exchange rates, $\hat{b}$ is the proportional change of b, and we have used the assumption that $r^* = 0$.

With these changes, the internal balance condition may now be written as: 2/

$$(14a) \quad y_n(\rho) = \theta c[y(\rho)-t,\ \hat{b},\ m+bf_p-d_p] + g_n,$$

---

1/ This simplifying assumption was also made in Montiel and Ostry (1992), on which the exposition in this and the following three sections draws.

2/ We have suppressed the real exchange rate as an argument from the supply of nontradables function since, under the real exchange rate rule, this relative price does not change.

which differs from (14) both because the domestic real interest rate is now endogenous and because the private sector's stock of foreign securities is valued at the free rate v rather than the official rate s. This introduces the multiplicative factor $b = v/s$. In equation (14a), $\rho$ and $f_p$ are exogenous variables, while $g_n$, t, and $d_p$ are policy-determined. To facilitate comparison with the model of the previous section we initially assume that, as in the previous section, monetary policy takes the form of holding constant the real stock of credit to the private sector ($d_p$). 1/ Under this policy, the real money supply m is an endogenous variable. Its behavior over time can be derived from the household budget constraint which yields the following expression for the accumulation of real money balances:

$$(22)\quad \dot{m} = y(\rho)-t-c[y(\rho)-t,r^*+\hat{b},m+bf_p-d_p]+r^*(bf_p-d_p)-\hat{b}d_p-\pi m-b\dot{f}_p+\dot{d}_p.$$

Since $\dot{f}_p=0$ when $r^*=0$, and since monetary policy holds $\dot{d}_p=0$, we can rewrite *equation (22) more simply as:*

$$(22a)\quad \dot{m} = y(\rho)-t-c[y(\rho)-t,\ \hat{b},\ m+bf_p-d_p] - \hat{b}d_p - \pi m.$$

Using equation (4) and the definition of $\hat{b}$, the money market equilibrium condition (5a) can be expressed as:

$$(5b)\quad m = L[\hat{b}+\pi,\ y(\rho)].$$

Solving this expression for the domestic inflation rate $\pi$ yields:

$$(23)\quad \pi = \pi(\hat{b},\ m;\ \rho),\ \pi_1 = -1 < 0;\ \pi_2 = 1/L_1 < 0;\ \pi_3 = -L_2y'/L_1 > 0.$$

Finally, equation (23) can be substituted into equation (22a), and by using the resulting expression together with (14a), the model can be expressed as a system of two differential equations in $\dot{b}$ and m. It can readily be shown, however, that the equilibrium defined by $\dot{m} = \hat{b} = 0$ is unstable (i.e., both roots of the system are positive). Since m and b are both "jumping" variables, therefore, the system will move instantaneously to the steady-state position $\dot{m} = \hat{b} = 0$, which represents the unique perfect foresight solution. 2/

Imposing the conditions $\dot{m} = \hat{b} = 0$ in equations (14a), (22a), and (23) yields a system of three equations in m, b, and $\pi$ which can be used to determine the effects of real shocks on the equilibrium values of these variables. Since our primary interest in this section is in the inflation rate, it is convenient to rewrite the system as a two-equation system in $\pi$ and b that can be analyzed graphically. To do so, note from (4a) that $\hat{v} = \pi$

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1/ Monetary targeting is taken up in the next section.

2/ The instability of the system defined by $\dot{m}=\hat{b}=0$ requires that the interest elasticity of money demand be less than one in absolute value, an assumption adopted in the previous section.

$-\pi^*$ when $\hat{b} = 0$ (since $\hat{b} = \hat{v} - \hat{s}$). We can therefore rewrite the money market clearing condition (5b) as:

(5c) $m = L[\pi, y(\rho)]$.

Substituting this equation into equations (14a) and (22a) (with $\hat{b} = \dot{m} = 0$) yields the following two-equation system in $\pi$ and b:

(24) $y_n(\rho) = \theta c(y(\rho)-t,0,L[\pi,y(\rho)]+bf_p-d_p) + g_n$,

(25) $0 = y(\rho)-t-c(y(\rho)-t,0,L[\pi,y(\rho)]+bf_p-d_p)-\pi L[\pi,y(\rho)]$.

The combinations of b and $\pi$ that satisfy equations (24) and (25) are portrayed in Figure 5. The schedule labelled NN is the locus of combinations of b and $\pi$ that clear the market for home goods (equation (24)). The slope of the NN schedule is:

(26) $d\pi/db|_{NN} = -f_p/L_1 > 0$.

The intuition underlying equation (26) is that a rise in b raises the real value of the private sector's financial wealth, and creates an incipient excess demand for home goods. To restore market clearing, a rise in the inflation rate, which reduces real wealth by lowering real money balances, is required.

The schedule labelled SS is the locus of combinations of b and $\pi$ that maintain the rate of growth of real money balances equal to zero (equation (25)). Its slope is given by:

(27) $d\pi/db|_{SS} = -c_3f_p/[m(1-\epsilon)+c_3L_1)$,

where $\epsilon$ is the absolute value of the interest elasticity of money demand. The numerator of equation (27) is negative since a rise in b raises wealth, increasing consumption expenditures ($c_3>0$) and reducing monetary accumulation. The denominator, however, may be positive or negative since the first term, $m(1-\epsilon)$, is positive (recall that $\epsilon < 1$) but the second term, $c_3L_1$, is negative. The sign of the denominator is ambiguous because an increase in inflation has an ambiguous effect on the accumulation of real money balances, m. On the one hand, an increase in $\pi$ raises the inflation tax when $\epsilon<1$, thereby reducing m; on the other hand, higher inflation reduces real balances, and hence wealth, which causes consumption to decline and saving and m to rise. For sufficiently inelastic money demand, however, the effect of inflation on consumption will be dominated by the effect on the inflation tax. This is the assumption underlying the negative slope of the SS schedule in Figure 5. 1/

