A Fiscal Theory of Currency Crises*

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Abstract

An exchange rate crisis is caused when the fiscal authority lets the present value of primary surpluses, inclusive of seigniorage, deviate from the value of government debt at the pegged exchange rate. In the absence of long-term government bonds, the exchange rate collapse must be instantaneous. With long-term government bonds, the collapse can be delayed at the discretion of the monetary authority. Fiscal policy is responsible for the inevitability of a crisis, while monetary policy determines its characteristics, that is the timing of the crisis and the magnitude of exchange rate depreciation.

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1 Introduction

Recent exchange rate crises are not all alike. Earlier crises, like those in Mexico (1976 and 1982) and Argentina (1975 and 1981) seemed to be due to ongoing expansion of domestic credit. Krugman's (1979) analogy of a foreign exchange crisis to the collapse of a government price support system for an exhaustible resource explained these crises well. Domestic credit growth depletes foreign exchange resources until near exhaustion. A final speculative attack exhausts the supply of reserves, reducing real money demand to its post-collapse equilibrium, with higher interest due to higher monetary growth. This model focused attention on inconsistent government policies as the reason exchange rate regimes fail. Inconsistent fundamentals imply an inevitable collapse.

The exchange rate crises in the ERM in 1992-1993 and in Mexico in 1994 did not seem to fit this pattern. In these crises, governments had *not* been pursuing steady domestic credit creation to finance deficits. Therefore, to explain these recent crises, a second generation of exchange rate crisis model was developed. Early papers include Obstfeld (1986), (1994), Eichengreen and Wyploz (1992), and Sachs, Tornell and Velasco (1996). This approach focuses on the dynamic inconsistency of optimal monetary policy. In a popular variant of these models, exchange rate depreciation (monetary policy) is seen as a stabilization tool, in which surprise depreciation can reduce unemployment. Exchange rate crises can be caused by anything which shocks an argument in the policy-maker's loss function, including a speculative attack itself. These models have expanded our understanding of exchange rate crises by focusing on the role of government choice in setting policy and in the potentially self-fulfilling nature of expectations in models with multiple equilibria.

The most recent round of crises in Southeast Asia (1997-98) has led to the development of additional models which emphasize the role of financial fragility in generating exchange rate crises. Radelet and Sachs (1998) characterize these crises as a "bank runs" on the central bank's reserves. Corsetti, Pesenti, and Roubini (1998) and Krugman (1997) attribute the crises to a combination of moral hazard and a change in expectations about the willingness of governments to stand behind bank loans.

Most of the theoretical literature focuses on the role of monetary policy in maintaining a fixed exchange rate. Specifically, a fixed rate constrains the monetary authority's choice of the interest rate and the exchange rate. The interesting question is what causes the change in policy. This paper analyzes the role of fiscal policy in generating the policy change, and, hence, in generating exchange rate crises. We show that once fiscal policy violates the constraint imposed by a fixed rate regime, there is no monetary policy consistent with the long-run viability of a fixed exchange rate regime.

We present a "fiscal theory of exchange rate crises" similar to the "fiscal theory of the price level" (Woodford 1994, Sims 1994). We demonstrate that the long-run viability of a fixed exchange rate system depends on the present value of future fiscal surpluses. When the fiscal authority chooses the present value of surpluses inconsistent with the pegged rate, the monetary authority is forced to abandon the exchange rate peg. The monetary authority does retain discretion, through its choice of the composition of government debt, in determining the timing and characteristics of the exchange rate crisis.[1] The resulting theory can be used to understand different types of exchange rate crises, including those following sustained periods of government budget deficits financed by reserve loss, as in the Latin American crises of the 1970's and 1980's, crises which surprise markets, as with the ERM crises in 1993, and crises caused by expectations of future fiscal expenditures with no sustained reserve loss, as in the Southeast Asian crises of 1997.[2]

The paper is organized as follows. Budget constraints play an important role in determining equilibrium consumption and in constraining the government's response to a crisis. Therefore, the next section describes budget constraints. The implications of fiscal policy and of intertemporal current account balance for the determination of the equilibrium exchange rate changes is presented in Section 3. Section 4 describes the role of monetary policy in determining the characteristics of an exchange rate crisis. Section 5 provides conclusions.

2 Budget Constraints

2.1 Representative Agent

Assume, initially, a certainty world. The domestic country is small, perfect foresight prevails, and both interest rate parity and purchasing power parity hold. World inflation is zero. Time is discrete, and assets are measured at the end of the period. The representative agent in the domestic small open economy has access to a foreign-currency-denominated bond (B^*),

[1] This role for monetary policy exists only if the government issues domestic-currency denominated long-term bonds.
[2] See Burnside, Eichenbaum and Rebelo (1998).

with a return of θ in foreign currency each period, a domestic government long-term bond (ρB), which pays one unit of domestic currency each period forever, and domestic currency (M). The time t price of the government perpetuity (ρ_t) is given by:

$$\rho_t = \frac{1}{1+i_t} + \left(\frac{1}{1+i_t}\right)\left(\frac{1}{1+i_{t+1}}\right) + \left(\frac{1}{1+i_t}\right)\left(\frac{1}{1+i_{t+1}}\right)\left(\frac{1}{1+i_{t+2}}\right) + ..., \qquad (1)$$

where i_t is the one-period nominal interest rate payable on assets held in period t. Equation (1) implies that the evolution of the bond price under perfect foresight is given by:

$$(1+i_t)\,\rho_t = 1 + \rho_{t+1}. \qquad (2)$$

The assumption that assets are perfect substitutes, together with purchasing power parity, yields an expression for the domestic interest rate:

$$(1+i_t) = (1+\theta)\,\frac{S_{t+1}}{S_t}, \qquad (3)$$

where S_t is the exchange rate and, equivalently, the domestic price level.[3] It is assumed that all domestic government bonds are held by domestic residents.[4]

Each period, the domestic agent receives a real endowment (y) and real government transfers (τ). Agents use the current value of their endowment plus transfers and interest, together with the stock of assets which they bring into the period, to purchase assets and to consume (c). The agent's budget constraint can be expressed as:

$$S_t B_t^* + \rho_t B_t + M_t + S_t c_t = S_t(1+\theta)B_{t-1}^* + (1+\rho_t)\,B_{t-1} + M_{t-1} + S_t\,(y_t + \tau_t)\,. \qquad (4)$$

[3] The foreign price level is implicitly normalized to unity.

[4] This assumption prevents the domestic government from collecting seigniorage revenue from ROW as a result of surprise inflation. In Section 4, the model is modified to allow a limited amount of uncertainty. Generalizing to a full-scale two country model, the results would hold qualitatively as long as domestic agents hold proportionately more domestic currency assets, i.e. exhibit home bias.

