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Country-Specific Risk Premium, Taylor Rules, and Exchange Rates*

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Abstract

The adoption of a Taylor-type monetary policy rule and an inflation target for emerging market economies that choose a flexible exchange rate regime is often advocated. This paper investigates the issue of exchange rate determination when interest-rate feedback rules are implemented in a continuous-time optimizing model of a small open economy facing an imperfect global capital market. It is demonstrated that when a risk premium on external debt affects the monetary policy transmission mechanism, the Taylor principle is not a necessary condition for determinacy of equilibrium. On the other hand, it is shown that exchange rate dynamics critically depends on whether monetary policy is active or passive.

JEL Classification: F31, F32, E52.

Keywords: Risk Premium on Foreign Debt; Taylor Rules; Exchange Rate Dynamics.

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1 Introduction

Modern research on monetary policy provides strong theoretical foundations for the use of simple interest-rate feedback rules, that specify the setting of the nominal interest rate as a function of endogenous variables, such as inflation and output. The standard literature emphasizes the stabilizing role of ‘active’ interest rate rules, that respond to increases in inflation with a more than one-to-one increase in the nominal interest rate (e.g., Taylor, 1999; King, 2000; Galí, 2003; Woodford 2003; McCallum, 2003). These policy rules *à la* Taylor (1993) have originally been designed for developed economies. An important related issue that has attracted growing attention in the recent policy debate is the design of monetary policy in emerging market and developing economies. The occurrence of exchange rate crises in emerging economies during the 1990s has warned against the adoption of ‘soft’ peg exchange rate regimes, as pointed out by Fischer (2001). In particular, Taylor (2001) argues that ‘for those emerging market economies that do not choose a policy of a ‘permanently’ fixed exchange rate (perhaps through a currency board or a common currency (dollarization)), then the only sound monetary policy is one based on the trinity of a flexible exchange rate, an inflation target, and a monetary policy rule’.

This paper presents an investigation of the dynamic effects of interest-rate feedback policies of Taylor’s style within a small open economy facing an imperfect world capital market. Specifically, the analysis is derived in a continuous-time optimizing general equilibrium framework with flexible exchange rates and an upward-sloping supply curve of foreign debt. Our focus on the implications of financial externalities, associated with the upward-sloping supply schedule of external debt, is motivated by the fact that emerging market and developing countries are subject to credit risk, which constrains their borrowing opportunities. The existence of a risk premium on foreign indebtedness in emerging market and developing economies constitutes a fairly well-established stylized fact (e.g., Agénor and Montiel, 1999; Montiel 2003).

The model considered in this paper is used to examine two relevant issues in monetary

theory. First, we investigate dynamic stability to evaluate whether uniqueness of equilibrium requires that the central bank reacts to inflation with a more than proportional increase in the nominal interest rate (the so-called ‘Taylor principle’), as predicted by the standard theory on Taylor rules (e.g., Woodford 2003). Second, we reconsider the issue of exchange rate dynamics in response to exogenous changes in the domestic nominal interest rate, government spending, the level of productivity, the subjective discount rate, the foreign nominal interest rate, and the foreign inflation rate.

We demonstrate that when a risk premium on external debt affects the monetary policy transmission mechanism, the Taylor principle is not a necessary condition for determinacy of equilibrium. That is, ‘passive’ interest rate policies, that underreact to inflation by increasing the nominal interest rate by less than a raise in domestic inflation, are compatible with saddle-path stability. The economic intuition for this result can be explained as follows.

Consider first a standard closed-economy framework, with either flexible or sticky prices. In such a setup, the destabilizing effect of passive monetary policies has the following rationale. If consumers expect a high level of inflation and monetary policy is passive, the real interest rate declines. As a result of the Euler equation, characterizing the consumption-saving optimal decision, households reduce savings and increase consumption. The associated increase in aggregate demand causes prices to increase, hence validating the initial inflation expectations. As a consequence, passive monetary policies generate indeterminacy of equilibrium. Monetary policies in the respect of the Taylor principle are necessary to induce a unique stable equilibrium.

Consider now what occurs in a small-open-economy framework in which the transmission mechanism of monetary policy is crucially affected by a risk premium on external debt. When monetary policy is passive, an upward perturbation in inflation causes the real interest rate to decrease and private consumption to increase, analogously to the closed-economy case. However, the increase in consumption tends to stimulate foreign

debt accumulation over time, hence leading to an increase in the country-specific risk premium. This makes the interest rate on foreign debt rise. *Ceteris paribus*, international parity conditions precluding arbitrage opportunities require an increase in the domestic real interest rate, which reduces aggregate demand and inflation. As a result, active monetary policies are not necessary to guarantee macroeconomic stability.

Despite the fact that saddle-path stability does not require an aggressive interest rate policy, the study of transitional dynamics we perform demonstrates that exchange rate adjustment in response to exogenous disturbances depends in a critical way on whether monetary policy is active or passive. In this respect, as we shall see, our analysis also yields additional insights into the question of exchange rate determination.

The scheme of the paper is as follows. Section 2 presents the model and describes the monetary policy regimes. Section 3 derives the perfect-foresight macroeconomic equilibrium. Section 4 develops the steady-state analysis. Section 5 studies the stability properties of the setup and examines the issue of transitional dynamics. Section 6 concludes.

2 The Model

Consider a small open economy operating in a world of ongoing inflation and flexible exchange rates. The economy is described by a one-good-monetary model and consists of four types of agents: consumers, firms, the government and the central bank. All agents have perfect foresight.

The domestic economy produces and consumes only one tradeable and non-storable good. Purchasing power parity (PPP) is assumed to hold at all times:

$$P = P^*E, \tag{1}$$

where P (P^*) is the domestic (foreign) price and E is the nominal exchange rate, defined

as units of domestic currency per unit of foreign currency. In percentage terms the PPP is given by:

$$\pi = \pi^* + e, \quad (2)$$

where π (π^*) is the inflation rate of the good in terms of domestic (foreign) currency and e is the rate of exchange depreciation of domestic currency.