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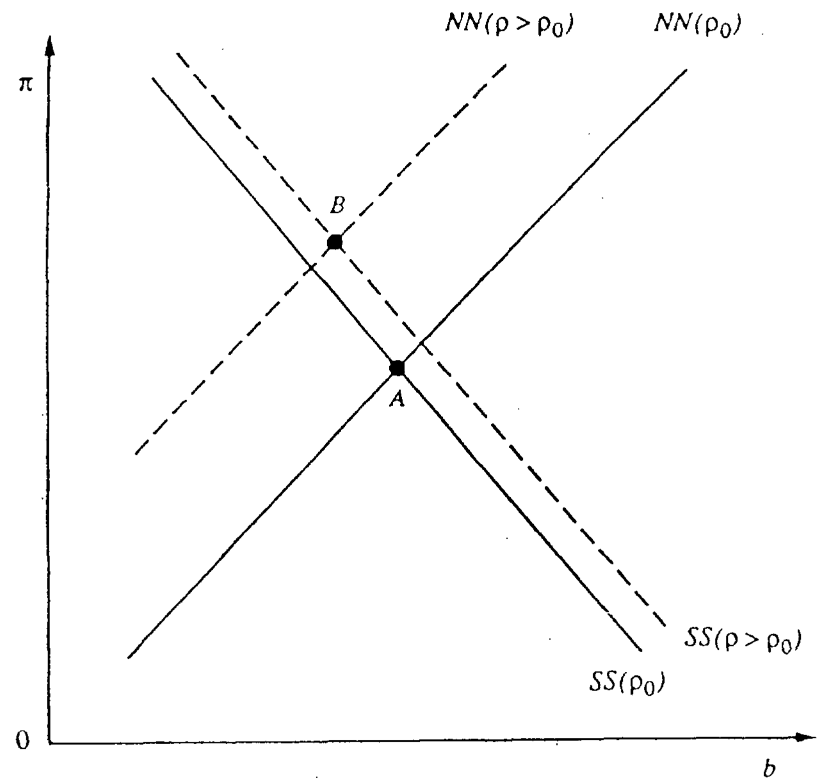
1/ Our comparative statics results do not, however, depend on the assumption that the SS schedule is negatively sloped.

Figure 5
Macroeconomic Equilibrium Under Capital Controls




Note: $\rho_0$ is the initial terms of trade defined as the price of exports relative to imports.

Consider now the effect of an improvement in the terms of trade, i.e., a rise in $\rho$. An improvement in the terms of trade raises the productivity of labor in the exportables sector and causes labor to shift from home goods production to export production. 1/ In addition, the rise in $\rho$ raises real income and hence the demand for home goods. For both reasons, an incipient excess demand for nontradables develops, the elimination of which requires a reduction in real wealth and hence in private spending on all goods, including nontradables. This is brought about by the adverse real-balance effect of a rise in inflation. Thus, the NN schedule in Figure 5 shifts vertically upwards, with the magnitude of the displacement given by:

$$(28) \quad d\pi/d\rho|_{NN} = [y_n' - \theta y'(c_1+c_3L_2)]/(\theta c_3L_1) > 0.$$

Turning to the SS schedule, a rise in $\rho$ raises real factor income y, which by itself would tend to raise the rate of monetary accumulation. However, it also raises real consumption spending, both directly through the marginal propensity to consume, and indirectly by increasing real wealth (through a positive real balance effect). In addition, the positive effect of an improvement in the terms of trade on money demand increases the inflation tax $\pi L$, thereby reducing m. Figure 5 is drawn on the assumption that the marginal saving propensity, $[1-c_1-(c_3+\pi^*)L_2]$, is positive, i.e., that the increase in real income associated with the terms of trade improvement raises income net of the inflation tax by more than it raises consumption. 2/ In this case, the SS schedule in Figure 5 shifts vertically upwards, by a magnitude which is given by:

$$(29) \quad d\pi/d\rho|_{SS} = y'[1-c_1-(c_3+\pi^*)L_2]/[m(1-\epsilon)+c_3L_1] > 0.$$

As can be seen, the shifts in both curves contribute to a rise in the inflation rate although they have opposite effects on the parallel market premium. Solving for the effects of the terms of trade shock on inflation gives:

$$(30) \quad d\pi/d\rho = [-y_n'c_3f_p+\theta y'c_1c_3f_p(1-\pi^*L_2)]/[m(1-\epsilon)f_p\theta c_3].$$

The denominator of this expression is positive under our maintained assumption that $\epsilon<1$. A sufficient condition for the numerator to be positive is that $\pi^*L_2<1$, i.e., that the increase in real income net of inflation tax associated with the improvement in the terms of trade is positive, a condition which is likely to be satisfied in practice. 3/ We

1/ The fact that $y_n' < 0$ can be rigorously shown by substituting into the output supply function the equilibrium real wage as a function of the terms of trade: See Khan and Montiel (1987).

2/ Again, our comparative statics results do not depend on this assumption.

3/ Notice that this condition is equivalent to the requirement that the product of the share of seignorage in real income and the income elasticity of money demand be less than unity, something that would be easily satisfied for any plausible values of the parameters.

conclude that an improvement in the terms of trade raises the steady-state inflation rate under real exchange rate targeting and no capital mobility. This is shown by the movement from Point A to Point B in Figure 5. The premium, b, will certainly decline for sufficiently inelastic money demand, but may increase otherwise.

## IV. Can a Money Supply Rule Stabilize Prices?

Suppose now that the authorities, anticipating the inflationary effects of a shock under real exchange rate targeting, attempt to stabilize the inflation rate (i.e., set $\pi = \pi^*$) by pursuing a monetary target. Under this regime, the nominal money supply continues to grow at the world rate of inflation $\pi^*$. This rule therefore implies:

(31) $\dot{m} = (\pi^* - \pi)m.$

Of course, holding the nominal money supply on this path requires abandoning the assumption that the real stock of credit $d_p$ is constant, since credit policy must now be geared to sterilizing the effects of the balance of payments on the money supply. Returning to the system consisting of equations (14a), (22a), and (23), the new monetary policy regime implies replacing $\dot{m}$ by $(\pi^*-\pi)m$ in equation (22a), with $d_p$ now an endogenous variable. Thus, equation (22a) is replaced by:

(32) $\dot{d}_p = \pi^* m - \{y(\rho)-t-c[y(\rho)-t,\ \hat{b},\ m+bf_p-d_p]\} + \hat{b}d_p.$

The new system consists of equations (14a), (32), (23), and (31). To solve this system, it is convenient to define a variable $w=bf_p-d_p$, which represents households' nonmonetary financial wealth. Since $\dot{w} = \hat{b}f_p-\dot{d}_p$, we can now rewrite (32) as:

(33) $\dot{w} = y(\rho)-t-c[y(\rho)-t,\ \hat{b},\ m+w] + \hat{b}w - \pi^* m.$

Next, the nontraded-goods market equilibrium condition (14a) can be solved for $\hat{b}$, yielding:

(34) $\hat{b} = b(m+w,\ \rho),\quad b_1 = -c_3/c_2 > 0,\quad b_2 = (y_n'-\theta c_1 y')/(\theta c_2) > 0.$

Substituting this expression into equations (23) and (33), and the resulting version of (23) into (31), produces a two-equation system in m and w given by:

(31a) $\dot{m} = \{\pi^* - \pi[b(m+w,\rho),\ m,\ \rho]\}m,$

(33a) $\dot{w} = y(\rho)-t-c[y(\rho)-t,\ b(m+w,\rho),\ m+w] - \pi^* m + b(m+w,\rho)w.$

It can be readily shown that the roots of this system are both positive. Since m and w are both "jumping" variables, this implies that the unique perfect foresight path is given by the solution of (31a) and (33a) with $m = w = 0$.