The agent is also assumed to satisfy a "no Ponzi game " (NPG) constraint, requiring[5]

$$\lim_{N\to\infty}\left(B_N^* + \frac{\rho_N B_N + M_N}{S_N}\right)\left(\frac{1}{1+\theta}\right)^N = 0. \tag{5}$$

The agent maximizes the present discounted value of utility, where utility contains consumption and real money balances,[6] subject to the budget constraint, equation (4), and the NPG constraint. The assumptions, that utility is logarithmic in consumption and real money balances[7] and that the discount rate equals the interest rate (θ), together, imply that consumption is constant at:

$$c_0 = \frac{\theta\gamma}{1+\theta}\left[(1+\theta)\,B_{-1}^* + \frac{M_{-1}}{S_0} + (1+\rho_0)\,\frac{B_{-1}}{S_0} + \sum_{t=0}^{\infty}(y_t+\tau_t)\left(\frac{1}{1+\theta}\right)^t\right]. \tag{6}$$

Equation (6) states that an agent's expenditures on consumption are proportional to the real value of the agent's resources. These include the value of initial financial wealth plus the present discounted value of endowment income and government transfers. Additionally, expenditures on money are proportional to consumption according to:[8]

$$\frac{i_0 M_0}{(1+i_0)\,S_0} = \frac{(1-\gamma)}{\gamma}c_0. \tag{7}$$

2.2 Government

Government expenditures include transfers to agents and interest on outstanding government bonds. Government bonds sold to domestic agents are assumed to be nominal perpetuities

5 The NPG constraint requires that the limit be non-negative. Additionally, an optimizing agent would not let the limit be positive.

6 The assumption that utility contains domestic real money balances and not foreign real money balances is meant to reflect the fact that most purchases are made using own currency.

7 The functional form is $\gamma \ln c_t + (1-\gamma)\ln\frac{M_t}{S_t}$. This assumption simplifies the analysis by making expenditure shares constant. However, the main results hold with a more general constant relative risk aversion specification.

8 To calculate this, note that $\frac{M_t}{S_t} - \frac{1}{1+\theta}\frac{M_t}{S_{t+1}} = \frac{M_t}{S_t}\frac{i_t}{1+i_t}$.

denominated in domestic currency. Government expenditures are financed by money growth, growth in bonds outstanding to the public, foreign exchange reserve loss, and interest on foreign exchange reserves. Foreign exchange reserves (F) are one-period, foreign-currency-denominated bonds, which pay an interest rate of θ. The government's budget constraint, in real terms, can be expressed as:

$$\tau_t + \frac{B_{t-1}}{S_t} = \frac{M_t - M_{t-1}}{S_t} + \frac{\rho_t (B_t - B_{t-1})}{S_t} - (F_t - F_{t-1}) + \theta F_{t-1}. \tag{8}$$

An equation for intertemporal government budget balance can be derived, by taking the present value of the government's point in time budget constraints and summing, to yield:

$$\begin{aligned} \sum_{t=0}^{\infty} \left[\frac{i_t}{1+i_t} \frac{M_t}{S_t} - \tau_t \right] \left(\frac{1}{1+\theta} \right)^t &= \frac{M_{-1} + (1+\rho_0) B_{-1}}{S_0} - (1+\theta) F_{-1} \\ &- \lim_{N \to \infty} \left(\frac{\rho_N B_N + M_N}{S_N} - F_N \right) \left(\frac{1}{1+\theta} \right)^N . \end{aligned} \tag{9}$$

This requires that the present value of government seigniorage revenue[9] $\left(\frac{i_t}{1+i_t}\frac{M_t}{S_t}\right)$ minus transfers, equivalently the present value of the primary surplus inclusive of seigniorage, equal the initial value of government debt, inclusive of interest, minus a limit term. We assume that government behavior assures that:

$$\lim_{N \to \infty} \left(\frac{\rho_N B_N + M_N}{S_N} - F_N \right) \left(\frac{1}{1+\theta} \right)^N \geq 0. \tag{10}$$

A negative limit would imply that the government is raising revenue which it never plans to spend. Since this appears unreasonable, this behavior is ruled out. However, we do not assume that government behavior rules out a positive limit, in which government spends more revenue than it raises. This is left for the market.[10]

[9] This can be viewed as the interest saved from issuing money instead of government debt.
[10] The full significance of this assumption will be clear by the end of section 2.3.

2.3 Country

The agent's budget constraint, equation (4), and the government's budget constraint, equation (8), can be aggregated to yield the country's budget constraint:

$$F_t + B_t^* = (1+\theta)\left(F_{t-1} + B_{t-1}^*\right) + y_t - c_t. \tag{11}$$

Equation (11) states that domestic net foreign assets $(F_t + B_t^*)$ increase as they earn interest and as endowment income plus interest income exceeds consumption expenditures. An expression for intertemporal current account balance can be derived by summing equation (11) forward and imposing

$$\lim_{N\to\infty} (F_N + B_N^*)\left(\frac{1}{1+\theta}\right)^N = 0. \tag{12}$$

Since consumption is constant, due to equality of interest and time preference, equation (11), together with the assumption of intertemporal current account balance (12), yield an alternative expression for consumption:

$$c_0 = \frac{\theta}{1+\theta}\left[(1+\theta)\left(F_{-1} + B_{-1}^*\right) + \sum_{t=0}^{\infty} y_t \left(\frac{1}{1+\theta}\right)^t\right]. \tag{13}$$

Equation (13) states that, under the assumption of intertemporal current account balance, consumption is proportional to the country's resources. These include the initial value of net foreign assets, inclusive of interest, plus the present value of the stream of future endowments.

It is necessary to justify the imposition of intertemporal current account balance. Consider a two-country world. If $\lim_{N\to\infty} (F_N + B_N^*)\left(\frac{1}{1+\theta}\right)^N \neq 0$, then intertemporal current account balance fails, implying that one country's agents are consuming more in present value terms than the present value of the country's resources. World goods market equilibrium implies that the sum of the two country limits must be zero, ruling out a non-zero limit term for the world, but not for a country. In a two-country world, goods market equilibrium implies that if one country has a positive limit, the other has an equal negative limit.[11]

We can make progress in justifying the zero limit term by combining this limit, given by equation (12), with the agent's NPG constraint, given by equation (5), to yield an equivalent limit condition:

$$\lim_{N\to\infty}\left(\frac{\rho_N B_N + M_N}{S_N} - F_N\right)\left(\frac{1}{1+\theta}\right)^N = 0. \tag{14}$$

This requires that the present value of government debt go to zero in the limit, or, equivalently, intertemporal government budget balance. Goods market equilibrium, therefore, requires that the sum of the limit terms for government debt be zero. If one country has a positive limit, the other must have an equal negative limit. Offsetting non-zero limits implies that the creditor country is raising government revenue from its own agents for the purpose of transferring resources to the debtor country. Equation (10) rules out this behavior.[12] Therefore, given that the agent satisfies his NPG constraint (equation 5), and that governments do not raise revenue which they do not plan to spend (equation 10), goods markets equilibrium requires intertemporal current account balance (equation 12), and intertemporal government budget balance, (equation 14).

