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Exchange Rate Dynamics Under Alternative Intervention Rules

by

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Abstract

Recent research on exchange rates have incorporated short-run intervention rules into models assuming rational expectations. Most of the papers focus only on a particular intervention rule, either the leaning against the wind policy (nominal exchange rate rule) or the policy of stabilizing the real exchange rate (real exchange rate rule). The objective of this paper is to examine the effects of these two alternative short-run intervention rules on the behavior of a small open economy. Using the Dornbusch (1976) model modified to allow for imperfect asset substitution, we analyze how the system responds to a given disturbance under each intervention rule. We show that these two intervention rules differ in that the nominal exchange rate rule can only moderate the movement of the nominal exchange rate while the real exchange rate rule can reverse the movement of the nominal exchange rate and, consequently, they differ in terms of the resulting size of exchange rate jump, speed of adjustment, and relationship between the exchange rate and the interest rate movements. These differences are important considerations for the choice of an exchange rate policy in a small open economy.

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I. Introduction

Monetary authorities intervene in foreign exchange markets to influence the course of their exchange rates. The two types of intervention policy according to its effect on the exchange rate are (1) an intervention action which can affect the equilibrium exchange rate and (2) an intervention rule which can affect the speed of exchange rate movement as well as the process through which the actual exchange rate approaches the equilibrium rate.[1] If the future is known with certainty, either policy can be used to influence the exchange rate. However, economies are hit by many different shocks, and policy makers generally do not know in advance what disturbance to occur and therefore prefer an intervention rule.

Recent research on exchange rates have incorporated short-run intervention rules into models assuming rational expecations. The papers usually focus on a particular short-run intervention rule, either the policy of stabilizing the nominal exchange rate, also known as the leaning against the wind policy, or the policy of stabilizing the real exchange rate (Branson (1984), Blundell-Wignall and Masson (1985), Pappell (1985)).

No one however has analyzed the dynamic behavior of a model under each of these two intervention rules except Mussa (1985)[2]. Mussa assumes perfect capital substitution and nonsterilization and focuses on the behavior of a model with moving equilibrium. This paper also deals with the behavior of the economy under each of the two intervention rules. However, we use a much simpler model which allows fully-sterilized intervention to have effects and focus not only on exchange rate movement but also on the movements of other relevant variables, such as income and interest rate. With such an analysis, we can show that the choice between the two rules is crucial in that they have different implications for the dynamics of the model.

This paper is organized as follows. In section II we present the model which is a slightly modified version of the Dornbusch model of exchange rate dynamics with variable output. In sections III and IV we examine the dynamics of the model under the policies of stabilizing the real exchange rate and the nominal exchange rate, respectively. The final section summarizes the results and conclusions of the paper.

II. The Framework

The model is a slightly modified version of the Dornbusch (1976) model and is described by the following relationships:

(1.a) $y = y_0 + \tau y - \sigma i + \delta(e-p+p_f)$

(1.b) $dp/dt = \pi(y-\tilde{y})$

(1.c) $m - p = \emptyset y - \beta i$

(1.d) $i = i_f + E(de/dt) - (1/\Phi)(f_0 + f_1 nfa - f_2 r)$

where y = log of income or output; i = domestic interest rate; i_f = foreign interest rate; e = log of exchange rate, measured in units of domestic currency per unit of foreign currency; p = log of domestic price level; p_f = log of foreign price level; $e-p+p_f$ = log of the real exchange rate; m = log of money supply; r = log of stock of reserves; nfa = log of stock of net foreign assets; f = log of private net foreign assets; and the "~" on top of a variable denotes a long-run equilibrium value. Both foreign variables, i_f and p_f, are exogenous. The structural parameters are positive and in addition, $0 < \tau < 1$. The model is the same as that of Dornbusch (1976) except for (1.d).

The goods market is described by (1.a) and (1.b). In equation (1.a), it is assumed that income is demand-determined and that aggregate demand depends positively on income, negatively on the domestic interest rate, and positively on the real exchange rate. Equation (1.b) states that the price level adjusts over time in response to a measure of excess demand, $(y-\tilde{y})$, at a speed equalling π, where the natural level of income $\tilde{y}$ is assumed to be exogenously fixed. Equation (1.c) is the equation for money market equilibrium where it is assumed that money demand is a positive function of income and a negative function of the domestic interest rate. We assume full-sterilization so that the money supply is exogenous.[3]

Equation (1.d) describes the foreign exchange market equilibrium condition, where under rational expectations (which under uncertainty is equivalent to perfect foresight) the expected and the actual changes in the exchange rate over time are equal.[4] It embodies the assumption of perfect capital mobility in that the return on domestic assets (i) always equals the net return on foreign assets $(i_f + E(de/dt) - (1/\Phi)(f_0 + f_1 nfa - f_2 r))$. However, it shows the imperfect substitution relation between domestic and foreign assets as reflected by the presence of risk-premium $(- (1/\Phi)(f_0 + f_1 nfa - f_2 r))$. We retain the assumption of perfect capital mobility but we assume imperfect capital substitutability to allow a fully-sterilized intervention policy to have effects. Note that when $\Phi = \infty$, domestic and foreign assets are perfect substitutes and the model reduces to the Dornbusch model where short-run intervention cannot affect the behavior of the system.