The immediate implication of this result is that the money-supply targeting rule considered in this section stabilizes the domestic inflation rate at the world rate $\pi^*$ even in the face of a terms of trade shock. This follows from (31a) with $m = 0$, since $\pi = \pi^*$ regardless of the value of $\rho$. Thus, when capital controls are perfect, a money supply rule can indeed stabilize the domestic inflation rate under a real exchange rate target. Notice that (31a) and (33a) also imply that in response to a change in $\rho$, m and w will in general undergo discrete changes. Since the <u>rate of growth</u> of the nominal money supply is fixed by the rule (32), a discrete change in m can come about either through a jump in the domestic price level or through a once-for-all change in the stock of credit $d_p$ to accomodate the impact of the terms of trade shock on the real demand for money. Thus, a jump in the price level can also be avoided under this rule if credit policy is accomodative.

To determine which way the stock of credit will have to move in order to stabilize the domestic price level on impact, equations (31a) and (33a), with $m = w = 0$, can be solved for the effects of the terms of trade improvement on the equilibrium values of m and w. In our case, it proves convenient to solve for m and m+w instead. The result is:

(35a) $dm/d\rho = -mc_3[y'(1-wL_2/L_1)-y_n'/\theta]/(c_2\Delta) > 0,$

(35b) $d(m+w)/d\rho = -m[y'(1-L_2\pi^*)-y_n'/\theta+(w-L_1\pi^*)(y_n'-\theta c_1y')/(\theta c_2)]/(\Delta L_1)<0,$

where $\Delta = -mc_3(\pi^*-w/L_1)/c_2 > 0$ is the determinant of the system (31a) and (33a). Thus, the favorable terms of trade shock results in an <u>increase</u> in the real demand for money, the accomodation of which requires a once-for-all expansion of credit to prevent a discrete fall in the domestic price level. At the same time, the free exchange rate must undergo a discrete appreciation. This follows from the result in equation (35b) that real wealth falls. Since $m+w=m+bf_p-d_p$, and since credit-financed changes in m leave $m-d_p$ unchanged, the exogeneity of $f_p$ under perfect capital controls implies that m+w can fall only through a reduction in the premium b.

In addition to the finding that monetary targeting can indeed stabilize the domestic inflation rate, the second key result of this section is that this initial change in the premium cannot be the end of the story. In fact, the premium will continue to change over time, even while m and w remain at their stationary values. To see this, notice from equation (34) that the increase in $\rho$ and decline in m+w will tend to move the rate of increase in the premium--which effectively represents movements in the domestic real interest rate--in opposite directions. The favorable terms of trade shock tends to induce an excess demand for nontraded goods, requiring an increase in the domestic real interest rate (i.e., in $\hat{b}$) to restore equilibrium in that market, while the reduction in household wealth m+w induces an excess supply of nontraded goods, requiring a fall in $\hat{b}$ to restore equilibrium. The net effect can be derived by using (35b) in (34), which yields:

$$(36)\quad d\hat{b}/d\rho = [y'(1-L_2\pi^*)-y_n'/\theta]/(L_1\pi^*-w) < 0.$$

Thus, the exchange rate (or equivalently the premium) in the parallel market undergoes a discrete initial drop and then appreciates continuously at a constant rate. The permanent rate of appreciation represents a reduction in the domestic real interest rate required to maintain equilibrium in the market for nontraded goods in the face of the reduction in the demand for such goods caused by the decline in real household wealth.

Under real exchange rate targeting, then, the only way that a permanent wedge between the domestic and foreign real interest rates can emerge is with an ever-widening gap between the commercial and financial exchange rates (i.e., $\hat{b} \neq 0$). 1/ While this may be sustainable in the short run, it is unlikely to be so in the long run, when an ever-widening gap between the two exchange rates would create unbounded incentives to engage in cross-transactions between official and unofficial markets.

To summarize the results of this section, under real exchange rate targeting, a favorable terms of trade shock leads to a current account surplus. To sterilize the monetary effects of the associated reserve inflow, the central bank is forced to contract credit. Fixing the money supply in this manner can indeed prevent the emergence of inflation. However, the continued credit contraction causes an appreciation of the financial exchange rate. Because the current account surplus is permanent, credit contraction must be continuous, which implies an ever-widening gap between the official and financial exchange rates. In the face of increasing incentives for cross-transactions, the separation between the markets must break down. Thus, the effectiveness of capital controls will not be sustainable under simultaneous real exchange rate and monetary targeting. We now examine whether monetary targeting can effectively stabilize the price level when capital controls are less than perfect.