[11] Sims (1994) uses goods market equilibrium in a closed economy to justify an analogous zero limit in a closed economy. Loyo (1998) and Dupor (1999) show that absence of intertemporal current account balance is a source of real indeterminacy.

[12] An alternative policy that would rule out intertemporal current account imbalance is the assumption that a government behaves to require the limit of the present value of its interest bearing debt to be zero, given monetary policy. With this policy, goods market equilibrium would require the present value of real money in each country sum to zero. Therefore, the limit on each government's present value debt must be zero.

In equilibrium, prices (here, the exchange rate and the price of long-term bonds) must adjust such that the goods market clears. Goods market equilibrium, together with government behavior, assure that the present value of government debt is zero in the limit. Hence, this is a "fiscal theory of the exchange rate," analogous to the "fiscal theory of the price level" (Leeper, 1991, Woodford 1994, 1995, Sims 1994). The theory could also be labeled a "current account theory of the exchange rate," since intertemporal government budget balance is equivalent to intertemporal current account balance. Requiring that prices equilibrate an agent's consumption from equation (6), with consumption necessary for intertemporal current account balance from equation (13), is identical to requiring that prices satisfy intertemporal government budget balance, equation (14).[13]

3 Equilibrium Exchange Rate Determination

The previous section established that intertemporal current account balance and, equivalently, intertemporal government budget balance, must hold when the goods market is in equilibrium. An equilibrium is defined as time paths for c_t, M_t, F_t, B_t, B_t^*, ρ_t, S_t, and i_t, given values for M_{-1}, F_{-1}, B_{-1}, B_{-1}^*, and time paths for τ_t and y_t, such that equations (6) and (13) for consumption are satisfied,[14] equation (7) for real money demand is satisfied,[15] equations (2) and (3) hold, and budget constraints, (4), (11), and (8), are satisfied.

[13] To prove this, use equation (9) to substitute for initial domestic real money and real bonds in equation (6). Substitute $\frac{i}{1+i}\frac{M}{S} = \frac{1-\gamma}{\gamma}c$ into the resulting equation and rearrange to express consumption as equation (13).

[14] This requires that the first order condition for consumption, together with the agent's NPG constraint and intertemporal current account balance (equivalently intertemporal government budget balance and goods market equlibrium) be satisfied.

[15] This requires the first order condition on money, money market equlibruim, and the agent's NPG constraint be satisfied.

Either the two expressions for consumption, equations (6) and (13), or the government's intertemporal budget constraint, equations (9) and (17), can be used to understand the fundamentals determining the collapse of fixed exchange rate regimes in equilibrium. Consider the two expressions for consumption, first. Given the specification of utility,[16] and assuming that agents satisfy their "no Ponzi game" constraint, consumption is given by equation (6). This states that consumption must be proportional to the real value of the *agent's* resources. These include the value of initial financial wealth plus the present value of endowments and government transfers. On the other hand, government behavior eliminating Ponzi games between governments, together with goods market equilibrium, implies that consumption is given by equation (13). This requires that consumption be proportional to the real value of the *country's* resources. These include the real value of initial net foreign assets plus the present value of endowments. These two expressions for consumption must be equal in equilibrium.

Consider the implications of the two consumption expressions for the current and future values of the exchange rate. The intertemporal current account expression for consumption, equation (13), contains only real variables, and, therefore, can be used to determine the equilibrium value of consumption, independent of nominal variables. Yet, equation (6) for consumption must also be satisfied. It contains nominal variables, particularly present and future values for the exchange rate. Current and future values for the exchange rate determine the agent's real value of wealth and therefore his consumption demand. The current

[16] Constant expenditure shares simplifies explicit solution, but the nature of the results should not change with more general utility.

exchange rate, S_0, directly determines the real value of nominal assets. Likewise, the price of long-term bonds, ρ_0, depends on future exchange rates. Therefore, in equilibrium, the sequence of exchange rates, which determine the initial value of the agent's wealth, must equate the expressions for consumption in equations (13) and (6). A fixed exchange rate system is viable in the long-run under two conditions. First, the exchange rate must not be expected to change, as reflected in the price of long-term bonds. Second, the pegged exchange rate, together with constant expected future interest rates, must yields consumption, from equation (6), equal to consumption required for intertemporal current account balance, equation (13). Hence, this provides a "current account theory" of the long-run viability of a pegged exchange rate.

Proponents of the "fiscal theory of the price level" emphasize equations (9) and (14) as determining nominal prices (in this model, S_0 and ρ_0) that yield intertemporal government budget balance (Leeper 1991, Sims 1994, Woodford 1994, 1995). Equilibrium is equivalently defined, substituting equations (9) and (14) in place of (6). Equations (9) and (14) require that the initial value of government debt equal the present value of future primary surpluses, inclusive of seigniorage revenue. Therefore, a fixed exchange rate system is viable in the long run if the exchange rate, as reflected in the price of long-term bonds, is not expected to change, and if the present value of primary surpluses, inclusive of seigniorage, equals the value of initial government debt at the pegged exchange rate. Hence, long-run exchange rate viability is crucially determined by fiscal policy, and this becomes a "fiscal theory" of the long-run viability of a pegged exchange rate.[17] It is shown below, that while fiscal policy determines long-run viability, monetary policy, defined as the composition of government debt, determines the timing and characteristics of the crisis.[18]

In summary, the exchange rate, equivalently the price level, determines the distribution of wealth between the private and government sectors. In equilibrium, the exchange rate is determined such that the private sector behaves in accordance with the country's intertemporal current account,[19] and the government sector behaves in accordance with intertemporal fiscal balance. In a certainty world, in which the price of long-term bonds is not expected to change and in which the pegged exchange rate is the equilibrium rate, there is no possibility of an exchange rate crisis. To introduce the possibility of a crisis, it is necessary to introduce shocks, which require an equilibrium redistribution of wealth between the private and public sectors. Such shocks change the present value of primary surpluses and cause equilibrium exchange rate crises.