Domestic residents may hold two assets: domestic money, which is not held by foreigners, and internationally-traded bonds. International capital mobility implies that interest parity of the following type holds:

$$R = R^* + e, \quad (3)$$

where R^* and R denote the foreign and the domestic nominal rate, respectively.

2.1 The Private Sector

The infinitely-lived representative consumer faces the following lifetime utility function:

$$\int_0^{\infty} [U(c, \ell) + V(m)] e^{-\beta t} dt, \quad (4)$$

where β is the rate of time preference and c , ℓ and m denote consumption, labor and real money balances, respectively. Functions $U(\cdot)$ and $V(\cdot)$ satisfy the following conditions: $U_c > 0$, $U_\ell < 0$, $V' > 0$, $U_{cc} < 0$, $U_{\ell\ell} < 0$, $U_{c\ell} < 0$, and $V'' < 0$.

The flow budget constraint in real terms is:

$$\dot{m} + \dot{a} = w\ell + z - \tau - c + (R^* - \pi^*)a - \pi m, \quad (5)$$

where a denotes world-traded bonds, w the wage rate, z profits, and τ lump-sum taxes. Throughout the paper, for any generic variable of the model x , \dot{x} denotes dx/dt .

The representative agent chooses the optimal plan for c , ℓ , m and a in order to maximize her lifetime utility (4), subject to (5) and given the initial conditions:

$$m(0) = \frac{M_0}{P(0)}, \quad a(0) = \frac{E_0 A_0}{P_0} = \frac{A_0}{P_0^*}, \quad (6)$$

where M and A denote the nominal stocks of money and of traded assets, respectively.

The solution to the consumer's optimization problem yields the following conditions:

$$U_c(c, \ell) - \mu = 0, \quad (7)$$

$$U_\ell(c, \ell) + w\mu = 0, \quad (8)$$

$$V'(m) - \mu\pi = -\dot{\mu} + \mu\beta, \quad (9)$$

$$\mu(R^* - \pi^*) = -\dot{\mu} + \mu\beta, \quad (10)$$

together with the flow budget constraint (5), the initial conditions (6), and the transversality conditions:

$$\lim_{t \rightarrow \infty} \mu m e^{-\beta t} = \lim_{t \rightarrow \infty} \mu a e^{-\beta t} = 0, \quad (11)$$

where $\mu e^{-\beta t}$ is the discounted Lagrange multiplier associated with the wealth accumulation equation (5).

Perfectly competitive firms face the following production function:

$$y = \Lambda \phi(\ell), \quad (12)$$

where y and ℓ denote output and the labor input, respectively, $\phi'(\cdot) > 0$, $\phi''(\cdot) < 0$, and Λ is a positive technology parameter. Each firm hires labor in order to maximize profits. At the optimum, labor marginal productivity is equal to the real wage rate:

$$\Lambda \phi'(\ell) = w. \quad (13)$$

Perfect competition ensures that profits are zero in equilibrium, so that $y = w\ell$.

2.2 The Public Sector

The public sector is composed by the government and the central bank. The domestic government faces the following flow budget constraint expressed in real terms:

$$\dot{m} + \dot{b} = g - \tau + (R - \pi)b - \pi m, \quad (14)$$

where g is public spending and b denotes the real stock of of traded bonds issued by the government. Lump-sum taxes are set in order to rule any explosive behavior of the government liabilities.

The central bank sets the nominal interest rate as an increasing function of the inflation rate in the spirit of Taylor (1993, 1999):

$$R = i + \rho(\pi), \quad (15)$$

where $\rho(\cdot)$ is continuous, non-decreasing, and there exists at least one $\bar{\pi} > -\beta$ such that $i + \rho(\bar{\pi}) = \beta + \bar{\pi}$; i is a positive parameter capturing exogenous deviations from the feedback component of the rule. Following Leeper (1991), the interest rate rule (15) is ‘active (‘passive’) if $\rho' > (<)1$. In other words, under an active (passive) monetary policy, the central bank responds to inflation by raising (lowering) the real interest rate and the so-called Taylor’s principle is (is not) satisfied.

2.3 Current Account Dynamics and the Risk Premium

Subtracting (14) from (5) one can obtain the budget constraint which describes the rate of change of net credit of the domestic economy which in turn equals the balance of payments on current accounts:

$$\dot{n} = y - c - g + (R^* - \pi^*)n, \quad (16)$$

where n denotes the net stock of traded bonds defined as $n = a - b$.

Henceforth, we shall assume that $n < 0$, in which case the home country is a net debtor. For convenience, we can thus rewrite (16) in terms of net foreign debt accumulation as:

$$\dot{f} = c + g - y + (R^* - \pi^*)f. \quad (17)$$

where, by definition, $f = -n$.

Following Bardhan (1967), Obstfeld (1982), Bhandari, Haque and Turnovsky (1990), and Turnovsky (1997), we assume that the home country has not access to a perfect world capital market, but faces an upward-sloping supply curve of foreign debt. From the standpoint of the borrowing economy, the nominal interest rate on foreign debt R^* can then be expressed as follows:

$$R^* = i^* + \sigma(f), \quad (18)$$

where i^* is the interest rate prevailing in the world market and $\sigma(f)$ is the country-specific risk premium. The function $\sigma(\cdot)$ is assumed to be continuous, increasing in f and strictly positive.