Alternative Intervention Rules

We complete the model with the specification of intervention function. We will consider two alternative reserve functions:

(1.e.i) $r = r_0 - u[(e-p+p_f)-(\tilde{e}-\tilde{p}-p_f)]$

(1.e.ii) $r = r_0 - u^*(e-\tilde{e})$

where we assume all throughout that the intervention parameters u and u* are equal and we denote the latter with a "*" simply to differentiate the two intervention rules.

Each function has an exogenous component intended to capture a discretionary policy or an intervention action and an endogenous component which captures a systematic policy or an intervention rule. The endogenous components of (1.e.i) and (1.e.ii) represent the real exchange rate rule and the nominal exchange rate rule, respectively. Under the former, the monetary authorities adjust the stock of reserves whenever the real exchange rate is not equal to its long-run equilibrium value; this form of intervention may cause a reversal in the movement of the nominal exchange rate. Under the latter, the monetary authorities adjust the stock of reserves whenever the nominal exchange rate is not equal to its long-run equilibrium value, seeking to slow down whatever nominal exchange rate movement the market produced in either direction. With the assumption of perfect foresight the intervention rule, which determines the entire future path of the monetary authorities' actions, affects the behavior of the price level and the exchange rate over time.

The Steady-State

Since our analysis is based on the assumption that relevant agents have perfect foresight, the dynamics of the system will depend in part on the agents' expectations about the steady-state. Thus, it is convenient that we characterize first this equilibrium. Then in the next two sections we will discuss the transitional dynamics of the model under each policy rule.

Under each intervention rule, the steady-state of the model is attained when E(de/dt) = de/dt = 0 and dp/dt = 0, and is described by:

(2.a) $\tilde{e} = m + [\beta + (\sigma/\delta)]\tilde{i} - (1/\delta)y_0 - p_f + [(1-\tau)/\delta - \emptyset]\tilde{y}$

(2.b) $\tilde{p} = m - \emptyset\tilde{y} + \beta\tilde{i}$

(2.c) $\tilde{i} = i_f - (1/\Psi)(f_0 + f_1 nfa - f_2\tilde{r})$

(2.d) $\tilde{r} = r_0$

where $\tilde{y}$ is assumed to be fixed at the natural level. Thus, the stationary equilibrium is invariant with respect to the type of intervention rule.

In the long-run, the system is neutral with respect to an exogenous change in the money supply in the sense that $d\tilde{e} = d\tilde{p} = dm$ and $d\tilde{y} = d(\tilde{e}-\tilde{p}+p_f) = d\tilde{i} = 0$. However, the system is nonhomogeneous with respect to shocks that affect $\tilde{i}$, such as changes in r_0 and i_f, in the sense that such shocks yield $d\tilde{e} > d\tilde{p}$ and therefore $d(\tilde{e}-\tilde{p}+p_f) \neq 0$; since $\tilde{i}$ now changes, $(\tilde{e}-\tilde{p}+p_f)$ must also change in the same direction to maintain long-run equilibrium in the goods market.

III. Intervention to Stabilize the Real Exchange Rate

The Solution to the Dynamics

The static equations of the model under the real exchange rule (1.e.i) are derived by solving (1.a) and (1.c) for the domestic interest rate and income consistent with money market equilibrium:

(3.a) $(i-\tilde{i})^{RR} = (1/V)[\emptyset\delta](e-\tilde{e})^{RR} + (1/V)[(1-\tau) - \emptyset\delta](p-\tilde{p})^{RR}$

(3.b) $(y-\tilde{y})^{RR} = (1/V)(\beta\delta)(e-\tilde{e})^{RR} - (1/V)[\sigma + \beta\delta](p-\tilde{p})^{RR}$

where $V = \emptyset\sigma + (1-\tau)\beta > 0$

and the superscript "RR" denotes a variable under the real exchange rule. Note that in the short-run, the equilibrating factor in the money market is the domestic interest rate.