[17] I thank two anonymous referees for pointing this out to me. There is one case in which fiscal policy might not be considered the cause of exchange rate crises. If the fiscal authority validates any price level by adjusting its primary surpluses to the existing value of government debt, then either monetary policy alone must determine prices (Leeper 1991) or prices become indeterminate (Sims 1994 and Woodford 1994). Cochrane argues strongly (1998a,b) that this case is not empirically revevant, and it is not explicitly considered here.

[18] Using a closed economy framework, Cochrane (1998 a,b) shows that the presence of long-term bonds is important in giving the government the ability to trade-off current and future inflation. In the absence of long-term, domestic-currency-denominated bonds, fiscal policy matters determines every aspect of an exchange rate crises.

[19] If the domestic country is either a net debtor or a net creditor in domestic-currency denominated assets, then exchange rate changes also transfer wealth between countries. This channel is omitted here to focus on the role of the exchange rate in transfering wealth between sectors within a country.

4 Exchange Rate Crises

In this section, we assume that level of government transfers (τ) is a random variable. Specifically, transfers evolve according to:

$$\tau_t = \tau_{t-1} + V(\Omega_{t-1}) + \Delta\tau_t.$$

This requires that transfers equal their value in the previous period, plus a deterministic feedback term $[V(\Omega_{t-1})]$, whereby the government can adjust current transfers in response to any variable contained in the set Ω_{t-1}, and a stochastic term $(\Delta\tau_t)$. The stochastic term has a mean of zero and a small probability of deviating from zero. Therefore, in the absence of government feedback $[V(\Omega_{t-1}) = 0]$, future transfers are expected to take on their current value, and any change in transfers is expected to be permanent. However, the feedback term does allow the government to offset current shocks in determining the future value of transfers.

Initially, the economy is assumed to be in an equilibrium in which no variable is expected to change. From the government's budget constraint, equation (8), this implies $\tau_0 + \frac{B_{-1}}{S} = \theta F_{-1}$. We consider alternative types of equilibria possible when τ increases by $\Delta\tau$ at time zero. We assume that policy, conditional on the change in transfers, is known. The characteristics of the exchange rate crisis, indeed, whether there is a crisis at all, depend on government policy. We analyze the case in which the fiscal authority chooses to let the increase in transfers be permanent, thereby increasing the present value of transfers. From equations (9) and (14), the current values for the exchange rate and the price of long-term bonds are no longer equilibrium values after a permanent increase in transfers. And there is no monetary policy which can restore equilibrium status to these variables at their current levels. Therefore, an increase in the present value of primary surpluses implies an inevitable exchange rate crisis. However, in the presence of long-term government bonds, monetary policy does determine the characteristics of the crisis, that is, its timing and the magnitude of the collapse-period depreciation.

The following sections describe exchange rate crises with characteristics, which differ because of alternative, known monetary policy responses to the time zero increase in transfers. In all cases, the time zero increase in transfers is assumed to be permanent. The only uncertainty in the economy is the small probability that there might be another change in transfers in the future, but the expected future change is zero. For the analysis, we assume no further change is realized. Since this particular form of uncertainty has no effect on the present value of resources available for consumption, the model exhibits certainty equivalence except for the price of long-term bonds. Under the assumption that the probability of a future change in transfers is small, the effect of uncertainty on long-term bond prices is negligible. In the interest of providing a model with closed form solutions, we ignore this negligible effect, and analyze a model which is characterized by perfect foresight after the initial sock. Consider, first, monetary policy which creates instantaneous collapse.

4.1 Instantaneous Collapse

The monetary authority can choose to terminate the exchange rate peg at the time of the policy disturbance. Assume that the monetary authority ends foreign exchange market intervention, and allows the change in transfers to be financed with growth of money and nominal government bonds at equal constant rates of η_0. This yields a post-collapse stationary equilibrium in which foreign exchange reserves are constant, post-collapse inflation and depreciation are constant at η_0, and the nominal interest rate is constant at $(1+\theta)(1+\eta_0)-1$. Therefore, the price of long-term bonds the instant after collapse is given by:

$$\rho_0^+ = \frac{1}{(1+\theta)(1+\eta_0)-1},$$

where a $(+)$ is used to denote the value of a price the instant after the shock.

The jump in the exchange rate can be calculated as the fall in the initial value of government debt necessary to match the increase in the present value of transfers.[20] This provides a private wealth reduction to offset the increase in present-value transfers and equivalently reduces the government's debt in accord with the reduction in the present value of primary surpluses, assuring goods market equilibrium. Using equations (9) and (14) together with the fact that expenditures on money $\left(\frac{i_t}{1+i_t}\frac{M_t}{S_t}\right)$ are constant in equilibrium, the exchange rate jump is given by:

$$\frac{S_0}{\bar{S}} = \frac{M_{-1} + \left(1+\rho_0^+\right) B_{-1}}{M_{-1} + (1+\rho_0) B_{-1} - \bar{S}\Delta\tau\left(\frac{1+\theta}{\theta}\right)}, \tag{15}$$

where $\bar{S}$ is the pegged exchange rate. Note that the higher is post-collapse inflation, the lower is the price of long-term bonds and the smaller the jump in the current exchange rate. Therefore, equation (15) is the constraint, which goods market equilibrium places on the monetary authority's choices of the magnitude of the current depreciation $\left(\frac{S_0}{\bar{S}}\right)$ and future inflation (η_0). If monetary policy chooses $\left(\frac{S_0}{\bar{S}}\right)$, then goods market equilibrium determines

[20]This requires using either equation (9), (7), and (13), or equations (6) and (13).

(η_0), and vice versa. The fact that monetary policy cannot determine both highlights the role of fiscal policy in causing the crisis.