3 Macroeconomic Equilibrium

Combining the set of optimality conditions (7)-(10) and (13) together with the interest rate on foreign debt function (18), the international parity conditions (2) and (3), the production function (12), the monetary policy rule (15), and the foreign debt accumulation equation (17), the perfect-foresight equilibrium can be described as follows:

$$\dot{\mu} = \mu\beta - (i^* + \sigma(f) - \pi^*)\mu, \quad (19)$$

$$\dot{f} = c + g - \Lambda\phi(\ell) + (i^* + \sigma(f) - \pi^*)f, \quad (20)$$

$$c = c(\mu, \Lambda), \quad c_\mu, c_\Lambda < 0, \quad (21)$$

$$\ell = \ell(\mu, \Lambda), \quad \ell_\mu, \ell_\Lambda > 0, \quad (22)$$

$$y = \Lambda\phi(\ell), \quad (23)$$

$$m = m(\mu) + \frac{1}{\rho' - 1} \eta(i^*, f, i, \pi^*), \quad m_\mu < 0, \eta_{i^*}, \eta_f < 0, \eta_i, \eta_{\pi^*} > 0, \quad (24)$$

$$e = \frac{1}{\rho' - 1} \epsilon(i^*, f, i, \pi^*), \quad \epsilon_{i^*}, \epsilon_f > 0, \epsilon_i, \epsilon_{\pi^*} < 0, \quad (25)$$

where (19) and (20) are the pair of equations describing the evolution of the economy over time and (21)-(25) describe the equilibrium paths for consumption, work effort, production, real money balances and the rate of exchange depreciation of domestic currency, respectively. See Appendix A for details.

4 Steady-State Analysis

Under perfect foresight, the transitional dynamics of the model depends in part on the expectations of the long-run steady state. This Section derives the steady-state equilibrium and the long-run effects of changes in both domestic and foreign exogenous variables.

The steady state of the economy is obtained when the shadow value of wealth is constant and external debt accumulation ceases, that is when $\dot{\mu} = \dot{f} = 0$. From (19)-(25), the steady state consists of the following set of relationships:

$$\beta = i^* + \sigma(\bar{f}) - \pi^*, \quad (26)$$

$$\Lambda\phi(\ell(\bar{\mu}, \Lambda)) = (i^* + \sigma(\bar{f}) - \pi^*)\bar{f} + c(\bar{\mu}, \Lambda) + g, \quad (27)$$

$$\bar{c} = c(\bar{\mu}, \Lambda), \quad (28)$$

$$\bar{\ell} = \ell(\bar{\mu}, \Lambda), \quad (29)$$

$$\bar{y} = \Lambda\phi(\bar{\ell}), \quad (30)$$

$$\bar{m} = m(\bar{\mu}) + \frac{1}{\rho' - 1} \eta(i^*, \bar{f}, i, \pi^*), \quad (31)$$

$$\bar{e} = \frac{1}{\rho' - 1} \epsilon(i^*, \bar{f}, i, \pi^*). \quad (32)$$

Equations (26)-(32) jointly determine the steady-state equilibrium solutions for $\bar{\mu}$, \bar{f} , \bar{c} , $\bar{\ell}$, \bar{y} , \bar{m} and \bar{e} as functions of the rate of time preference β , the technology parameter Λ , public spending g , the monetary policy rule exogenous component i , foreign inflation π^* , and the interest rate prevailing in the world market i^* .

To study exchange rate dynamics, it is convenient to write down the long-run responses to changes in exogenous variables of foreign debt and of the rate of depreciation, respectively. The responses to changes in domestic variables are given by:

$$\frac{d\bar{f}}{di} = 0, \quad \frac{d\bar{f}}{d\beta} = \frac{1}{\sigma'} > 0, \quad \frac{d\bar{f}}{d\Lambda} = \frac{d\bar{f}}{dg} = 0, \quad (33)$$

$$\frac{d\bar{e}}{di} = -\frac{1}{\rho' - 1} < (>)0, \quad \frac{d\bar{e}}{d\beta} = \frac{1}{\rho' - 1} > (<)1 \text{ if } \rho > (<)1 \text{ and } \frac{d\bar{e}}{d\Lambda} = \frac{d\bar{e}}{dg} = 0. \quad (34)$$

On the other hand, the responses to changes in the foreign variables are given by:

$$\frac{d\bar{f}}{d\pi^*} = \frac{1}{\sigma'} > 0, \quad \frac{d\bar{f}}{di^*} = -\frac{1}{\sigma'} < 0, \quad (35)$$

$$\frac{d\bar{e}}{d\pi^*} = -1, \quad \frac{d\bar{e}}{di^*} = 0. \quad (36)$$

The long-run responses of all endogenous variables of the economy to changes in the exogenous variables of both domestic and foreign origin are reported in Tables 1 and 2, respectively, where $\Delta \equiv -\sigma' (c_\mu(\bar{\mu}, \Lambda) - \Lambda\phi'\ell_\mu(\bar{\mu}, \Lambda)) > 0$. Full derivations are developed in Appendix B.

5 Transitional Dynamics

Linearizing the differential equations (19)-(20) around the steady-state equilibrium $\{\bar{\mu}, \bar{f}\}$ yields:

$$\begin{pmatrix} \dot{f} \\ \dot{\mu} \end{pmatrix} = \begin{pmatrix} \beta + \sigma' \bar{f} & c_{\mu}(\bar{\mu}, \Lambda) - \Lambda \phi' \ell_{\mu}(\bar{\mu}, \Lambda) \\ -\sigma' \bar{\mu} & 0 \end{pmatrix} \begin{pmatrix} f - \bar{f} \\ \mu - \bar{\mu} \end{pmatrix}. \quad (37)$$

The above system displays one predetermined variable, f , and one jumping variable, μ . In order to have a unique perfect-foresight equilibrium in the neighborhood of the steady state (i.e., saddle-path stability), the Jacobian of the system must have eigenvalues of opposite sign. This property is satisfied by the system (37), since the determinant of the Jacobian, given by $\sigma' \bar{\mu} [c_{\mu}(\bar{\mu}, \Lambda) - \Lambda \phi' \ell_{\mu}(\bar{\mu}, \Lambda)]$, is negative. The Taylor principle, $\rho' > 1$, is not necessary to bring about equilibrium determinacy. Intuitively, this is because the time path of inflation depends not only on the central bank's behavior, but also on the time path of external debt and the international parity conditions. Whether monetary policy is active or passive is immaterial for determinacy.