In the foreign exchange market, the equilibrating factor is the exchange rate. This can be seen by substituting (1.e.i) into (11.d):

$$(3.a)' \quad (i-\tilde{i})^{RR} = E(de/dt)^{RR} - Fu[(e-\tilde{e})^{RR} - (p-\tilde{p})^{RR}]$$

where $F = (1/\Phi)f_2$

Given the change in the domestic interest rate in (3.a) and the change in the net return on foreign assets (3.a)', the exchange rate changes to maintain equilibrium in both the money market and the foreign exchange market.

Next, we derive the dynamic equations of the model. The assumption of perfect foresight implies that the actual and expected change in the exchange rate over time (de/dt) depends on the entire model. Given the domestic interest rate that clears the money and goods markets (3.a) and the semi-reduced-form foreign exchange market equilibrium condition (3.a)', we can get the equation for de/dt. The adjustment of the price level over time (dp/dt) is an assumed feature of the model and its equation is derived simply by substituting (3.b) into (1.b). We can write these equations in a matrix form:

$$(3.c) \quad \begin{bmatrix} (de/dt)^{RR} \\ (dp/dt)^{RR} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} (e-\tilde{e})^{RR} \\ (p-\tilde{p})^{RR} \end{bmatrix}$$

where $a_{11} = (1/V)[\text{Ø}\delta + VFu] > 0 \qquad a_{21} = (\pi/V)(\beta\delta) > 0$

$a_{12} = (1/V)[(1-\tau) - \text{Ø}\delta - VFu] \qquad a_{22} = -(\pi/V)[\sigma + \beta\delta] < 0$

The matrix equation (3.c), along with equations (3.a) and (3.b), fully describes the evolution of the exchange rate and the price level, respectively, over time. These equations, however, do not explicitly show the nature of the system's equilibrium nor the system's dynamic properties.

Consider first the nature of the system's equilibrium. The determinant of the matrix in (3.c) is unambiguously negative implying that whatever the sign of the trace, the two roots are real and opposite in sign:

$$R_1, R_2 = \{tr(A) \pm [(-tr(A))^2 - 4(det(A))]^{1/2}\}/2$$

where $tr(A) = R_1 + R_2 = a_{11} + a_{22}$

$$\det(A) = R_1R_2 = a_{11}a_{22} - a_{21}a_{12} = -(\pi/V)[\sigma Fu + \delta] < 0$$

and $R_1 < 0$ and $R_2 > 0$. This means that the steady-state of the model is a saddlepoint.

Given $R_1 < 0$ and $R_2 > 0$, the general solution to dynamic system (3.c) is of the following form:

(4.a) $(e(t))^{RR} = \tilde{e} + b_{11}K_1\exp(R_1t) + b_{12}K_2\exp(R_2t)$

(4.b) $(p(t))^{RR} = \tilde{p} + b_{21}K_1\exp(R_1t) + b_{22}K_2\exp(R_2t)$

where $b_{1j} = 1$ $\quad b_{2j} = (R_j - a_{11})/a_{12}$ $\quad K_j = c_{j1}(e(0)-\tilde{e})^{RR} + c_{j2}(p(0)-\tilde{p})^{RR}$

and $e(0)$ and $p(0)$ are the initial values and $\tilde{e}$ and $\tilde{p}$ are the new steady-state values of the exchange rate and the price level; and, c_{ij}'s are the elements of the inverse of the matrix containing b_{ij}'s.

Starting from an initial steady-state where $e = \tilde{e}(0)$ and $p = \tilde{p}(0)$, any shock that affects p will yield a new saddlepoint where $e = \tilde{e}$ and $p = \tilde{p}$. If K_1 is zero and K_2 is nonzero, the model is explosive. But if K_1 is nonzero and K_2 is zero, the model is convergent. Thus, (4.a) and (4.b) show the saddlepoint behavior of the system.

We now consider the bounded solution to (3.c). The assumption that the price level is sticky implies that at $t = 0$ the price level has a predetermined value and therefore the system cannot jump to the new equilibrium. To reach this new equilibrium, the exchange rate must first jump, thereby placing the system onto the path which converges to the new equilibrium. The condition that the coefficients asociated with the unstable or positive root must equal zero, which is satisfied when:

$$K_2 = c_{21}(e(0)-\tilde{e})^{RR} + c_{22}(p(0)-\tilde{p})^{RR} = 0$$

where $c_{21} = (a_{11}-R_1)/(R_2-R_1)$ $\qquad c_{22} = a_{12}/(R_2-R_1)$

determines the stabilizing jump in the exchange rate:

(5.a) $(e(0)-\tilde{e})^{RR} = -[a_{12}/(a_{11}-R_1)](p(0)-\tilde{p})^{RR}$

where $(a_{11}-R_1) > 0$ and since the price level cannot jump, $(p(0)-\tilde{p})^{RR} = (p(0)-\tilde{p}) = -d\tilde{p}$. Note that perverse exchange rate response is not possible, i.e., e will move in the same direction as $\tilde{e}$, because $\tilde{e}$ and $\tilde{p}$ move in the same direction and the term $a_{12}/(a_{11}-R_1)$, if negative, is less than one in absolute value.