Open market operations must support the choice such that an agent's expenditures on money are unchanged in the two equilibria (equations 7 and 13). This requires:

$$\frac{M_0}{S_0}\left[\frac{(1+\theta)(1+\eta_0)-1}{(1+\theta)(1+\eta_0)}\right]=\frac{M_{-1}}{\bar{S}}\left[\frac{\theta}{1+\theta}\right]. \tag{16}$$

Therefore, equations (15) and (16) place two constraints on three variables, $\frac{S_0}{\bar{S}}$, η_0, and M_0. At one extreme, a policy of no post-collapse inflation $(\eta_0 = 0)$ implies that open market operations set money at:

$$M_0 = M_{-1}\frac{S_0}{\bar{S}} = M_{-1}\left[\frac{\theta M_{-1}+(1+\theta)B_{-1}}{\theta M_{-1}+(1+\theta)\left(B_{-1}-\bar{S}\Delta\tau\right)}\right],$$

with the depreciation given by the term in brackets.[21]

Alternatively, equation (15) implies that a policy of no depreciation $\left(\frac{S_0}{\bar{S}}=1\right)$ requires that post-collapse inflation be given by:

$$\eta_0 = \frac{\theta\bar{S}\Delta\tau}{\left(B_{-1}-(1+\theta)\bar{S}\Delta\tau\right)},$$

With this value of η_0 and no exchange rate jump, equation (16) requires that open market operations set money at:

$$M_0 = M_{-1}\frac{B_{-1}-\bar{S}\Delta\tau}{B_{-1}}.$$

Note two characteristics of these results. First, equation (15) shows that the monetary authority can choose a policy in which there is no contemporaneous exchange rate depreciation, only if the value of its long-term bonds exceeds the present value of the increase in

[21] To compute this, use equation (15) with $\rho_0 = \rho_0^+ = \theta^{-1}$.

transfer payments, that is if

$$\rho_0 B_{-1} \geq \bar{S}\Delta\tau\frac{1+\theta}{\theta} \tag{17}$$

Otherwise, a fall in the value of long-term bonds (with $\rho_0^+ \geq 0$) cannot generate a wealth effect of sufficient magnitude. In the special case in which there are no long-term bonds, the jump in the current exchange rate must provide the full wealth effect. This is given by equation (15) with $B_{-1} = 0$, and monetary policy plays no role in determining its magnitude. This case is probably relevant for many small economies which have experienced crises, in which government debt is often short-term.[22] Second, note that with sufficient long-term government bonds, the fixed rate can collapse without permanent post-collapse monetary expansion and inflation. The instantaneous depreciation can provide the full wealth effect necessitated by the fiscal change.

To summarize, consider the characteristics of an exchange rate crisis, in response to an unexpected increase in the present value of government transfers, that arrives contemporaneously with the shock. Since the shock to transfers is a surprise, the exchange rate collapse is a surprise and is not preceded by a speculative attack. Yet, the crisis is caused by fundamentals. The monetary authority reacts to the increase in the expected present value of transfers by terminating foreign exchange market intervention, thereby ending the peg. A wealth effect of the appropriate magnitude, to maintain consumption at the level for goods market equilibrium and, equivalently, to reduce government debt in accord with

[22]In these small countries, government debt is also often denominated in foreign currency, making it useless for the small country's attempts to use monetary policy to determine the characteristics of the exchange rate collapse. Loyo (1998) considers exchange rate determination in a two country model in which countries can issue debt denominated in foreign currency.

the decrease in present value surpluses, is created with a combination of a current exchange rate depreciation and expected future depreciation. Open-market operations, and hence, monetary policy, determine the combination. The crisis occurs because the fiscal authority allows the shochastic shock to affect the expected present value of primary surpluses inclusive of seigniorage. The characteristics of the crisis, its timing and the magnitude of the depreciation, are determined by monetary policy.

4.2 Postponed collapse

If the government has a sufficient quantity of long-term bonds outstanding, then the monetary authority can choose to postpone exchange rate collapse by letting the price of long-term bonds fall to provide a wealth effect of the appropriate magnitude. The fall in the real value of bonds must equal the present value of new transfers. With no contemporaneous depreciation, the price of long-term bonds, the instant after the shock, is determined by equation (16) as:

$$\rho_0^+ = \left[\frac{B_{-1} - \bar{S}\Delta\tau\,(1+\theta)}{\theta B_{-1}} \right].$$

A necessary condition for postponed collapse to be an equilibrium is $\rho_0^+ \geq 0$.

Note that the fall in the price of long-term bonds implies a future increase in exchange rates, and, therefore, a future exchange rate crisis. Again, the characteristics of the crisis, both the timing and the magnitude of the depreciation, are determined by monetary policy. Since monetary policy, conditional on the increase in transfers, is known, and since both the expected and realized future increase in transfers is zero, the equilibrium path is a perfect foresight path.

To pin down the characteristics of the crisis, it is necessary to solve for the price of long term bonds in the period before collapse and in the period of collapse. Letting T denote the period of exchange rate collapse, and using the definition of ρ, given by equation (1), the price of long-term bonds after the policy change can also be expressed as:

$$\rho_0^+ = \frac{1}{\theta} + \left(\frac{1}{1+\theta}\right)^{T-1} \left(\rho_{T-1} - \frac{1}{\theta}\right).$$

Equating the two expressions for ρ_0^+, and solving for the bond price in the period prior to exchange rate collapse yields:

$$\rho_{T-1} = \frac{B_{-1} - \bar{S}\Delta\tau \left(1+\theta\right)^T}{\theta B_{-1}}. \tag{18}$$

Assuming that growth rates of money and exchange rates after the collapse are given by the constant η_T, equation (1), implies that the post-collapse price of long-term bonds is constant at:

$$\rho_T = \frac{1}{\left(1+\theta\right)\left(1+\eta_T\right) - 1} = \frac{1}{i_T}. \tag{19}$$

Using equations (2) and (3), the price of bond in periods T and $T-1$ is related by:

$$\left[\left(1+\theta\right)\frac{S_T}{\bar{S}}\right]\rho_{T-1} = 1 + \rho_T. \tag{20}$$

Combining (18), (19), and (20) yields an equation, imposed by goods market equilibrium, restricting the magnitude of depreciation $\left(\frac{S_T}{\bar{S}}\right)$ in the period of collapse, the post-collapse rate of depreciation $(1+\eta_T)$, and the time to collapse, T:

$$\frac{S_T}{\bar{S}}\left[\frac{B_{-1} - \bar{S}\Delta\tau\left(1+\theta\right)^T}{B_{-1}}\right] = \frac{\left(1+\eta_T\right)\theta}{\left(1+\theta\right)\left(1+\eta_T\right)-1} \quad \text{for } T \geq 1. \tag{21}$$

Note several implications of this equation. First, the time to collapse, T, cannot be too large since the price of long-term government bonds, given by equation (18), cannot fall below zero. Monetary policy can postpone collapse only if there exists a sufficient quantity of long-term bonds, such that, as government debt increases over the periods prior to collapse $(t < T)$, the price of long-term bonds can fall. This allows the real value of government debt to remain constant at the pegged exchange rate (from equation 9). Therefore, there is an upper limit on the time to collapse, and this is determined by the quantity of long-term government bonds. Foreign exchange reserves do not determine the upper bound on the time to collapse because the monetary authority can always sell its official holdings of government bonds to obtain additional reserves for pegging the rate.