Focusing now on the stable path, the solutions for f and e are given by:

$$f = \bar{f} + (f_0 - \bar{f}) e^{\lambda t}, \quad (38)$$

$$e = \bar{e} + \frac{1}{\rho' - 1} \epsilon_f (f - \bar{f}), \quad (39)$$

where $\lambda < 0$ is the stable eigenvalue and f_0 is the initial condition on foreign debt (see Appendix C for full derivations). Using the steady-state multipliers given by (33)-(36), the impact effects on the rate of depreciation of changes in domestic and foreign variables are, respectively:

$$\frac{de(0)^+}{di} = -\frac{1}{\rho' - 1} < (>) 0 \quad \text{if } \rho > (<) 1, \quad \frac{de(0)^+}{d\beta} = \frac{de(0)^+}{d\Lambda} = \frac{de(0)^+}{dg} = 0, \quad (40)$$

$$\frac{de(0)^+}{d\pi^*} = -\frac{\rho'}{\rho' - 1} < (>)0, \frac{de(0)^+}{di^*} = \frac{1}{\rho' - 1} > (<)0 \quad \text{if } \rho > (<)1. \quad (41)$$

The impact effects on all endogenous variables of changes in domestic and foreign variables are summarized in Tables 3 and 4 (see Appendix D for details).

From the analysis of both the steady-state equilibrium and the transitional dynamics, it emerges that the dynamic behavior of the nominal exchange rate critically depends upon whether the monetary policy reaction coefficient ρ' is above or below unity. Examining (39), in fact, the exchange depreciation rate is correlated with foreign debt along the transitional path towards the steady-state equilibrium, with a coefficient, $\epsilon_f/(\rho' - 1)$, which is greater (lower) than zero if $\rho' > (<)1$. An intuitive explanation is the following. A change in external indebtedness alters the international parity conditions given by the risk-adjusted interest rate parity, thereby influencing exchange rate dynamics. In particular, an increase in foreign debt makes the country-specific risk premium rise, leading to an increase in the nominal interest rate faced by the small open economy. This brings about an increase in the domestic nominal interest rate net of domestic currency depreciation, according to the risk-adjusted interest rate parity condition. Recalling the PPP condition, it also follows that the domestic real interest rate has to raise. The key point is that when monetary policy is active (passive), an increase in the domestic real interest rate may occur if and only if there is an increase (decrease) in the exchange depreciation rate. Exchange rate dynamics are thus qualitatively affected by whether the interest rate rule is active or passive. This is illustrated in Figures 1-2.

Specifically, Figures 1 and 2 plot the time path of the nominal exchange depreciation rate in response to changes in i , β , π^* and i^* under active and passive monetary policy, respectively.

Figure 1a shows that the rate of exchange depreciation instantaneously declines in response to an increase in i . In this case there is no transitional dynamics, since in the steady state a change in the nominal interest rate does not affect foreign indebtedness. The

exchange rate jumps instantaneously to the new steady state. Intuitively, an exogenous rise in i must crowd out the endogenous component of the domestic real interest rate ($\rho(\pi) - \pi$), in order to restore both the risk-adjusted interest rate parity and the PPP. Since monetary policy overreacts to inflation, the endogenous component of the domestic real interest rate decreases only when the rate of exchange depreciation decreases.

On the other hand, an increase in the rate of time preference β increases the level of indebtedness and hence the cost of external borrowing. In this case, the combination of the active Taylor rule with the risk-corrected interest parity and the PPP implies an increase in the depreciation rate of the domestic currency. The exchange rate, in fact, starts to increase converging gradually to its long-run equilibrium (see Figure 1b).

An increase in foreign inflation π^* causes external indebtedness to raise and the rate of exchange depreciation to fall in the long run, as it emerges from equations (35) and (36). Under an active monetary policy, a rise in foreign inflation implies a reduction on impact of the domestic currency depreciation rate, which overshoots its long-run value (see Figure 1c). After the initial downward jump, in fact, e starts to increase, approaching asymptotically a new steady-state below its original level.

Figure 1d shows that an increase in the world interest rate i^* determines an upward jump of the rate of exchange depreciation on impact, since foreign bonds become more attractive. This implies a decline in the steady-state foreign debt, as it emerges from (35). As long as the monetary authorities are engaged in an active interest rate policy, the reduction in the level of external debt over time must be associated with a decline in e , along the adjustment path towards the new steady-state equilibrium. This can occur if only if there is an instantaneous upward jump in e .

From Figures 2a-2d, one can see how the responses of the nominal exchange rate obtained under an interest rate rule satisfying the Taylor principle are reversed in the case of an accommodating monetary policy, underreacting to inflation. A passive Taylor rule requires a decline in the exchange depreciation rate each time that a domestic real

interest rate increase is necessary to restore the equilibrium due, for example, to increases in β or i^* (see Figures 2b and 2d). On the other hand, an increase in i requires a reduction in the endogenous component of the domestic real rate implying, under a passive rule, a higher depreciation rate (see Figure 2a). An increase in foreign inflation requires a long-run fall in the rate of exchange depreciation, although it brings about an upward jump of e on impact (see Figure 2c). In this case, only the short-run response crucially depends on the monetary policy regime, while the effects of the PPP prevail in the long run.