Equation (5.a) is the key equation of the model. It determines not only the extent of the jump in the exchange rate but also the nature of adjustment toward the new equilibrium. Specifically, when $a_{12} < 0$ ($a_{12} > 0$) the exchange rate will undershoot (overshoot) its new long-run equilibrium value, and during adjustment the exchange rate and the price level move in the same (opposite) direction(s).

To see why the sign of a_{12} determines whether the exchange rate will initially exhibit overshooting or undershooting, consider any shock that increases the equilibrium price level. Following such a shock, the exchange rate undergoes a depreciation. With the short-run price level sticky, the real exchange rate depreciates as well and this in turn causes income to increase (see (3.b)). At the initial short-run domestic interest rate and price level, this increase in income may tend to cause money market disequilibrium (see 1.c) and to maintain equilibrium the domestic interest rate must change (by $(d\tilde{i} - (1/V)((1-\tau)-\emptyset\delta))d\tilde{p})$, see (3.a)); at the same time, such a shock may cause the net return on foreign assets to change (by $(d\tilde{f} - Fud\tilde{p})$, see (3.a)'). If the change in the return on domestic assets is less (greater) than the change in the net return on foreign assets, implying that

$a_{12} = (1/V)((1-\tau)-\emptyset\delta) - Fu > 0\ (< 0)$, then the exchange rate will have to overshoot (undershoot) its new long-run equilibrium value so as to maintain equilibrium in both the money and the foreign exchange markets. In the borderline case where the initial changes in the domestic and net foreign interest rates are equal, implying that $a_{12} = (1/V)((1-\tau)-\emptyset\delta) - Fu = 0$, there is neither overshooting nor undershooting.

The relationships between the exchange rate and the other short-run variables at $t = 0$, at the time of the shock and the jump, using (3.a), (3.b) and (5.a), are:

$$\text{(5.b)}\quad (i(0)-\tilde{i})^{RR} = \{[((1-\tau)-\emptyset\delta)R_1-Fu]/Va_{12}\}(\tilde{e}(0)-e)^{RR}$$
$$= (1/V)\{-(1-\tau) + \emptyset\delta[1 + a_{12}/(a_{11}-R_1)]\}d\tilde{p}$$

$$\text{(5.c)}\quad (y(0)-\tilde{y})^{RR} = (1/V)\{(\sigma + \beta\delta)/[a_{12}/(a_{11}-R_1)] + \beta\delta\}(e(0)-\tilde{e})^{RR} > 0$$
$$= (1/V)\{\sigma + \beta\delta[1 + a_{12}/(a_{11}-R_1)]\}d\tilde{p} > 0$$

$$\text{(5.d)}\quad (r(0)-\tilde{r})^{RR} = -u[1 + (a_{11}-R_1)/a_{12}](e(0)-\tilde{e})^{RR} = -u[1 + a_{12}/(a_{11}-R_1)]d\tilde{p}$$

where by assumption $d\tilde{p} > 0$. Equation (5.b) shows that $i(0)^{RR}$ will be below (below, equal to or above) its new equilibrium value if $a_{12} \geq 0$ $(a_{12} < 0)$. The sign of (5.c), on the other hand, is always positive, implying that any shock that causes the equilibrium price level to increase will cause income to increase. Equation (5.d) is always negative because short-run intervention always causes $r(0)^{RR}$ to fall below its long-run equilibrium value; this implies that intervention not only can dampen but can also reverse both changes in the interest rate and the exchange rate (see (3.a)' and (5.b)).

After the system jumps, the time paths of the exchange rate and the price level are given by:

$$\text{(6.a)}\quad e(t)^{RR} = \tilde{e} + b_{11}K_1\exp(R_1t) = \tilde{e} + (e(0)-\tilde{e})\exp(R_1t)$$

$$\text{(6.b)}\quad p(t)^{RR} = \tilde{p} + b_{21}K_1\exp(R_1t) = \tilde{p} + (p(0)-\tilde{p})\exp(R_1t)$$

It is clear from (6.a) and (6.b) that as t approaches ∞, both e and p approach their new steady-state values $\tilde{e}$ and $\tilde{p}$. Given these solutions, the solution to other variables can be found.

