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Currency Crises and Contingent Liabilities*

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Abstract

A contingent liability is a commitment to finance a liability that will be realized in the future with some probability. Increasingly, international organizations emphasize the dangers of contingent liabilities when providing advice to their member governments. Why? One answer is obvious-if significant contingent liabilities are realized they commit governments to substantial fiscal costs. However, there is a further reason for this advice: by taking on a contingent liability the government can actually increase the probability with which the underlying economic event takes place. With a focus on the financial sector, this paper describes the process by which government guarantees can lead to increased economic fragility. It also discusses how a government's decisions regarding the financing of contingent liabilities affect its ability to control inflation and the value of local currency.

*The opinions expressed in this paper are the author's and not necessarily those of the World Bank.

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A contingent liability is a commitment to take on an actual liability if some economic event happens in the future. There are many examples of contingent liabilities that governments take on: social security, loan guarantees, commitments to provide commodities to the public at fixed prices, deposit insurance, and guarantees to the creditors of public sector enterprises. Increasingly, international organizations emphasize the dangers of contingent liabilities when providing advice to their member governments. Why are contingent liabilities dangerous? One answer is obvious—if significant contingent liabilities are realized the government can face substantial fiscal costs. And large fiscal costs can lead to crises if governments are ill-prepared to meet them. Furthermore, even when governments are willing to prepare themselves, they may face difficulty in doing so: the magnitude of a contingent liability may not be that well known in advance, and the timing of its realization may be relatively unpredictable.

But there is a more subtle reason for pointing out the dangers of contingent liabilities. By taking on a contingent liability the government can actually increase the probability with which the underlying economic event takes place. Some examples are helpful. As an example of a standard contingent liability, suppose a government provides free earthquake insurance. This creates a contingent liability, but the probability of the earthquake happening—a necessary condition for the government to bear a fiscal cost—is independent of the government's action. This is not to say that the government's decision does not affect other agents' choices, say with respect to locating themselves near fault lines in the Earth's crust. By its action, the government does provide an incentive for people to pay less attention to earthquake risk, and this does increase its expected payout in the event that an earthquake occurs. But the likelihood of an earthquake remains unchanged. As an example, of a nonstandard contingent liability, suppose that a government, fixing its exchange rate, issues the following guarantee to creditors of banks: "in the event that we abandon the fixed exchange rate, if banks fail we will honor their liabilities."[1] This not only changes the behavior of bank creditors (the recipients of the insurance) by making them less cautious in their lending. It also changes the behavior of banks. In this paper, I describe how banks' behavior, in the face of government guarantees, changes in such a way that the banking system becomes more fragile. Banks become more likely to take on exchange rate risk. Therefore, the government becomes more

[1] Mishkin (1996) and Obstfeld (1998) argue that a fixed exchange rate arrangement effectively is an implicit government guarantee of this kind. The role of the fixed exchange rate as a guarantee is also emphasized by Corsetti, Pesenti and Roubini (1999) and Dooley (2000).

likely to incur the fiscal cost associated with bank failures. And incurring this fiscal cost makes the probability of bank failures higher.

The second purpose of this paper is to highlight the economic consequences of government decisions regarding the financing of contingent liabilities. To pay for a contingent liability that has been realized, a government must use a combination of: (i) explicit fiscal reforms involving higher taxes net of spending, (ii) explicit default, (iii) printing more money, (iv) deflating the real value of local currency debt, (v) implicit fiscal reforms caused by movements in relative prices, or (vi) subsidized foreign lending.[2] These different ways of financing contingent liabilities have different consequences for the severity of a currency crisis associated with the realization of a contingent liability and for the amount of inflation that is observed in the post-crisis period.

The first section of the paper presents modified, and extended versions of the models in Burnside, Eichenbaum and Rebelo (2000, 2001a), to show how credible government guarantees to bank creditors can make a banking system more fragile. In particular, we will see that when governments issue guarantees, banks will not hedge against exchange rate risk.[3] This raises the spectre of self-fulfilling speculative attacks against a currency. If agents come to believe that the exchange rate regime will collapse, they will speculate against local currency–ultimately causing the central bank to float the exchange rate.[4] The central bank's decision to float, in turn, will lead to a depreciation of the currency–in anticipation of the government choosing to print money—which will ultimately lead to the failure of unhedged banks. These bank failures will, in turn, require the government to honor its bailout guarantee. When it does so by printing money, it rationalizes the speculative attack.[5] We will see that in equilibrium, a successful self-fulfilling speculative attack, in which the currency depreciates by a fixed amount, will be strictly more likely in an economy where the government has taken on a contingent liability associated with bank bailouts. This paradox,

[2] Jeanne and Zettlemeyer (2000) have argued that the subsidy value of official international lending in the wake of recent crises has been relatively small.

[3] The lack of hedging by banks plays a crucial role in several papers motivated by the Asian crisis, for example, Aghion, Bacchetta and Banerjee (2000), Chang and Velasco (1999, 2000), and Krugman (1999).