## V. The Model with Leakages

The results of the previous section suggest that our model should explicitly incorporate the effects of incentives to engage in cross-transactions that arise when a substantial gap begins to emerge between the financial and commercial exchange rates. In this section, we incorporate such "leakages" between markets in the simplest way possible. We make the conventional assumption that when the financial exchange rate v is

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1/ Notice also that, since $\dot{w} = b\dot{f}_p - \dot{d}_p$ is constant and $\dot{f}_p$ is exogenous, the fact that $\hat{b} < 0$ implies that $\dot{d}_p < 0$. This perpetual credit contraction, resulting from the need to sterilize permanently the current account surplus induced by the favorable terms of trade shock, creates continual pressure on the financial exchange rate to appreciate.

depreciated (appreciated) relative to the commercial rate s, i.e., $b > 1$ ($b < 1$), arbitrage flows are created between these two markets. 1/ Thus, inflows into the parallel market will be an increasing function k(.) of the premium b-1:

$$(37)\quad \dot{F}_p = k(b-1) + i^*F_p, \quad k(0) = 0,\ k'(0) > 0,$$

where the second term in (37) represents interest earnings on holdings of foreign securities (which we have already assumed to be exchanged through the parallel market). Using the definition of the real value of foreign securities $f_p$ we can rewrite equation (37) as: 2/

$$(37a)\quad \dot{f}_p = k(b-1).$$

Thus, given the properties of the k(.) function, it is clear that when $b=1$ so that there is no premium, inflows into the parallel market in the form of interest earnings are just sufficient to offset the erosion in the real value of foreign securities due to foreign inflation, as in the last section. When $b > 1$, however, households are able to direct foreign exchange into the free market, implying that $\dot{f}_p$ is positive. Increases in b further increase inflows into this market. Conversely, when $b < 1$, $\dot{f}_p$ is negative as individuals find it profitable to sell in the official market foreign exchange acquired in the unofficial market. Although inflows are negative in this case, they become less negative as b rises towards 1, so that k(.) is still an increasing function as stated in equation (37).

Consider once again the regime of Section II in which the authorities keep the real stock of credit $d_p$ constant. The internal balance condition continues to be given by equation (14a), which can be solved for $\hat{b}$ as a function of b, $f_p$, and m:

$$(38)\quad \hat{b} = \Phi(b,\ f_p,\ m),\ \Phi_1=-f_pc_3/c_2 > 0;\ \Phi_2=-c_3/c_2 > 0;\ \Phi_3=-c_3/c_2 > 0.$$

A rise in b, $f_p$, or m raises real private holdings of financial wealth and creates an excess demand for home goods, the elimination of which requires a rise in the domestic real interest rate, and hence in $\hat{b}$.

Substituting equation (38) and the definition of $\hat{v}$ into the money market equilibrium condition (equation (5a)) and solving for $\pi$ gives:

$$(39)\quad \pi = \omega(b,\ f_p,\ m),\ \ \omega_1=f_pc_3/c_2 < 0;\ \omega_2=c_3/c_2 < 0;\ \omega_3=c_3/c_2+1/L_1<0.$$

A rise in b or $f_p$ raises the domestic interest rate, thereby lowering money demand and creating excess supply in the money market. Equally, a rise in m creates an excess supply of real balances. In all three cases, therefore, a fall in the inflation rate $\pi$ is required to restore money market

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1/ See, for example, Guidotti (1988) and Bhandari and Végh (1990).
2/ Recall the assumption $i^* = \pi^*$.

equilibrium. Substituting equations (37), (38), and (39) into the private sector's budget constraint and setting $d_p = 0$ gives the following expression for $\dot{m}$:

$$(40)\quad \dot{m} = y(\rho)-t-c[y(\rho)-t,\Phi(b,f_p,m),m+bf_p-d_p]-\omega(b,f_p,m)m-\Phi(b,f_p,m)d_p-bk(b-1)$$

$$= \Psi(b,f_p,m),\ \Psi_1=-k'-Rf_pc_3/c_2;\ \Psi_2=-Rc_3/c_2;\ \Psi_3=-Rc_3/c_2-(1-\epsilon)m/L_1,$$

where $R = (m-d_p)$ represents the central bank's holdings of foreign exchange reserves which are assumed to be positive. 1/ With $\epsilon$ less than unity, $\Psi_1$ is ambiguous in sign (since $k'>0$), but $\Psi_2$ and $\Psi_3$ are both positive. 2/ Equations (37a), (38), and (40) form a three-equation dynamic system in b, $f_p$, and m. The trace of the matrix associated with this dynamic system is equal to $\Phi_1 + \Psi_3$, which is positive, implying that not all the roots of the system can be negative. The determinant of the matrix associated with the dynamic system is equal to $-m(1-\epsilon)k'c_3/(c_2L_1)$, which is negative, implying that the number of negative roots must be odd. From these two facts, it follows that the matrix associated with the dynamic system possesses exactly one negative and two positive roots. Recalling that the system possesses a single predetermined variable ($f_p$), it follows that the equilibrium defined by $\dot{f}_p = \dot{b} = \dot{m} = 0$ is a saddlepoint.

Rather than solve for the dynamics of the system, which are not of immediate interest, we proceed directly to analyze the effects of a terms of trade shock on the long-run equilibrium, focusing particularly as before on the effects on the steady-state rate of inflation. Since in the steady state, the real stock of foreign securities must be constant (i.e., $\dot{f}_p = 0$), it is clear from equation (37a) that the premium must also reach a constant value, i.e., b = 1. Having established that b is constant (i.e., $\dot{b} = 0$), the internal balance condition (equation (14a)) now determines the level of private wealth, $m+bf_p-d_p$. With b and $f_p$ reaching constant values (equation (37a)) and with monetary policy holding $d_p$ constant, it is clear that internal balance requires m to be constant. Therefore, the private sector budget constraint (equation (22)) may be written as in Section III above with $\dot{m}=\dot{b}=\dot{f}_p=\dot{d}_p=0$. It follows that the steady state of the system is formally identical to the one analyzed in Section III (given specifically by equations (24) and (25) above). Because b and $f_p$ enter the steady-state model only multiplicatively, the solutions for $bf_p$ and $\pi$ will be identical in this section with those in Section III. The only difference between the models is that, rather than determining $\pi$ and b as in Section III, the system now determines the steady-state values of $\pi$ and $f_p$. In particular, under the domestic credit rule $d_p = 0$, the steady-state response of the rate of inflation to a terms of trade shock is the same in the model with leakages as in the model without.

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1/ If the central bank extends credit to the government, $m-d_p$ is reserves plus credit to the government; in either case, $m-d_p$ is positive.

2/ As mentioned previously, all results are evaluated around an initial steady state with b=1.

The analysis of this section thus indicates first that the incorporation of leakages into the basic model of capital controls implies that, rather than adjusting instantaneously to terms of trade or other shocks, the economy moves gradually towards a steady-state equilibrium, with its position at any instant being driven by the value of the system's only predetermined variable, $f_p$. In the steady state, the only differences between the models with or without leakages concerns the values of b and $f_p$. In the model of Section III, $f_p$ is exogenous while b is endogenous, and vice-versa in the model with leakages. Since b and $f_p$ only enter the system as a product, it is clear that the value of $bf_p$ must be the same in both cases. Equally, it is clear that the values of all other endogenous variables, and specifically the inflation rate, to which the economy ultimately converges in the steady state, are the same in the models with or without leakages. Therefore, as in Section III, an improvement in the terms of trade is inflationary under real exchange rate targeting in the model with leakages, with the long-run effect on $\pi$ being given by the expression in equation (30). With this result in hand, we now proceed to address the issue of whether a monetary policy rule can contain this inflationary impact once the possibility of leakages is taken into account.