The equation for the stable path, using (6.a) and (6.b), is:

(7) $(e(t)-\tilde{e})^{RR} = -[a_{12}/(a_{11}-R_1)](p(t)-\tilde{p})^{RR}$

and along this path:

(8.a) $(de/dt)^{RR} = R_1(e(t)-\tilde{e})^{RR} = R_1 b_{11} K_1 \exp(R_1 t)$

where $(-R_1)$ is the system's speed of adjustment.[5] Given a shock that increases the equilibrium price level and if the exchange rate initially undershoots (overshoots) its new long-run equilibrium value, i.e., $a_{12} < 0$ ($a_{12} > 0$), then $(de/dt)^{RR} < 0$ ($(de/dt)^{RR} > 0$) or equivalently the transition is characterized by exchange rate appreciation (depreciation).

Thus, given a disturbance that affects the equilibrium price level, the system adjusts in two stages. First, following the disturbance the exchange rate jumps to place the system onto the stable path. This jump in the exchange rate triggers the adjustment of other short-run variables. Second, following the jump, the system moves along a saddlepath converging to the equilibrium; during this transition, the dynamics of the system and hence the exchange rate are governed by the slowly adjusting price level.

The Role of u

We now examine the effects of a weaker or stronger rule as reflected by the size of intervention parameter. The effect of u on $(e(0)-\tilde{e})^{RR}$:

(9.a) $d((e(0)-\tilde{e})^{RR})/du = -F/(a_{11}-R_1)$

$$- [F/(a_{11}-R_1)][a_{12}/(a_{11}-R_1)][1/2]$$

$$\{1 + [(-a_{11} + (\pi/V)(\beta\delta-\sigma))/ ((-a_{11} + (\pi/V)(\beta\delta-\sigma))^2 + 4(\pi/V)(\beta\delta a_{12} + (\beta\delta+\sigma)Fu + \sigma^2\delta))^{1/2})]\}$$

is unambiguously negative regardless of the sign of a_{12}. In the case where the initial response is overshooting (undershooting, $(e(0)-\tilde{e})^{RR}$ which is positive (negative) becomes smaller (larger in absolute value) as u increases. This means that the effect of a larger u is to dampen (exaggerate) the extent of overshooting (undershooting). Note however that since u affects a_{12}, a value of u that is large enough may reverse the movement of the exchange rate.

The effect of u on the system's speed of adjustment, $(-R_1)$:

$$(9.b)\quad d(-R_1)/du = -(F/2)\{1 + [(-a_{11} + (\pi/V)(\beta\delta-\sigma))/ ((-a_{11} + (\pi/V)(\beta\delta-\sigma))^2 + 4(\pi/V)(\beta\delta a_{12} + (\beta\delta+\sigma)Fu + \sigma^2\delta))^{1/2})]\}$$

is negative (positive) if $a_{12} > 0$ ($a_{12} < 0$). This means that when the initial exchange rate response is overshooting (undershooting) so that during transition the exchange rate is appreciating (depreciating), the effect of a larger u is to decrease (increase) the speed of exchange rate appreciation (depreciation). Consequently, $d(de/dt)^{RR}/du$ must be positive.

Given that the intervention policy which stabilizes the real exchange rate can reverse overshooting, the monetary authorities may choose:

$$(10)\quad u = [(1-\tau) - \emptyset\delta]/VF$$

such that a_{12} equals zero. This choice of u ensures that the stable trajectory leading toward the new steady-state coincides with the horizontal de/dt=0 curve and, therefore, the exchange rate neither overshoots nor undershoots its new long-run equilibrium value.

IV. Intervention to Stabilize the Nominal Exchange Rate

The Solution to the Dynamics

The dynamics of the model under this rule (1.e.ii) are described by:

$$(11.a)\quad (i-\tilde{i})^{NR} = (1/V)[\emptyset\delta](e-\tilde{e})^{NR} + (1/V)[(1-\tau) - \emptyset\delta](p-\tilde{p})^{NR}$$

$$(11.b)\quad (y-\tilde{y})^{NR} = (1/V)(\beta\delta)(e-\tilde{e})^{NR} - (1/V)[\sigma + \beta\delta](p-\tilde{p})^{NR}$$

$$(11.c)\quad \begin{bmatrix}(de/dt)^{NR}\\(dp/dt)^{NR}\end{bmatrix} = \begin{bmatrix}a_{11} & a_{12}^{*}\\a_{21} & a_{22}\end{bmatrix}\begin{bmatrix}(e-\tilde{e})^{NR}\\(p-\tilde{p})^{NR}\end{bmatrix}$$

where $a_{12}^{*} = a_{12} + Fu^{*} = ((1-\tau) - \emptyset\delta)/V$

and the superscript "NR" denotes a variable under a nominal exchange rate rule, and by assumption $u = u^{*}$. The dynamic matrix equation (11.c) describes the fundamental dynamics of the system which, when combined with the static equations (11.a) and (11.b), determine the evolution of the system over time.