Second, the longer collapse is postponed, the larger is post-collapse inflation for a given depreciation, and the larger is depreciation, for a given post-collapse inflation. This is necessary because the initial bond price $\left(\rho_0^+\right)$ is the discounted value of future nominal interest rates. The longer the increase in nominal interest rates is postponed, the larger the increase must be to generate a fall in time zero bond prices of the necessary magnitude.

Finally, note that the monetary authority can choose two of the three variables, subject to restrictions imposed by goods market equilibrium. Given these choices, market equilibrium, represented by equation (21), determines the third. Restrictions imposed by goods market equilibrium on monetary choices, (equation 21), are that T must not be too large, and that at least one of $\left(\frac{S_T}{S}\right)$ or $(1 + \eta_T)$ must be allowed to adjust.

Below, different assumptions about monetary policy are made to illustrate delayed crises with differing characteristics. The first two models use the quantity of foreign exchange reserves as determinants of collapse time, since such models are common in the literature. We also discuss models in which collapse timing is not due to reserves.

4.2.1 A Krugman model

To understand the effects of monetary policy on the characteristics of the crisis, it is useful to begin with an example familiar from the exchange rate collapse literature. Consider the Krugman (1979), Flood - Garber (1984) scenario (hereafter KFG), in which the government relentlessly issues domestic credit to finance a deficit. The rate of growth of domestic credit is an exogenous constant both before and after the collapse. Over the period in which the exchange rate remains fixed, the increase in domestic credit is offset one-for-one by a fall in foreign exchange reserves, such that the money supply is constant. Once foreign exchange reserves reach zero, the exchange rate pegging operation ceases. At the beginning of the collapse period, a speculative attack exhausts official reserves, and the authorities let the exchange rate float. The attack serves to reduce real money balances consistent with the post-collapse higher inflation rate. It is possible to specify monetary policy to yield *almost* all of these results using the model in this paper.

Assume that the monetary authority's rule for determining collapse time is the following. All new transfers are financed with foreign exchange reserves. Once foreign exchange reserves reach zero, foreign exchange market intervention stops, ending the peg. Consider money market equilibrium. From equations (7) and (13), expenditures on money must remain constant in every period. Therefore, money market equilibrium requires:

$$\frac{i_0}{1+i_0}\frac{M_0}{\bar{S}} = \frac{i_{T-1}}{1+i_{T-1}}\frac{M_{T-1}}{\bar{S}} = \frac{i_T}{1+i_T}\frac{M_T}{S_T}. \tag{22}$$

Flood and Garber (1984) define a shadow floating exchange rate, $\tilde{S}_t$, as the value of the equilibrium exchange rate, conditional on a reserve-exhausting speculative attack at time t. They assume that agents would attack in period t and exhaust the authorities' stock of foreign exchange reserves only if such an attack would not result in capital loss. That is, agents attack if and only if $\tilde{S}_t/\bar{S} \geq 1$.

To calculate $\tilde{S}_t$, is it necessary to calculate $\tilde{M}_t$, the money supply, conditional on a reserve depleting speculative attack at time t. Obstfeld (1986) showed that in a discrete time certainty model, there could be two speculative attacks. Therefore, a period of speculative attack is not uniquely identified with the period of exchange rate collapse. In Obstfeld, the second speculative attack depletes reserves and results in the collapse of the fixed exchange rate, as in KFG. The first attack occurs for the following reason. In equilibrium, the pre-collapse period interest rate is $1+\tilde{i}_{t-1} = (1+\theta)\frac{\tilde{S}_t}{\bar{S}}$. Therefore, when $\tilde{S}_t/\bar{S} > 1$, money market equilibrium in the period prior to collapse requires fewer real money balances. Agents reduce their real money balances in the pre-collapse period through a speculative attack, which reduces, but does not deplete, reserves. The two speculative attacks, imply that the money supply, conditional on a reserve depleting speculative attack in period t, is given by: $\tilde{M}_t = M_{-1} - \bar{S}\left(\delta_{t-1} + \delta_t\right)$.

To calculate reserve loss in the period prior to collapse, use the first equality in equation

(22), substituting $\tilde{i}_{t-1}$ for i_{T-1} to yield:

$$\delta_{t-1} = \frac{M_{-1}}{\bar{S}} \left(\frac{\left(\tilde{S}_t/\bar{S}\right) - 1}{(1+\theta)\left(\tilde{S}_t/\bar{S}\right) - 1} \right). \tag{23}$$

To calculate reserve loss in the period of collapse, recall that the authorities exhaust their foreign exchange reserves in the period of collapse by assumption. Therefore, $\delta_t = F_t$. It is necessary to calculate reserves in period t, conditional on a preliminary speculative attack in period $t-1$. Under the assumptions that the initial equilibrium is stationary equilibrium and that new transfers are financed with foreign exchange reserves prior to collapse, the government's budget constraint, equation (8), becomes a first order difference equation in foreign exchange reserves

$$F_t = F_{t-1}(1+\theta) - \theta F_{-1} - \Delta\tau. \tag{24}$$

In the absence of discrete reserve loss, due to a speculative attack, foreign exchange reserves are determined by the solution to this difference equation. Therefore, prior to the speculative attack, foreign exchange reserves at time $t-1$ are given by:

$$F_{t-1} = F_{-1} - \frac{\Delta\tau}{\theta}\left[(1+\theta)^t - 1\right]. \tag{25}$$

From equations (24) and (25), foreign exchange reserves, one period later, prior to the reserve-depleting time t speculative attack, are given by

$$F_t = F_{-1} - \frac{\Delta\tau}{\theta}\left[(1+\theta)^{t+1} - 1\right] - \delta_{t-1}(1+\theta) = \delta_t. \tag{26}$$

Therefore, reserve loss in the period of exchange rate collapse is given by equation (26).

Now, $\tilde{M}_t$ can be obtained by subtracting the domestic currency value of δ_t, given by equation (26), and δ_{t-1}, given by equation (23,) from M_{-1}. The shadow floating exchange rate yields money market equilibrium at $M_t = \tilde{M}_t$. Using equation (22) and the post-collapse interest rate $1 + \tilde{i}_t = (1+\theta)(1+\eta_t)$, the shadow floating exchange rate solves:

$$\left(\frac{\theta}{1+\theta}\right)\frac{M_{-1}}{\bar{S}} = \left[\frac{(1+\theta)(1+\eta_t)-1}{(1+\theta)(1+\eta_t)}\right]\left[\frac{M_{-1}-\bar{S}(\delta_{t-1}+\delta_t)}{\tilde{S}_t}\right]. \tag{27}$$

Expressing (27) in terms of the ratio of the shadow rate to the spot rate, and using equation (21) with $T = t$ to substitute for $\left[\frac{(1+\theta)(1+\eta_t)-1}{(1+\theta)(1+\eta_t)}\right]$, the shadow rate relative to the fixed rate becomes:

$$\left(\frac{\tilde{S}_t}{\bar{S}}\right)^2 = \left[\frac{B_{-1}-\bar{S}\Delta\tau(1+\theta)^t}{B_{-1}M_{-1}}\right]\left[\frac{\theta M_{-1}}{(1+\theta)\left(\tilde{S}_t/\bar{S}\right)-1} - \bar{S}F_{-1} + \frac{\bar{S}\Delta\tau}{\theta}\left((1+\theta)^{t+1}-1\right)\right] \tag{28}$$

The time for the collapse of the fixed exchange rate system, T, is the minimum t for which $\frac{\tilde{S}_t}{\bar{S}} \geq 1$. Given T, equations (28) and (21) with $T = t$, can be used to determine the jump in the exchange rate upon collapse $\left(S_T/\bar{S}\right)$, and the post-collapse rates of monetary growth and inflation (η_T).