## VI. The Effect of a Monetary Rule in the Model with Leakages

To analyze the consequences of monetary targeting in the presence of leakages, we again assume that the authorities adopt the money supply rule (31). To derive the required rate of credit expansion, substitute (31) in (22) as before and solve for $d_p$ without, however, setting $f_p = 0$ in this case. The resulting credit policy is given by:

$$(41)\quad \dot{d}_p = \pi^* m - \{y(\rho)-t-c[y(\rho)-t,\ \hat{b},\ m+bf_p-d_p]\} + \hat{b}d_p + b\dot{f}_p,$$

which differs from (32) only by the inclusion of the term $b\dot{f}_p$, representing the credit expansion required to offset the monetary consequences of leakages into the unofficial foreign exchange market.

The resulting model consists of the nontraded goods market clearing condition (14a), the money market equilibrium equation (23), equation (31) describing the evolution of the real money supply, the leakage function (37a), and the credit rule (41). Proceeding as in Section IV by making use of the variable $w = bf_p-d_p$, and noting that now $w = bf_p+bf_p-d_p$, we can again substitute into the credit rule, in this case, equation (41). It is immediately clear, however, that the resulting version of (41) is identical to equation (33a). Thus, the system that emerges in this section is identical to that of Section IV, with the addition of the leakage function (37a).

The introduction of leakages, however, turns out to have radical implications for the model of Section IV. The interpretation of the system is exactly as before except that corresponding to the new leakage function (37a), the variable $f_p$ now becomes predetermined, rather than exogenous.

Since the system is forward-looking, the solution implies working backward from a steady-state configuration. Consider, then, the steady-state version of the model. For the system to reach a steady state, the predetermined variable $f_p$ must satisfy $\dot{f}_p=0$. From (37a), this requires b=1, i.e., the premium must disappear in the steady state, and $f_p$ becomes an endogenous variable. Recall, however, from Section III that in the steady state the model determines values for both w and $\hat{b}$. By examining equations (31a) and (33a), moreover, it is easy to verify that $f_p$ does not appear in the model's steady-state equations. The condition $\dot{f}_p=0$, with $f_p$ made endogenous, therefore in effect introduces an additional restriction on the model (b=1, so $\hat{b}=0$), without introducing an additional endogenous variable (since $f_p$ does not appear in the model). It is not surprising, therefore, that this model does not possess a steady-state solution. There is no perfect-foresight path consistent with monetary targeting in the model with leakages.

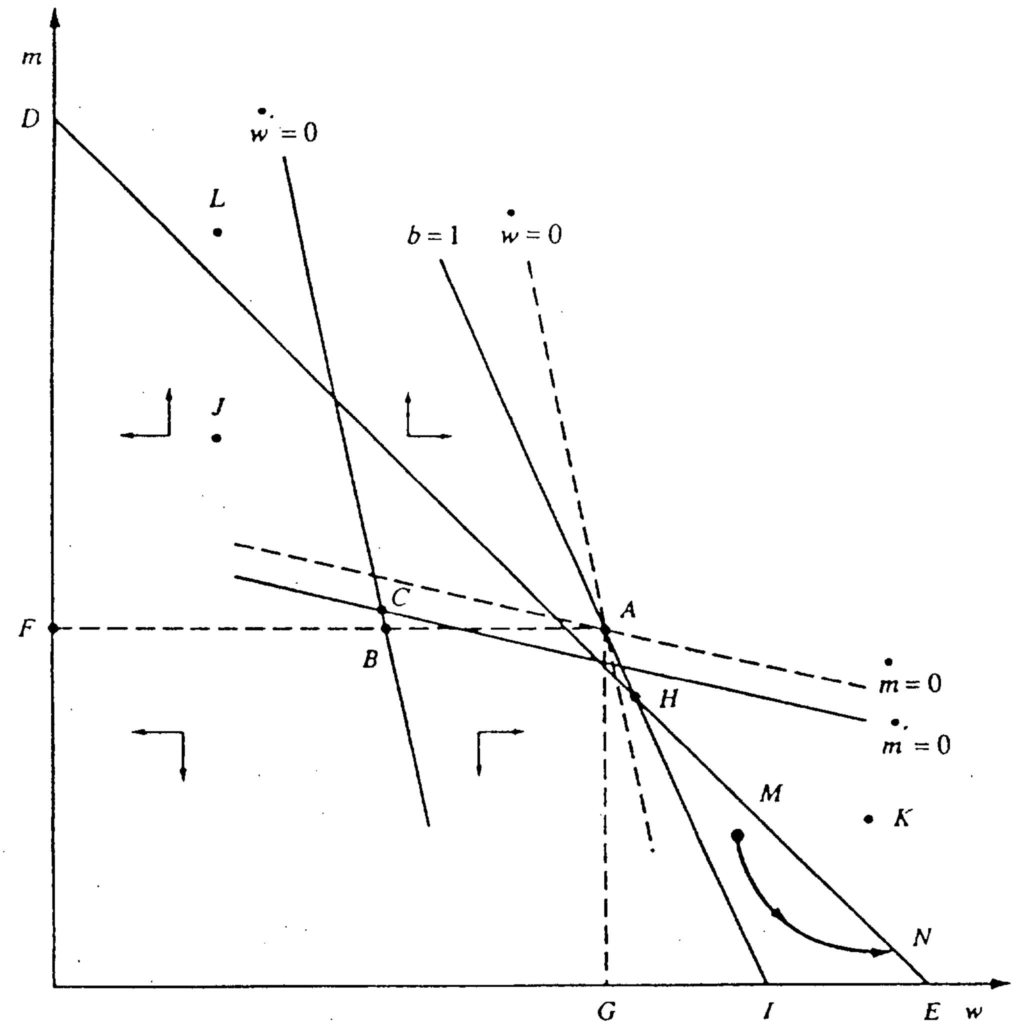
The economics underlying this result are straightforward. In brief, the presence of leakages implies that in the long run the economy effectively exhibits perfect capital mobility. Changes in the stock of credit will not, therefore, affect the real money supply. Instead, since the system determines an equilibrium value of the stock of real nonmonetary assets w, changes in $d_p$ will simply be offset by corresponding changes in $f_p$, just as in our previous model, and monetary policy will be powerless to alter the economy's steady-state inflation rate. The only steady-state solution of the system, therefore, is that of the previous section, with $\pi > \pi^*$ in response to a permanent improvement in the terms of trade. Money supply targeting cannot provide an alternative nominal anchor in this case, simply because monetary policy cannot control the money supply in the long run in the presence of leakages.