6 Conclusions

External indebtedness poses constraints on the borrowing opportunities of emerging market and developing economies, as empirically evidenced. We have analyzed the dynamic effects of interest rate rules in the spirit of Taylor (1993, 1999) in an optimizing model of exchange rate determination that incorporates a risk premium on foreign debt. An imperfect global capital market has strong implications for the design of monetary policy rules in emerging market economies that do not choose to adopt a ‘hard’ peg exchange rate regime. In particular, it is demonstrated that when external borrowing is subject to credit risk, the usual requirement that the monetary authorities should fight inflation aggressively by raising the nominal interest rate more than proportionally with respect to increases in inflation is not necessary to ensure equilibrium stability and uniqueness. On the other hand, our analytical findings show that the dynamics of exchange rates, when the central bank implements interest rate policies, are critically affected by whether monetary policy overreacts or underreacts to inflation. In this respect, the present paper adds interesting insights to the classical theoretical debate on exchange rate determination.

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Appendix A

Consumption and labor supply can be expressed as function of μ and Λ as follows. Totally differentiate (7) and (8), given (13), and write the results in matrix notation:

$$\begin{pmatrix} U_{cc} & U_{cl} \\ U_{lc} & U_{\ell\ell} + \Lambda\phi''\mu \end{pmatrix} \begin{pmatrix} dc \\ d\ell \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ -\Lambda\phi' & -\phi'\mu \end{pmatrix} \begin{pmatrix} d\mu \\ d\Lambda \end{pmatrix}. \quad (\text{A1})$$

Let $\Psi \equiv U_{cc}(U_{\ell\ell} + \Lambda\phi''\mu) - U_{cl}^2 > 0$. We obtain the following results:

$$c_\mu = \frac{dc}{d\mu} = \frac{\begin{vmatrix} 1 & U_{cl} \\ -\Lambda\phi' & U_{\ell\ell} + \Lambda\phi''\mu \end{vmatrix}}{\Psi} = \frac{U_{\ell\ell} + \Lambda\phi''\mu + U_{cl}\Lambda\phi'}{\Psi} < 0, \quad (\text{A2})$$

$$c_\Lambda = \frac{dc}{d\Lambda} = \frac{\begin{vmatrix} 0 & U_{cl} \\ -\phi'\mu & U_{\ell\ell} + \Lambda\phi''\mu \end{vmatrix}}{\Psi} = \frac{U_{cl}\phi'\mu}{\Psi} < 0, \quad (\text{A3})$$

$$\ell_\mu = \frac{d\ell}{d\mu} = \frac{\begin{vmatrix} U_{cc} & 1 \\ U_{lc} & -\Lambda\phi' \end{vmatrix}}{\Psi} = -\frac{U_{cc}\Lambda\phi' + U_{lc}}{\Psi} > 0, \quad (\text{A4})$$

$$\ell_{\Lambda} = \frac{d\ell}{d\Lambda} = \frac{\begin{vmatrix} U_{cc} & 0 \\ U_{lc} & -\phi'\mu \end{vmatrix}}{\Psi} = -\frac{U_{cc}\phi'\mu}{\Psi} > 0. \quad (\text{A5})$$

Consider now the derivation of the exchange rate determination function (25). By combining equations (2)-(3) with the Taylor rule (15), we obtain:

$$i^* + \sigma(f) + e = i + \rho(\pi^* + e). \quad (\text{A6})$$

Totally differentiating the above expression gives:

$$de(\rho' - 1) = di^* + \sigma' df - di + \rho' d\pi^*. \quad (\text{A7})$$

Letting $\frac{de}{di^*}(\rho' - 1) = \epsilon_{i^*} = 1$, $\frac{de}{df}(\rho' - 1) = \epsilon_f = \sigma'$, $\frac{de}{di}(\rho' - 1) = \epsilon_i = -1$ and $\frac{de}{d\pi^*}(\rho' - 1) = \epsilon_{\pi^*} = -\rho'$, equation (25) immediately follows.

Finally, the equation describing the time path of real money balances can be obtained by combining (9) with (??), given the Taylor rule (15):

$$V'(m) = \mu(i + \rho(\pi^* + e)). \quad (\text{A8})$$

Totally differentiating yields:

$$V'' dm = R d\mu + \mu(di + \rho' d\pi^* + \rho' de), \quad (\text{A9})$$

which, given (A7), can be re-written as:

$$dm = \frac{R}{V''} d\mu + \frac{1}{\rho' - 1} \frac{\rho' \sigma' df - di - \rho' d\pi^* + \rho' di^*}{V''} \mu. \quad (\text{A10})$$

Letting $\frac{dm}{d\mu} = m_{\mu} = \frac{R}{V''}$, $\frac{dm}{di^*}(\rho' - 1) = \eta_{i^*} = \frac{\rho'\mu}{V''}$, $\frac{dm}{df}(\rho' - 1) = \eta_f = \frac{\rho'\sigma'\mu}{V''}$, $\frac{dm}{di}(\rho' - 1) = \eta_i = -\frac{\mu}{V''}$ and $\frac{dm}{d\pi^*}(\rho' - 1) = \eta_{\pi^*} = -\frac{\rho'\mu}{V''}$, equation (24) immediately follows.

Appendix B

Totally differentiate (26) and (27) and express the results in matrix notation:

$$\begin{pmatrix} 0 & \sigma' \\ c_\mu(\bar{\mu}, \Lambda) - \Lambda\phi'\ell_\mu(\bar{\mu}, \Lambda) & \beta \end{pmatrix} \begin{pmatrix} d\bar{\mu} \\ d\bar{f} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 1 & -1 \\ -\bar{f} & \kappa & -1 & 0 & 0 \end{pmatrix} \begin{pmatrix} d\beta \\ d\Lambda \\ dg \\ d\pi^* \\ di^* \end{pmatrix},$$

where $\kappa \equiv \phi(\ell(\bar{\mu}, \Lambda)) + \Lambda\phi'\ell_\Lambda(\bar{\mu}, \Lambda) - c_\Lambda(\bar{\mu}, \Lambda) > 0$.