The characteristic roots associated with (11.c) are:

$$R_1^{*}, R_2^{*} = \{tr(A^{*}) \pm [(-tr(A^{*}))^2 - 4(det(A^{*}))]^{1/2}\}/2$$

where $tr(A^{*}) = R_1^{*} + R_2^{*} = a_{11} + a_{22}$

$$det(A^{*}) = R_1^{*}R_2^{*} = a_{11}a_{22} - a_{21}a_{12}^{*} = -(\pi/V)\{[\sigma Fu^{*} + \delta] + [\beta\delta Fu^{*}]\} < 0$$

and $R_1^{*} < 0$ and $R_2^{*} > 0$. As in the real exchange rate rule, the determinant is unambiguously negative, implying that the two roots are real and opposite in sign. Thus, the steady-state of the model under the nominal exchange rate rule is also a saddlepoint. Notice that $(-R_1^{*}) > (-R_1)$, implying that the nominal exchange rate rule results in a faster speed of adjustment.

Again, for the system to be dynamically stable once a shock displaces it from an initial steady-state where $e = \tilde{e}(0)$ and $p = \tilde{p}(0)$, the exchange rate must jump to place the system onto the path converging to a new equilibrium where $e = \tilde{e}$ and $p = \tilde{p}$. It can be shown that the stabilizing jump in the exchange rate is:

$$(12.a)\ (e(0)-\tilde{e})^{NR} = -[a_{12}^*/(a_{11}-R_1^*)](p(0)-\tilde{p})^{NR}$$

$$= (e(0)-\tilde{e})^{RR}$$

$$+ [Fu/(a_{11}-R_1^*)]\{1-[(1-\tau)-\emptyset\delta-VFu][(R_1-R_1^*)/VFu(a_{11}-R_1)]\}d\tilde{p}$$

where $(p(0)-\tilde{p})^{NR} = (p(0)-\tilde{p}) = -d\tilde{p}$ and the $\{.\}$ term in (12.a) is positive. Notice that u^* does not affect a_{12}^*; since $(a_{11}-R_1^*) > 0$, this implies that the nominal exchange rate rule can only change the magnitude but not the sign of slope of the stable trajectory leading to the new steady-state. In contrast with the real exchange rate rule, this rule can dampen but cannot reverse the movement of the nominal exchange rate.

The condition for exchange rate overshooting (undershooting) is that a_{12}^* must be positive (negative). The explanation, similar to that given under the real exchange rule, can be inferred from (1.c), (11.a), (11.b), and the following semi-reduced-form foreign exchange market equilibrium condition (derived using (1.d) and (1.e.ii)):

$$(12.b)'\ (i-\tilde{i})^{NR} = E(de/dt)^{NR} - Fu^*(e-\tilde{e})^{NR}$$

As before, if, at the initial short-run exchange rate and price level, the change in the return on domestic assets (also equal to $(d\tilde{i} - ((1-\tau)-\emptyset\delta)/V)d\tilde{p})$ is less (greater) than the change in the net return on foreign assets (now equal to $d\tilde{i}$), the exchange rate will overshoot (undershoot) its new long-run equilibrium value to maintain equilibrium in both the money and foreign exchange markets.

Notice also from (12.a) that $(e(0)-\tilde{e})^{NR} > (e(0)-\tilde{e})^{NR}$. Specifically: (a) if $a_{12} > 0$, then $a_{12}^*/(a_{11}-R_1^*) > a_{12}/(a_{11}-R_1) > 0$, implying that the extent of exchange rate overshooting is larger under the nominal exchange rate rule; (b) if $a_{12} = 0$, then $a_{12}^*/(a_{11}-R_1^*) > a_{12}/(a_{11}-R_1) = 0$, implying that the exchange rate neither overshoots nor undershoots under the real exchange rate rule but will overshoot under the nominal exchange rate rule; and, (c) if $a_{12} < 0$, then $a_{12}/(a_{11}-R_1) < 0$ and $a_{12}^*/(a_{11}-R_1^*) \gtreqless 0$, implying that the exchange rate will undershoot under the real exchange rate rule but may overshoot, undershoot, or neither under the nominal exchange rate rule. The reason is that while both rules cause the domestic interest rate to change (if it changes) in the same direction, they differ in that the short-run intervention real intervention rule, as reflected by the term Fu, affects the net return on foreign assets.