Note that the jump in the exchange rate upon collapse must be small.[23] In particular, $S_T/\bar{S} - 1 < \eta_T$. This follows from equation (22). Since $M_{T-1} - \delta_T = M_T$, with $\delta_T > 0$, and $S_T/\bar{S} \geq 1$, then $\frac{M_{T-1}}{\bar{S}} > \frac{M_T}{S_T}$. Therefore, money market equilibrium, given by equation (22), implies $i_{T-1} < i_T$. Since $1 + i_{T-1} = (1+\theta)\frac{S_T}{\bar{S}}$,and $1 + i_T = (1+\theta)(1+\eta_T)$, then $S_T/\bar{S} < 1 + \eta_T$.

Therefore, the current model is consistent with the popular KFG story about exchange rate collapse if the post-collapse inflation rate is endogenized. In particular, post-collapse

[23]These results are similar to those in Obstfeld (1986) except that he does not have equation (21) and has an exogenous post-collapse inflation rate.

inflation must be higher the longer collapse is postponed. Note, however, that the story does not work at all if there are insufficient long-term government bonds. For the story to be consistent with equilibrium, the price of long-term government bonds in the period prior to collapse, given by equation (18), must be positive. In their absence, monetary policy plays no role, and instantaneous collapse, presented in the previous section, is the only equilibrium.

4.2.2 A KFG model modified to allow sterilization

The standard KFG story has been criticized because it does not allow governments to sterilize the effects of the speculative attack on the money supply. As emphasized by Flood and Marion (1996) and Flood, Garber, and Kramer (1996), central banks do sterilize the effects of exchange rate crises on their money supplies. Therefore, we modify the immediately preceding model of delayed collapse by assuming that the authorities sterilize the effects of a speculative attack one period later.

Consider money market equilibrium (equation 22). The money supply is constant until the period immediately preceding the collapse. In the period prior to exchange rate collapse, the interest rate is given by $1 + i_{T-1} = (1 + \theta) \frac{S_T}{\bar{S}}$. Therefore, for $S_T/\bar{S} > 1$, there will be a speculative attack in the period prior to exchange rate collapse to reduce the money supply to its pre-collapse-period equilibrium level. The assumption, that the effects of the speculative attack on the money supply are not sterilized within the period, implies that the money supply in the period prior to collapse is given by: $M_{T-1} = M_{-1} - \bar{S}\delta_{T-1}$, where $\bar{S}\delta_{T-1}$ is the magnitude of the speculative attack in that period. In period T, the authorities sterilize the effects of the speculative attack. In equilibrium, they do not have enough foreign exchange reserves to maintain the fixed rate in the face of another speculative attack, so they allow the exchange rate to increase. No additional foreign exchange reserves are lost, and money grows at the constant rate η_T, such that $M_T = M_{-1}(1+\eta_T)$, and $S_{T+1} = S_T(1+\eta_T)$. Using this, together with $\rho_T = i_T^{-1}$ and $i_{-1} = \theta$, and equating the first and last terms in equation (22) yields and expression for the collapse-period price of long-term bonds as:

$$\rho_T = \frac{\bar{S}}{\theta S_T}. \tag{29}$$

This implies that the price of long-term bonds is proportional to the collapse-period depreciation. Equation (29) can be used to relate the post-collapse rate of inflation to the collapse-period depreciation:[24]

$$\eta_T = \frac{\theta}{1+\theta}\left(\frac{S_T - \bar{S}}{\bar{S}}\right). \tag{30}$$

Note that the magnitudes of the collapse-period depreciation and the post-collapse rate of inflation are positively related. Additionally, equation (30) shows that exchange rate depreciation in the period of collapse is large relative to post-collapse inflation. In particular, $S_T/\bar{S} - 1$ necessarily exceeds η_T.

Reserve loss in the period prior to collapse is calculated exactly as in the preceding model. Using the first equality in equation (22) yields equation (23), where t should be understood as T, and $\tilde{S}_t$ as S_T. Comparative statics, using equation (23), reveal that the magnitude of the reserve loss, necessary to yield money market equilibrium in the period prior to collapse, is increasing in the expected rate of exchange rate change.

[24]To derive this recall that $1 + i_T = (1+\theta)(1+\eta_T)$.

Equations (18), (20), and (29), can be used to express collapse-period depreciation as a function of collapse time according to:

$$\frac{\bar{S}}{S_T} = \frac{-\theta + \sqrt{\theta^2 + 4\theta\left(1+\theta\right)\left(\frac{B_{-1} - \bar{S}\Delta\tau(1+\theta)^T}{\theta B_{-1}}\right)}}{2}. \tag{31}$$

Therefore, the magnitude of the collapse-period depreciation is increasing in the time to collapse. This is because depreciation of a given magnitude yields a smaller wealth effect the further in the future it occurs.

Consider determination of the time to collapse, T. Note that $S_T/\bar{S}$ is increasing in T, and that δ_{T-1} is increasing in $S_T/\bar{S}$. Therefore, the longer collapse is postponed, the larger is the pre-collapse-period speculative attack necessary to maintain money market equilibrium in the period prior to collapse. Additionally, from equation (25), foreign exchange reserves are falling in T. This implies that the collapse time can be computed by determining the last period, in which the government will retain adequate reserves, for the speculative attack to reduce the money supply to its lower equilibrium pre-collapse-period level. This yields the solution for $T-1$. Any earlier speculative attack which forced collapse next period would result in too little money for equilibrium in the pre-collapse-period. And an early speculative attack which was too small to force collapse, would yield too few money balances for equilibrium given that no exchange rate change would occur in the subsequent period. A later speculative attack would find insufficient reserves to reduce the money supply by the required equilibrium amount.