Letting $\Delta \equiv -\sigma'(c_\mu(\bar{\mu}, \Lambda) - \Lambda\phi'\ell_\mu(\bar{\mu}, \Lambda)) > 0$ we obtain the following set of derivatives:

$$\frac{d\bar{\mu}}{d\beta} = \frac{\begin{vmatrix} 1 & \sigma' \\ -\bar{f} & \beta \end{vmatrix}}{\Delta} = \frac{\beta + \sigma'\bar{f}}{\Delta} > 0, \quad (\text{B1})$$

$$\frac{d\bar{\mu}}{d\Lambda} = \frac{\begin{vmatrix} 0 & \sigma' \\ \kappa & -\beta \end{vmatrix}}{\Delta} = -\frac{\kappa\sigma'}{\Delta} < 0, \quad (\text{B2})$$

$$\frac{d\bar{\mu}}{dg} = \frac{\begin{vmatrix} 0 & \sigma' \\ -1 & \beta \end{vmatrix}}{\Delta} = \frac{\sigma'}{\Delta} > 0, \quad (\text{B3})$$

$$\frac{d\bar{\mu}}{d\pi^*} = \frac{\begin{vmatrix} 1 & \sigma' \\ 0 & \beta \end{vmatrix}}{\Delta} = \frac{\beta}{\Delta} > 0, \quad (\text{B4})$$

$$\frac{d\bar{\mu}}{di^*} = \frac{\begin{vmatrix} -1 & \sigma' \\ 0 & \beta \end{vmatrix}}{\Delta} = -\frac{\beta}{\Delta} < 0, \quad (\text{B5})$$

$$\frac{d\bar{f}}{d\beta} = \frac{\begin{vmatrix} 0 & 1 \\ [c_\mu(\bar{\mu}, \Lambda) - \Lambda\phi'\ell_\mu(\bar{\mu}, \Lambda)] & -\bar{f} \end{vmatrix}}{\Delta} = -\frac{c_\mu(\bar{\mu}, \Lambda) - \Lambda\phi'\ell_\mu(\bar{\mu}, \Lambda)}{\Delta} = \frac{1}{\sigma'} > 0, \quad (\text{B6})$$

$$\frac{d\bar{f}}{d\Lambda} = \frac{\begin{vmatrix} 0 & 0 \\ c_\mu(\bar{\mu}, \Lambda) - \Lambda\phi'\ell_\mu(\bar{\mu}, \Lambda) & \kappa \end{vmatrix}}{\Delta} = 0, \quad (\text{B7})$$

$$\frac{d\bar{f}}{dg} = \frac{\begin{vmatrix} 0 & 0 \\ c_\mu(\bar{\mu}, \Lambda) - \Lambda\phi'\ell_\mu(\bar{\mu}, \Lambda) & -1 \end{vmatrix}}{\Delta} = 0, \quad (\text{B8})$$

$$\frac{d\bar{f}}{d\pi^*} = \frac{\begin{vmatrix} 0 & 1 \\ c_\mu(\bar{\mu}, \Lambda) - \Lambda\phi'\ell_\mu(\bar{\mu}, \Lambda) & 0 \end{vmatrix}}{\Delta} = -\frac{c_\mu(\bar{\mu}, \Lambda) - \Lambda\phi'\ell_\mu(\bar{\mu}, \Lambda)}{\Delta} = \frac{1}{\sigma'} > 0, \quad (\text{B9})$$

$$\frac{d\bar{f}}{di^*} = \frac{\begin{vmatrix} 0 & -1 \\ c_\mu(\bar{\mu}, \Lambda) - \Lambda\phi'\ell_\mu(\bar{\mu}, \Lambda) & 0 \end{vmatrix}}{\Delta} = \frac{c_\mu(\bar{\mu}, \Lambda) - \Lambda\phi'\ell_\mu(\bar{\mu}, \Lambda)}{\Delta} = -\frac{1}{\sigma'} < 0. \quad (\text{B10})$$

Given the above results and using (21)-(25), one obtains the long-run effects on consumption, labor inputs, income, real money balances and exchange rates. This shows results reported in Tables 1 and 2.

Appendix C

Focusing on the stable path, the solutions for μ , f , c , ℓ , y , m and e are of the following form:

$$\mu = \bar{\mu} - \frac{\sigma'\bar{\mu}}{\lambda} (f_0 - \bar{f}) e^{\lambda t}, \quad (\text{C1})$$

$$f = \bar{f} + (f_0 - \bar{f}) e^{\lambda t}, \quad (\text{C2})$$

$$c = \bar{c} + c_\mu(\mu - \bar{\mu}), \quad (\text{C3})$$

$$\ell = \bar{\ell} + \ell_{\mu}(\mu - \bar{\mu}), \quad (\text{C4})$$

$$y = \bar{y} + \phi' \ell_{\mu}(\mu - \bar{\mu}), \quad (\text{C5})$$

$$m = \bar{m} + m_{\mu}(\mu - \bar{\mu}) + \frac{1}{\rho' - 1} \eta_f (f - \bar{f}), \quad (\text{C6})$$

$$e = \bar{e} + \frac{1}{\rho' - 1} \epsilon_f (f - \bar{f}), \quad (\text{C7})$$

where $\lambda < 0$ is the stable eigenvalue and f_0 is the initial condition on foreign debt.