Suppose, however, that, in full awareness of this result, the authorities nevertheless respond to a terms of trade shock by <u>temporarily</u> supplementing their real exchange rate target with capital controls and a money supply target, intending to abandon such controls at some future date. Could such a policy, while it is in place, succeed in stabilizing the domestic inflation rate at the world rate $\pi^*$?

This question is addressed in Figure 6. Setting $\dot{m} = 0$ in equation (31a) and $\dot{w} = 0$ in (33a) yields the dotted loci labeled with the corresponding conditions in Figure 6. Along the $\dot{m} = 0$ locus, the domestic rate of inflation $\pi$ equals the world rate $\pi^*$, so that with the target growth rate of the domestic money supply set equal to $\pi^*$, the real money supply is unchanged. Along the $\dot{w} = 0$ locus, real household nonmonetary financial wealth is unchanged. 1/ The relative slopes of these loci follow from:

1/ We assume that the $\dot{w} = 0$ locus is negatively sloped, which will be the case if the world rate of inflation is small. Our results do not depend on this assumption, however.

Figure 6
Dynamics Under Temporary Capital Controls



(42) $dm/dw|\dot{w}=0=(-wc_3/c_2)/(\pi^*+wc_3/c_2) < dm/dw|\dot{m}=0=(c_3/c_2)/(c_3/c_2+1/L_1) < 0.$

A favorable terms of trade shock in the context of real exchange rate and monetary targeting causes the $\dot{w}$ = 0 locus to shift to the left. 1/ The $\dot{m}$ = 0 locus may shift in either direction, but in any case will intersect the new $\dot{w}$ = 0 locus (labeled $\dot{w}'$ = 0) to the northwest of point B, so that the intersection of the two loci corresponds to a lower value of w and higher value of m, say at point C. This follows from equations (35a) and (35b) in Section IV, and corresponds to the perfect foresight equilibrium in the absence of leakages between markets.

In the presence of leakages, however, the point C no longer represents an equilibrium. To study the economy's dynamics in this case, consider the family of loci in Figure 6 corresponding to constant values of real private wealth $a_p$ = m+w. Each member of this family has slope -1, and one such member, denoted DE, is indicated in Figure 6. Another such locus, corresponding to a higher value of $a_p$, passes through the initial equilibrium at A, while yet a third, with the lowest value of $a_p$, passes through C. The relationship between the value of $a_p$ at C and its initial value at A is derived in equation (35b). It is also possible to show that, once capital controls are abandoned, the long-run equilibrium value of $a_p$, which we refer to as $a_p^*$, will settle somewhere between its value at C and at A--i.e., the long-run free capital mobility equilibrium must be along a locus such as DE. 2/

To see how the economy gets from A to its long-run position along DE in the presence of leakages, notice that along a perfect foresight path neither the premium b nor the aggregate price level can be expected to move discontinuously, since this would create arbitrage opportunities among assets or across time. The implication of this is that household wealth cannot jump at the instant that capital controls are abandoned--i.e., the perfect-foresight path must move the economy on to the locus DE at that instant. 3/ On impact, then, the economy must move into a region in the m-w plane from which it can reach DE at the appropriate instant. Notice that both m and w can jump to the perfect-foresight path, as in Section IV. Because the nominal values of the stocks of money, foreign assets, and credit are all predetermined, these jumps must come about through changes in the premium b and in the aggregate price level. From such an initial point, the dynamics of the system must obey the directional arrows indicated in

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1/ The magnitude of the shift is given by $dw/d\rho|\dot{w}=0=[y'(1-wc_1/c_2)-y_n'/\theta(1-w/c_2)]/(wc_3/c_2)<0$.

2/ This can be shown as follows. Totally differentiating equation (14a) under the assumption of perfect capital mobility so that b=1 (and therefore $\hat{b}$=0), we have that $d(m+w)/d\rho = (y_n'-\theta c_1 y')/\theta c_3 < 0$. Comparing this to the result in (35b) shows that the reduction in m+w is smaller under perfect capital mobility than under perfect capital controls.

3/ Since m+w cannot jump at the moment that controls are abandoned, equation (14a) implies that $\hat{b}$ also cannot change discontinuously.

Figure 6, which are derived with reference to the $\dot{m}' = 0$ and $\dot{w}' = 0$ loci, since these govern the system's dynamics until capital controls are abandoned.

To see where the economy moves on impact, consider first the locus of all points that can be reached from A by a jump in the price level, with b unchanged at its initial value of unity. This locus is labeled b=1 in Figure 6. It has a negative slope (because an increase in the price level reduces both m and $d_p$, and the latter increases w) which is greater than unity in absolute value. To reach points to the left of this locus b has to fall, while to reach points to the right b has to rise. Points that are simultaneously below the b=1 and DE loci, such as J, cannot be on a perfect foresight path, because such points are characterized by b<1 and $m+w<a_p^*$. The latter implies, from equation (34), that $\hat{b}<0$, so b is unable to reach its final value of unity when controls are abandoned without undergoing a discrete upward jump, an event which we have previously ruled out. Similarly, points simultaneously above both loci, such as K, have b>1 and $m+w>a_p^*$ so $\hat{b}>0$, and the same problem arises (except that a discrete drop is required in this case). Finally, it can be shown that the locus DE cannot be reached from points above DE and $m'=0$, but below b=1, such as L. 1/ It follows that on impact the economy must jump to a position below $m'=0$, and between the loci b=1 and DE, to a point such as M in Figure 6. From M, the economy must follow a path such as the one indicated in the figure, reaching a point such as N on the locus DE at the instant capital controls are abandoned.