Using (11.a), (11.b) and (12.a), the relationships between the exchange rate and the other short-run variables under the nominal exchange rate rule at $t = 0$ are:

$$(12.b)\quad (i(0)-\tilde{i})^{NR} = (R_1^*-Fu^*)(e(0)-\tilde{e})^{NR}$$
$$= (i(0)-\tilde{i})^{RR}$$
$$+ \emptyset\delta[Fu/(a_{11}-R_1^*)]\{1-[(1-\tau)-\emptyset\delta-VFu][(R_1-R_1^*)/VFu(a_{11}-R_1)]\}d\tilde{p}$$

$$(12.c)\quad (y(0)-y)^{NR} = (y(0)-\tilde{y})^{RR}$$
$$+ \beta\delta[Fu/(a_{11}-R_1^*)]\{1-[(1-\tau)-\emptyset\delta-VFu][(R_1-R_1^*)/VFu(a_{11}-R_1)]d\tilde{p} > 0$$

$$(12.d)\quad (r(0)-\tilde{r})^{NR} = -u^*(e(0)-\tilde{e})^{NR} = -u^*[a_{12}^*/(a_{11}-R_1^*)]d\tilde{p}$$

where $\{.\} > 0$ and $d\tilde{p} > 0$. Equation (12.b) shows that now $(e(0)-\tilde{e})^{NR}$ and $(i(0)-\tilde{i})^{NR}$ are always opposite in sign since $(R_1^*-Fu^*)$ is unambiguously negative and because the role of short-run intervention is simply to dampen the exchange rate change. Equation (12.d) shows that $r(0)^{NR}$ will be below (above) its long-run equilibrium value if a_{12}^* is positive (negative), thereby dampening the interest rate movement and therefore the exchange rate movement (see (12.b)' and (12.c)). As in the real exchange rate rule, the deviation of income from its long-run equilibrium value is also positive but now this deviation is larger due to a greater real exchange rate depreciation.

After the jump, the system moves along a path converging toward the new equilibrium. Along this path:

$$(13)\quad (e(t)-\tilde{e})^{NR} = -\,[a_{12}^*/(a_{11}-R_1^*)](\tilde{p}(t)-p)^{NR}$$

$$(14)\quad (de/dt)^{NR} = R_1^*(\tilde{e}(t)-e)^{NR}$$

where $(-R_1^*)$ is the system's speed of adjustment under the nominal exchange rate rule. Given that $dp > 0$, then $p(t)^{NR} > (p(t)^{RR}$, and $(e(t)-\tilde{e})^{NR} > (e(t)-\tilde{e})^{RR}$, that is, the negatively (positively) sloped stable trajectory is steeper (flatter) under this rule than under the real exchange rate rule. Consequently, $(de/dt)^{NR} < (de/dt)^{RR}$, implying that the rate of exchange rate depreciation (appreciation) over time is smaller (larger) under this rule. This so because this rule results in a larger initial exchange rate deviation is larger and and a faster speed of exchange rate adjustment. Thus, as t approaches infinity, the system under the nominal exchange rate rule approaches its new steady-state equilibrium at a faster speed of adjustment.

<u>The Role of u*</u>

The nominal exchange rate rule can also affect the initial exchange rate deviation and the system's speed of adjustment:

$$(15.a)\quad d((e(0)-\tilde{e})^{NR})/du^* = -\,[F/(a_{11}-R_1^*)][a_{12}^*/(a_{11}^*-R_1^*)][1/2]\{1 + [(-a_{11} + a_{22})/((-a_{11} + a_{22})^2 + 4a_{21}a_{12})^{1/2}]\}$$

$$(15.b)\quad d(-R_1^*)/du^* = -\,(F/2)\{1 + [(-a_{11} + a_{22})/((-a_{11} + a_{22})^2 + 4a_{21}a_{12})^{1/2}]\}$$

where (15.a) is always negative while (15.b) is negative (positive) if a_{12}^* is positive (negative). The effect of u* on $(de/dt)^{NR}$ can also be shown to be positive. Thus, the nominal exchange rate rule can only moderate exchange rate movement. It can only dampen (exaggerate) overshooting (undershooting) whereas the real exchange rate rule may even reverse the direction of exchange rate movement.

In sum, regardless of the type of shock, both rules tend to dampen the movement in the exchange rate but they differ in that the nominal exchange rate rule results in a greater initial adjustment of the system, i.e., $(y(0)-\tilde{y})^{NR} > (y(0)-\tilde{y})^{RR}$, $(i(0)-\tilde{i})^{NR} > (i(0)-\tilde{i})^{RR}$, and $(e(0)-\tilde{e})^{NR} > (e(0)-\tilde{e})^{RR}$ and, therefore, a faster transitional adjustment.[6]

V. Conclusions

This paper has studied the consequences of adopting two alternative intervention rules, the policy of leaning against the wind and the policy of stabilizing the real exchange rate, in a slightly modified Dornbusch model which is characterized by imperfect asset substitution. We have assessed the effects of stronger or weaker policy rules, as represented by larger or smaller values of intervention parameter, and have shown that the nominal exchange rate rule can only moderate the movement of the nominal exchange rate while the real exchange rate rule may result in a reversal in the movement of the exchange rate. We have also demontrated that the two alternative rules are different in terms of the resulting: (a) speed of adjustment; (b) size of exchange rate jump; (c) nature of adjustment; and, (d) relationship between interest rate and exchange rate movements. These differences show that the choice between the two intervention rule is important for theoretical and empirical applications.