Appendix D

At time $t = 0$, differentiating (C1)-(C7) with respect to some arbitrary variable, say x , yields:

$$\frac{d\mu(0)^+}{dx} = \frac{d\bar{\mu}}{dx} + \frac{\sigma' \bar{\mu}}{\lambda} \frac{d\bar{f}}{dx}, \quad (\text{D1})$$

$$\frac{df(0)^+}{dx} = 0, \quad (\text{D2})$$

$$\frac{dc(0)^+}{dx} = \frac{d\bar{c}}{dx} + c_{\mu} \left(\frac{d\mu(0)}{dx} - \frac{d\bar{\mu}}{dx} \right), \quad (\text{D3})$$

$$\frac{d\ell(0)^+}{dx} = \frac{d\bar{\ell}}{dx} + \ell_{\mu} \left(\frac{d\mu(0)}{dx} - \frac{d\bar{\mu}}{dx} \right), \quad (\text{D4})$$

$$\frac{dy(0)^+}{dx} = \frac{d\bar{y}}{dx} + \phi' \ell_{\mu} \left(\frac{d\mu(0)}{dx} - \frac{d\bar{\mu}}{dx} \right), \quad (\text{D5})$$

$$\frac{dm(0)^+}{dx} = \frac{d\bar{m}}{dx} + m_{\mu} \left(\frac{d\mu(0)}{dx} - \frac{d\bar{\mu}}{dx} \right) - \frac{1}{\rho' - 1} \eta_f \frac{d\bar{f}}{dx}, \quad (\text{D6})$$

$$\frac{de(0)^+}{dx} = \frac{d\bar{e}}{dx} - \frac{\sigma'}{\rho' - 1} \frac{d\bar{f}}{dx}. \quad (\text{D7})$$

From the above relationships for $x = i, \beta, \Lambda, g, i, \pi^*$, using the results reported in Tables 1 and 2, one can easily obtain the impact effects of Tables 3 and 4.

Table 1: Steady-State Effects of Changes in Domestic Variables

	i	β	Λ	g
$\bar{\mu}$	0	$\frac{\beta+\sigma'\bar{f}}{\Delta} > 0$	$-\frac{[\phi(\bar{\ell})+\Lambda\phi'\ell_{\Lambda}-c_{\Lambda}]\sigma'}{\Delta} < 0$	$\frac{\sigma'}{\Delta} > 0$
\bar{f}	0	$\frac{1}{\sigma'} > 0$	0	0
\bar{c}	0	$c_{\mu}\frac{\beta+\sigma'\bar{f}}{\Delta} < 0$	$c_{\Lambda} - \frac{[\phi(\bar{\ell})+\Lambda\phi'\ell_{\Lambda}-c_{\Lambda}]\sigma'c_{\mu}}{\Delta} > 0$	$\frac{\sigma'c_{\mu}}{\Delta} < 0$
$\bar{\ell}$	0	$\ell_{\mu}\frac{\beta+\sigma'\bar{f}}{\Delta} > 0$	$\ell_{\Lambda} - \frac{[\phi(\bar{\ell})+\Lambda\phi'\ell_{\Lambda}-c_{\Lambda}]\sigma'\ell_{\mu}}{\Delta} \leq 0$	$\frac{\sigma'\ell_{\mu}}{\Delta} > 0$
\bar{y}	0	$\phi'\ell_{\mu}\frac{\beta+\sigma'\bar{f}}{\Delta} > 0$	$\phi'\ell_{\Lambda} - \frac{[\phi(\bar{\ell})+\Lambda\phi'\ell_{\Lambda}-c_{\Lambda}]\sigma'\phi'\ell_{\mu}}{\Delta} \leq 0$	$\frac{\sigma'\phi'\ell_{\mu}}{\Delta} > 0$
\bar{m}	$-\frac{\mu}{V''}\frac{1}{\rho'-1} \geq 0$	$\frac{R}{V''}\frac{\beta+\sigma'\bar{f}}{\Delta} + \frac{\mu}{V''(\rho'-1)}\rho' \leq 0$	$-\frac{[\phi(\bar{\ell})+\Lambda\phi'\ell_{\Lambda}-c_{\Lambda}]\sigma'}{\Delta}\frac{R}{V''} > 0$	$\frac{\sigma'}{\Delta}\frac{R}{V''} < 0$
\bar{e}	$-\frac{1}{\rho'-1} \leq 0$	$\frac{1}{\rho'-1} \geq 0$	0	0

Table 2: Steady-State Effects of Changes in Foreign Variables

	π^*	i^*
$\bar{\mu}$	$\frac{\beta}{\Delta} > 0$	$-\frac{\beta}{\Delta} < 0$
\bar{f}	$\frac{1}{\sigma'} > 0$	$-\frac{1}{\sigma'} < 0$
\bar{c}	$-c_{\mu}\frac{\beta}{\Delta} < 0$	$c_{\mu}\frac{\beta}{\Delta} > 0$
$\bar{\ell}$	$-\ell_{\mu}\frac{\beta}{\Delta} > 0$	$\ell_{\mu}\frac{\beta}{\Delta} < 0$
\bar{y}	$-\phi'\ell_{\mu}\frac{\beta}{\Delta} > 0$	$\phi'\ell_{\mu}\frac{\beta}{\Delta} < 0$
\bar{m}	$\frac{R}{V''}\frac{\beta}{\Delta} < 0$	$-\frac{R}{V''}\frac{\beta}{\Delta} > 0$
\bar{e}	-1	0

Table 3: Impact Effects of Changes in Domestic Variables

	i	β	Λ	g
$\mu(0)^+$	0	$\frac{d\bar{\mu}}{d\beta} - \frac{\bar{\mu}}{\lambda_1} > 0$	$\frac{d\bar{\mu}}{d\Lambda} < 0$	$\frac{d\bar{\mu}}{dg} > 0$
$c(0)^+$	0	$\frac{d\bar{c}}{d\beta} - c_\mu \frac{\bar{\mu}}{\lambda_1} < 0$	$\frac{d\bar{c}}{d\Lambda} \begin{matrix} \geq \\ \leq \end{matrix} 0$	$\frac{d\bar{c}}{dg} < 0$
$\ell(0)^+$	0	$\frac{d\bar{\ell}}{d\beta} - \frac{\bar{\mu}}{\lambda_1} \ell_\mu > 0$	$\frac{d\bar{\ell}}{d\Lambda} \begin{matrix} \leq \\ \geq \end{matrix} 0$	$\frac{d\bar{\ell}}{dg} > 0$
$y(0)^+$	0	$\frac{d\bar{y}}{d\beta} - \frac{\bar{\mu}}{\lambda_1} \phi' \ell_\mu > 0$	$\frac{d\bar{y}}{d\Lambda} \begin{matrix} \leq \\ \geq \end{matrix} 0$	$\frac{d\bar{y}}{dg} > 0$
$m(0)^+$	$-\frac{\mu}{V''} \frac{1}{\rho'-1} \geq 0$	$\frac{R}{V''} \frac{\beta + \sigma' f}{\Delta} - \frac{R}{V''} \frac{\bar{\mu}}{\lambda_1} < 0$	$-\frac{[\phi(\bar{\ell}) + \phi' \ell_\Lambda - c_\Lambda] \sigma'}{\Delta} \frac{R}{V''} > 0$	$\frac{\sigma'}{\Delta} \frac{R}{V''} < 0$
$e(0)^+$	$-\frac{1}{\rho'-1} \leq 0$	0	0	0