Consider the characteristics of this exchange rate crisis. The government begins a policy of domestic credit growth for the purpose of raising transfers. Fundamentals are on an unsustainable path, and sustained reserve loss is a symptom. To maintain consumption at its unchanged equilibrium level in the presence of higher present-value transfers, the price of long-term bonds must fall. This implies expected future exchange rate depreciation. Agents know the magnitude of reserves that the authorities will need to commit to maintain the exchange rate in the final period prior to the depreciation. They also know the rate at which the authorities are losing reserves. Therefore, they compute the time for the speculative attack as the last period in which the authorities will have the necessary reserves. In this period, interest rates rise in anticipation of next period's depreciation. Money demand falls, so agents mount a speculative attack to reduce money supply. Governments allow the speculative attack to reduce the money supply and increase interest rates in defense of the currency for one last period.[25] In the next period, the government knows it has insufficient reserves to withstand another speculative attack. And agents would attack again, if the government failed to allow a depreciation, because the expected exchange rate depreciation one period later is larger, requiring an additional fall in the money supply. Therefore, the government uses no more reserves and lets the exchange rate rise. Reserve losses due to last period's speculative attack are sterilized, bringing the interest rate down. The interest rate falls, but not to pre-collapse levels. Interest rates remain higher due to the increased post-collapse rate of exchange rate depreciation.

The story improves on original perfect foresight generation one models in describing the period of exchange rate crisis. Governments are expected to defend their currencies prior to

[25] If the government is unwilling to defend the currency in the period before the collapse, then in this rational expectations model, instantaneous collapse is the only equilibrium.

collapse by letting interest rates rise. Additionally, both the magnitude of the interest rate increase prior to the depreciation and the expected depreciation can be quite large, consistent with empirical evidence. The rate of depreciation in the collapse-period and the interest rate in the pre-collapse period both exceed their post-collapse counterparts. And governments are allowed to sterilize the effects of the speculative attack after the exchange rate floats, such that the money supply dips only in the period in which the government defends the peg with high interest rates. Additionally, the magnitude of depreciation is endogenously determined by the magnitude of the shock, the quantity of long-term government bonds, and the time to depreciation (equivalently reserve use).

4.2.3 Exogenous collapse timing

In the previous two models, monetary policy was specified to yield speculative attack and collapse of the fixed exchange rate regime, with the timing based on reserve exhaustion. However, there is nothing in the model which requires collapse time to be determined by reserves. In fact, if we had considered an exchange rate crisis due to an anticipated future shock, then there would be no reason for reserves to be falling in advance of the shock. And collapse could easily occur before the shock, consistent with equations (21). There is an upper bound on T, but this upper bound is determined by the quantity of long-term government bonds, not by the quantity of reserves.

Consider, briefly, cases in which collapse timing is not determined by reserves, but by exogenous known political events.[26] With rational expectations and full knowledge of all

[26] This could be something like election timing.

processes except the stochastic change in transfers, agents know monetary policy, conditional on the time zero increase in transfers, and therefore, they can compute the collapse time. For the case in which the monetary authority chooses to minimize depreciation in the period of collapse, a speculative attack in the period of collapse together with a smaller pre-collapse-period attack reduces the money supply to its post-collapse desired level with money growth determined by equation (21). For the case in which the monetary authority chooses to set post-collapse inflation equal to zero, equation (21) determines the collapse-period depreciation. A speculative attack one period prior to the collapse reduces real money balances to the level demanded, given the increase in nominal interest rates due to the expected depreciation.[27] Therefore, when collapse timing is not chosen using a foreign exchange reserve rule, there is no link between the timing of a speculative attack and the quantity of reserves, or between the quantity of reserves and the timing of exchange rate collapse.

It would also be possible to determine collapse time as an exogenous private sector decision to engage in speculative attack. Consider, first, the case in which the permanent increase in government transfers makes collapse inevitable. In a perfect foresight equilibrium, all agents know the collapse time, and the government is expected to cooperate in choosing post-collapse inflation and the magnitude of depreciation such that equation (21) is satisfied, given the private sector's choice of T.[28] The characteristics of the crisis depend on known monetary policy for combining depreciation with post-collapse inflation to satisfy equation (21), with T given, as described above. However, this is not a self-fulfilling

[27] Intermediate cases are possible.

[28] If the monetary authority were not expected to satisfy equation (21) at the known collapse time, then the only equilibrium would be instantaneous collapse.

crisis. The speculative attack determines only the timing of the exchange rate crisis. Its inevitability is determined by fiscal policy.

Consider, briefly, the case of self-fulfilling speculative attack and crisis. That is, the private sector chooses to mount a speculative attack, even when fiscal policy satisfies equations (9) and (14) at the pegged exchange rate and at a constant world interest rate. A monetary policy, designed to sterilize the effect of the speculative attack on the supply of money would leave equations and (9) and (14) unchanged, maintaining both the domestic price level and the interest rate at levels consistent with the pegged exchange rate. Therefore, a known commitment, by the monetary authority to sterilize an unnecessary speculative attack, could eliminate self-fulfilling crises.

5 Conclusion

This paper presents a fiscal theory of exchange rate crises. When the fiscal authority allows the present value of primary surpluses inclusive of seigniorage to differ from the current value of government debt at the pegged exchange rate and a constant expected future interest rate, then the pegged rate must collapse. The current exchange rate and expected future exchange rates, through the price of long-term government bonds, must equate the value of government debt to the present value of primary surpluses. In the absence of long-term government bonds, the exchange rate collapse must be instantaneous. In the presence of a sufficient quantity of long-term bonds, the collapse can be delayed at the discretion of the monetary authority. The paper shows that while fiscal policy is responsible for generating the crisis, monetary policy is responsible for its characteristics. These include the timing of the crisis and the magnitude of the collapse-period depreciation.

This theory implies that exchange rate collapse is due to fundamentals, and is therefore a "generation one" model of exchange rate collapse. However, the theory shifts the focus for the cause of collapse away from monetary policy toward fiscal policy. And it demonstrates that fundamentals-generated collapse need not occur following a sustained period of policy misalignment and reserve loss. It can occur instantaneously with the policy change, or can even anticipate the policy change. Therefore, a fundamentals-based model can explain exchange rate crises, which seem to take markets by surprise, as well as those which occur when the authority has a substantial quantity of reserves. Additionally, the model shows that monetary policy choice is important in determining the characteristics of a crisis, though not the crisis itself. Hence, the fiscal authority's choice to let a shock affect the present value of primary surpluses, together with monetary authority's choice about depreciation magnitude and timing, determine, respectively, the inevitability and the characteristics of an exchange rate crisis.

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