Notes

1. Intervention rules may also classified as contemporaneous or noncontemporaneous (see Turnovsky (1985b) and Blundell-Wignall and Masson (1985)). In the case of the latter, intervention is one of the sources of the dynamics aside from the sluggishly adjusting price level. Another distinction is, of course, between sterilized and nonsterilized intervention.

2. Mussa's model has a moving long-run equilibrium while our model has a stationary equilibrium.

3. We are implicitly assuming that the money supply function has the following form: $m = h_1c + h_2r$, where the domestic credit (c) function is given by $c = c_0 - c_1r$. The semi-reduced-form money supply function then is $m = h_1c_0 + (h_2-h_1c_1)r$. For full-sterilization to occur, $(h_2-h_1c_1)$ must equal zero.

4. Equation (1.d), actually, is the inverted net private foreign asset demand function $f^d = -\Phi[i-i_f-E(de/dt)]$, where $f^d = f$, and f is the net private foreign asset supply (see Frankel (1983)). To be able to incorporate intervention we have used the identity $f \equiv f_0 + f_1nfa - f_2r$. Equation (1.d) can also be derived using either the mean-variance approach (Black (1985)) or an optimization model (Turnovsky (1985a)).

5. Notice that $(-R_1)$, which is a function of all parameters in the system, is also the perfect-foresight-consistent regressive-expectations coefficient.

6. Under the real exchange rate rule, an increase i_f causes both $\tilde{e}$ and $\tilde{p}$ to increase and therefore e to depreciate, which in turn causes y to increase (see (5.a), (5.b) and (5.c)). At the initial e, p and i, this increase in y tends to cause an excess demand in the money market (see 1.c) and to restore equilibrium i must increase (by $(1 + ((1/V)(-(1-\tau)+ Ø\delta))\beta > 0)$, see (3.a)); at the same time, this increase in i_f will cause the net return on foreign assets to increase, remain constant or decrease (by $(1 - Fu\beta)$, see (3.a)'). The

exchange rate will: (a) overshoot ($a_{12} > 0$) if i increases by less than the increase in the return on foreign assets; (b) neither overshoot nor undershoot ($a_{12} = 0$) if the increase in i equals the increase in the net return on foreign assets; and (c) undershoot ($a_{12} < 0$) if i increases by more than the net return on foreign assets, which may increase, decrease, or remain the same. Under the nominal exchange rule (see (12.a), (12.b) and (12.c)), an increase in i_f always causes the net return on foreign assets to increase and (a) when $a_{12} \geq 0$, it follows that $a_{12}^* > 0$ and e will overshoot and i will increase but $(i(0)-\tilde{i}) < 0$; and, (b) when $a_{12} < 0$, a_{12}^* may be positive, negative or zero, and e may overshoot, undershoot or neither while i will increase but $(i(0)-\tilde{i})$ may be negative, positive or zero.

The effects of an exogenous increase in r_0, on the other hand, are qualitatively the same as those of an increase in i_f except that the former are due to imperfect asset substitutability.

An increase in m, at the initial e and p, may cause i to decrease, remain the same or increase under both rules but always causes the net return on foreign assets to decrease (remain the same) under the real (nominal) exchange rate rule; in contrast, an increase in i_f always causes i to increase under both rules and also always causes (may cause) the net return on foreign assets to increase (decrease, remain the same or increase) under the nominal (real) exchange rate rule. Again: (a) if the change in i is less (greater) than the change in the net return on foreign assets, then e will have to overshoot (undershoot) its new long-run equilibrium value so as to maintain equilibrium in both the money and the foreign exchange markets; (b) $(i(0)-\tilde{i})^{NR}$ and $(e(0)-\tilde{e})^{NR}$ (and therefore a_{12}) are always opposite in sign; and, (c) $(e(0)-\tilde{e})^{NR} > (e(0)-\tilde{e})^{RR}$, $(i(0)-\tilde{i})^{NR} > (i(0)-\tilde{i})^{RR}$, and $(y(0)-\tilde{y})^{NR} > (y(0)-\tilde{y})^{RR}$.

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