The relevant observation about this path for present purposes is that along MN the real money supply is continuously falling. Since, from equation (31a), this implies that $\pi>\pi^*$ along MN, it follows that targeting the growth rate of the money supply at its pre-shock level succeeds neither in stabilizing the price level--which jumps on impact--nor the rate of inflation, which remains above the world rate even as the domestic money supply is targeted to grow at the world inflation rate $\pi^*$ by continuous sterilization with capital controls. Moreover, Section II showed that the

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1/ Above the $\dot{m}' = 0$ locus, the directional arrows in Figure 6 imply that m is increasing, which from (31a) implies that $\pi < \pi^*$. As shown in Section II, we know that when capital controls are ultimately abandoned, say at time T, the rate of inflation $\pi(T)$ will be above the world rate $\pi^*$, which implies that above $m' = 0$, $\pi < \pi(T)$. Summing equations (31a) and (33a) gives an expression for $a_p$ which is decreasing in $\pi$. Since real wealth is constant in the absence of capital controls, it follows $a_p(\pi) = 0$ for $\pi = \pi(T)$ and, since $a_p(\pi)$ is a decreasing function, it follows that for values of $\pi < \pi(T)$ (such as at point L in Figure 6), $a_p > 0$. To sum up the argument thus far, $a_p$ must be positive for all points in the indicated region, that is above $m' = 0$ and DE but below b = 1. However, in order to reach DE from a position in the indicated region, $a_p$ has to be falling, so $a_p < 0$. We conclude therefore that it is not possible to reach the locus DE, along which the equilibrium at time T must lie, from a position in the indicated region.

steady-state domestic inflation rate remains above the world rate when capital controls are eventually abandoned. It follows, then, that in the presence of leakages, targeting the money supply fails to stabilize the rate of inflation over all time horizons.

## VII. Conclusion

This paper has attempted to analyze some of the important macroeconomic issues surrounding real exchange rate targeting in developing countries. The first part of the paper sought to answer two main questions in the context of a reference model that assumed perfect capital mobility. First, how does the level at which the authorities choose to target the real exchange rate affect the economy's steady-state rate of inflation? Here, it was found that the more depreciated the real exchange rate target relative to the equilibrium rate, the higher will be the level of inflation. Second, what is the effect of real disturbances, taken for our purposes to be terms of trade shocks, on the inflation rate? It was found that whereas real shocks would have no effect on the steady-state inflation rate under a fixed nominal exchange rate or crawling-peg regime, this was no longer the case under real exchange rate targeting. For example, it was shown that an improvement in the terms of trade would raise the economy's steady-state inflation level under real exchange rate targeting and that the attempt to mitigate this outcome by altering domestic credit policy would prove to be fruitless.

Given the results in the first part of the paper and in particular the fact that, under perfect capital mobility, domestic credit policy could not substitute for the traditional role of the exchange rate as the nominal anchor for the domestic price level, the second part of the paper considered the case in which capital controls were imposed, thereby rendering sterilization feasible, and asked whether money-supply targeting could stabilize the price level in response to shocks when the authorities targeted the real exchange rate. It was argued that when capital controls are perfect, so that the government can permanently segment official and unofficial markets for foreign exchange, the inflation rate can indeed be stabilized in the face of exogenous shocks when the authorities follow an appropriately chosen money-supply rule. However, we also showed that the stabilization of the inflation rate carried with it the implication that in the long-run equilibrium, an ever-widening gap between the official and unofficial exchange rates would emerge. Since this growing gap between the two exchange rates would ultimately create unbounded incentives to engage in cross-transactions between official and unofficial markets, we argued that the effectiveness of capital controls could not ultimately be sustained.

The paper went on to examine whether monetary targeting could effectively stabilize the inflation rate when these incentives for cross-transactions create leakages between official and unofficial markets for foreign exchange. Our finding once again was that using money as a nominal anchor for the price level is problematic. Although the model with cross-transactions did not possess the difficulty that the gap between official and unofficial exchange rates grew continuously in the steady state, and hence avoided some of the problems that were inherent in the model with perfect capital controls, our conclusion was nonetheless that a money-supply rule could not prevent the emergence of inflation when the economy was subjected to a permanent terms of trade shock. The reason was simply that, in the presence of leakages, the long-run behavior of the economy must be identical to that of an economy without any capital controls, i.e., with perfect capital mobility. Since, under perfect capital mobility, changes in the stock of credit cannot affect the real money supply, so too in the model with leakages, the money supply becomes endogenous and hence cannot be used as a nominal anchor for the domestic price level. In addition, however, the paper showed that if capital controls are used temporarily to target the rate of growth of the money supply, a monetary rule would still fail to stabilize the rate of inflation even in the short run.

To conclude, then, this study finds little support for the view that a money-supply rule can stabilize the inflation rate when the authorities target the real exchange rate. When, as under real exchange rate targeting, the nominal exchange rate cannot serve as an anchor for the domestic price level, we find that the money supply cannot serve as an alternative nominal anchor.

## The Model with Sticky Wages

The analysis in the text was conducted in the context of a model with fully flexible nominal wages and prices. A notable feature of the reference model of Section II, for example, was that the economy adjusted immediately to shocks, with wages, the level of real private sector wealth, and the rate of inflation all adjusting instantaneously to their new, long-run, equilibrium values, and full employment prevailing continuously. This immediate adjustment would not be observed if nominal wages exhibited some degree of stickiness. In such a situation, moreover, shocks such as those analyzed in the text would have Keynesian employment effects. The purpose of this appendix is to examine the dynamic path followed by an economy that shares all the main features of the one described in Section II--particularly in terms of its overall structure and adherence to a real exchange rate target--except for the fact that in the labor market a Phillips curve is assumed to determine the rate of nominal wage adjustment in the short run. This simple modification of the basic model is sufficient to analyze deviations of real output from its full employment level, as well as to generate interesting dynamic paths for the other main variables of interest (particularly real wages and real wealth accumulation, and hence external current balances), even in the model with perfect capital mobility.