Table 4: Impact Effects of Changes in Foreign Variables

	π^*	i^*
$\mu(0)^+$	$\frac{d\bar{\mu}}{d\pi^*} - \frac{\bar{\mu}}{\lambda_1} > 0$	$\frac{d\bar{\mu}}{di^*} + \frac{\bar{\mu}}{\lambda_1} < 0$
$c(0)^+$	$\frac{d\bar{c}}{d\pi^*} - c_\mu \frac{\bar{\mu}}{\lambda_1} < 0$	$\frac{d\bar{c}}{di^*} + c_\mu \frac{\bar{\mu}}{\lambda_1} > 0$
$\ell(0)^+$	$\frac{d\bar{\ell}}{d\pi^*} - \ell_\mu \frac{\bar{\mu}}{\lambda_1} > 0$	$\frac{d\bar{\ell}}{di^*} + \ell_\mu \frac{\bar{\mu}}{\lambda_1} < 0$
$y(0)^+$	$\frac{d\bar{y}}{d\pi^*} - \phi' \ell_\mu \frac{\bar{\mu}}{\lambda_1} > 0$	$\frac{d\bar{y}}{di^*} + \phi' \ell_\mu \frac{\bar{\mu}}{\lambda_1} < 0$
$m(0)^+$	$\frac{1}{V''} \left(\frac{\beta R}{\Delta} - \frac{R\bar{\mu}}{\lambda_1} - \frac{\rho' \bar{\mu}}{\rho'-1} \right) \geq 0$	$\frac{1}{V''} \left(-\frac{\beta R}{\Delta} + \frac{R\bar{\mu}}{\lambda_1} + \frac{\rho' \bar{\mu}}{\rho'-1} \right) \leq 0$
$e(0)^+$	$-\frac{1}{\rho'-1} \rho' \leq 0$	$\frac{1}{\rho'-1} \geq 0$

Figure 1: Exchange Rate Dynamics under Active Monetary Policy, $\rho' > 1$

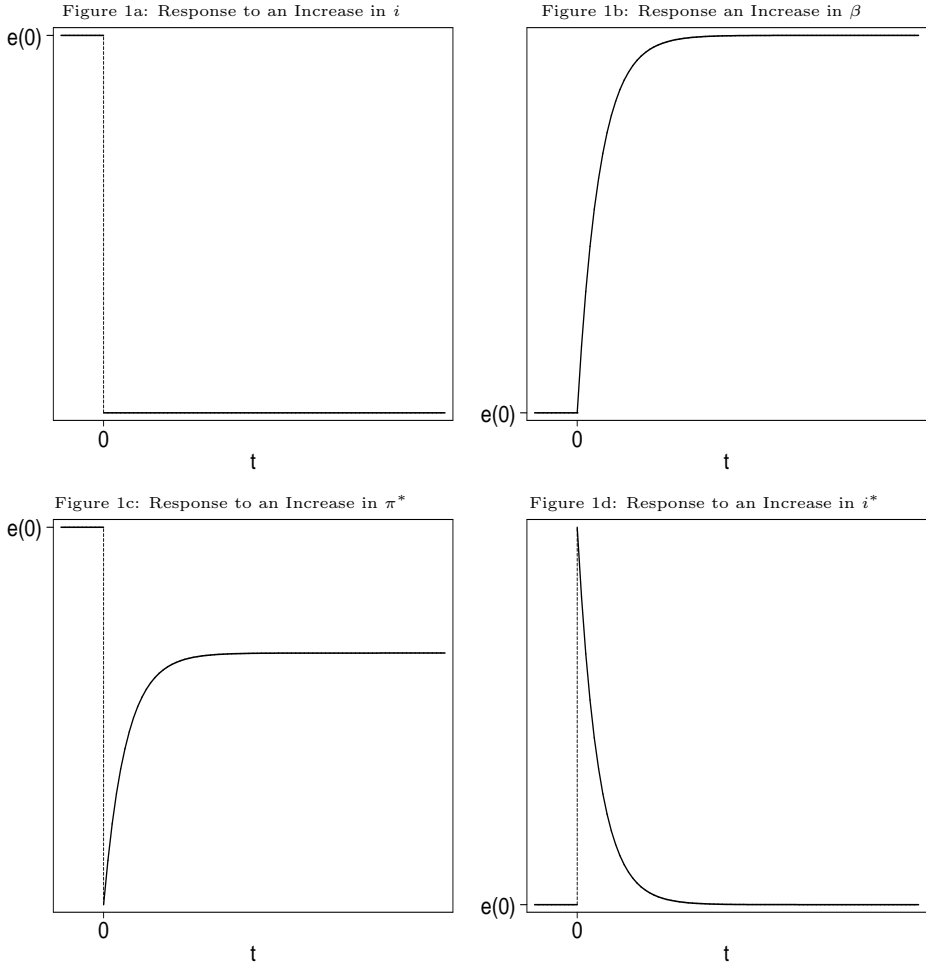


Figure 2: Exchange Rate Dynamics under Passive Monetary Policy, $\rho' < 1$