Suppose that the nominal wage, W, while fully flexible in the long run, is a predetermined variable in the short run, whose rate of change is given by the following simple Phillips curve adjustment rule:

$$\text{(A1)} \quad \hat{W} = G[L_x(W/P_x) + L_n(W/P_n) - \bar{L}] + \pi, \quad G(0) = 0, \; G'(0) > 0,$$

where $\bar{L}$ is the fixed supply of labor, and $L_x$ and $L_n$ represent labor demand in the exportable and nontraded sectors, respectively (each inversely related to the sectoral product wage). Equation (A1) states that the rate of change of nominal wages is equal to the rate of expected (equals actual) price inflation plus some positive function of the extent of demand pressure in the labor market. By using the definition of the real wage $w = W/P_z$ and the real exchange rate rule (equation 4 in the text), it is straightforward to show that equation (A1) is equivalent to:

$$\text{(A2)} \quad \hat{w} = G[L_x(W/P_x)+L_n(W/P_n)-\bar{L}] = G[L_x(w/\rho)+L_n(ew)-\bar{L}] = g(w,\rho,e).$$

Thus, equation (A2) determines the evolution of the real wage out of steady state (as a function of the level of the real wage, the terms of trade and the real exchange rate target) while setting $\hat{w} = 0$ in (A2) determines the equilibrium value of w in the steady state (where excess demand for labor is equal to zero), as a function of $\rho$ and e.

Consider now the condition for market clearing in the home goods sector. Recall that in the flexible-wage version of the model the nontradables market clearing condition (equation 14) determined the level of real wealth $a_p$ through movements in the nominal exchange rate, or equivalently, in the domestic price level. The story is almost the same here, except that now, with the nominal wage W predetermined, movements in the nominal exchange rate simultaneously determine both the real wage w and the level of real wealth $a_p$ in the short run. Any shock that affects equilibrium in the home goods sector will therefore bring about some change in the nominal exchange rate, s, which in turn will cause the level of the real wage and the level of real private wealth to jump. Thus, in the long run, equation (A2) will determine the level of the real wage and the nontradables market clearing condition (equation 14) will determine the level of real wealth; in the short run, both the level of the real wage and the level of real wealth will be determined in the nontradables market via changes in the domestic price level.

Some of these considerations are illustrated in Figure 7. On the vertical axis, we plot the level of real private wealth $a_p$, while on the horizontal axis, we plot the real wage, w. The line labelled ww depicts equation (A2) with $\hat{w} = 0$. It intersects the horizontal axis at the initial steady state level of the real wage. To the left of the ww line, real wages are rising, and conversely to the right of ww, real wages are falling (equation A2). The locus labelled HH passing through point A represents those combinations of w and $a_p$ that are consistent with zero excess demand for home goods (equation 14). A rise in w reduces supply of nontraded goods (by raising the real product wage in that sector), the elimination of which requires a fall in $a_p$ to reduce demand in line with the reduction in supply. Thus, the HH schedule must have a negative slope: 1/

(A3) $da_p/dw = [(\partial y_n/\partial w)(1-\theta c_1)-\theta c_1(\partial y_x/\partial w)]/\theta c_3 < 0.$

At point A, the intersection of the HH and ww loci determine the initial levels of $a_p$ and w, consistent with simultaneous equilibrium in the market for home goods and labor. 2/ Since $a_p=(sF_p+M-D_p)/P_z$ and $w=W/P_z$, it can be shown that changes in s (or equivalently in $P_z$) will induce $a_p$ and w to move along a locus given by $a_p=F_p+(M-D_p)w/W$ which passes through A. If $F_p$ and $(M-D_p)$ are both positive, this locus has a positive slope and positive intercept. It is depicted by KK in Figure 7.

Figure 7 is useful for analyzing both the transitional dynamics and long-run response of the economy to real shocks. To take our example, suppose that from an initial equilibrium at point A in the figure, the economy experiences an improvement in its terms of trade, that is a rise in

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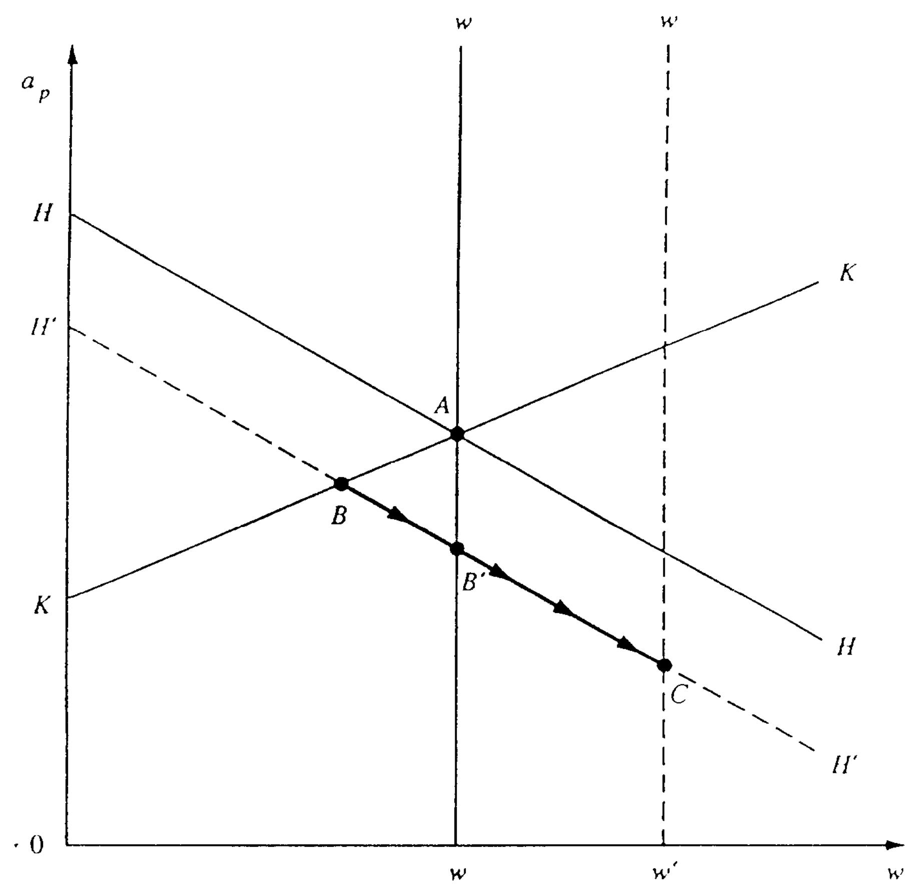
1/ In addition, a rise in w reduces the level of real factor income, y, which indirectly depresses the private sector's demand for nontradables. It is assumed that the direct supply effect of a rise in w dominates the indirect demand effect, so that a rise in w at a given level of $a_p$ results in excess demand for home goods.

2/ The position of the locus NN in Section II is determined by the intersection of the ww and HH loci in $(a_p,w)$ space.

Figure 7
An Improvement in the Terms of Trade in the Rigid-Wage Model



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