[4] The view that the behavior of speculators is important in currency crises has been emphasized by Obstfeld (1986a, 1996), Cole and Kehoe (1996), Sachs, Tornell and Velasco (1996), Radelet and Sachs (1998) and Chang and Velasco (1999).

[5] The fact that the money being printed is ultimately the cause of the currency crisis links our paper to the first-generation literature that emphasizes the role of monetary finance in currency crises. See, for example, Krugman (1979), Flood and Garber (1984), Obstfeld (1986b), Calvo (1987), Drazen and Helpman (1987), Wijnbergen (1991), Corsetti, Pesenti and Roubini (1999), Lahiri and Vegh (2000), and Burnside, Eichenbaum, and Rebelo (2001b,c).

that government guarantees make for less, not more, stability is consistent with empirical evidence in Demirgüç-Kunt and Detragiache (2000).

The second section of the paper modifies and extends the analysis in Burnside, Eichenbaum and Rebelo (2001b,c) to study the effects of government financing choices. A key conclusion that we will draw, is that the degree of inflation that arises out of a currency crisis will depend critically on whether tradable and nontradable prices move closely in step with one another. In a model with a single good, where purchasing power parity (PPP) holds, if the government simply prints money to finance a financial sector bailout, this will result in a great deal of inflation. On the other hand, we will see that if nontradable goods prices are sticky in the short-run, and if the government pursues some combinations of strategies (iii)-(v), listed above, the degree of post-crisis inflation can be quite modest. Importantly, following any of these strategies, which all involve raising seignorage-like revenue, requires that the government abandon a fixed or heavily managed exchange rate regime.

1. Guarantees and Fragility

Here we will consider a simple partial equilibrium model of a small open economy. There is a single good, no trade barriers, and purchasing power parity holds:

$$P_t = S_t P_t^*. \tag{1.1}$$

Here P_t and P_t^* denote the domestic and foreign price level respectively, while S_t denotes the exchange rate defined as units of domestic currency per unit of foreign currency. We let $P_t^* = 1$ for all t, for simplicity.

Our economy will consist of four types of agents: holders of domestic currency, foreign investors, domestic banks, and the government. There is no source of fundamental uncertainty in the model. That is, there are no technology shocks, no terms of trade shocks, etc. To highlight the role that government guarantees play in making the banking system more fragile, we allow for only one potential source of uncertainty: changes in agents beliefs.

1.1. Beliefs

In our analysis of a potential currency crisis at time t, we assume that a fixed exchange rate regime has been in effect for all periods $s < t$. That is, we assume that $S_s = S^I$ for $s < t$. As illustrated in Figure 1, we assume that holders of domestic currency coordinate on some i.i.d.

signal, Q_t, observed at the beginning of each period. The signal has the simple probability distribution

$$Q_t = \begin{cases} 0 & \text{with probability } 1-q \\ 1 & \text{with probability } q. \end{cases} \tag{1.2}$$

If $Q_t = 1$, agents anticipate that the exchange rate regime will be abandoned within the period, and that $S_{t+j} = S^D\gamma^j$, $j \geq 0$, for some $S^D \geq S^I$ and $\gamma \geq 1$. If $Q_t = 0$, agents anticipate that $S_t = S^I$. As Figure 1 illustrates, when $Q_t = 0$, agents also understand that the future path of the exchange rate will be determined by further shocks to agents' beliefs.

1.2. Timing Assumptions and the Central Bank's Threshold Rule

Here we describe our model's timing assumptions for a period, t, that begins under the fixed exchange rate regime. We suppose that there is a unit measure of identical holders of domestic currency that come into period t with M_{t-1} units of money. We assume that the following sequence of events takes place.

1. Agents coordinate their beliefs based on the signal, Q_t, as described above.

2. If agents want to adjust their money holdings in response to the signal, they go to the central bank window in order to do so.

3. Agents' requests to exchange local currency for foreign currency are honored simultaneously, continuously, and not in proportion to the size of the request, by the central bank at the fixed exchange rate S^I. If the central bank ever loses χ units of foreign currency, it floats the exchange rate, and closes its foreign exchange window permanently.[6] This can happen before all requests are honored.

4. The money and goods markets open simultaneously. Markets clear. Holders of domestic money determine their end-of-period money holdings, M_t.

1.3. Money Demand

We assume that agents hold money for liquidity services that are proportional to the value of transactions at time t, Y_tP_t. Money is also a store of value that earns a zero nominal return. Of course, agents who hold at least χ units of money at the end of time t also expect to make arbitrage profits of $\chi(1 - S^I/S^D)$ in the event that $Q_{t+1} = 0$. But, because of the nature of

[6] The assumption that the central bank uses a threshold rule is standard in the literature. See Krugman (1979) and Flood and Garber (1984). See Drazen and Helpman (1987), Wijnbergen (1991) and Burnside, Eichenbaum and Rebelo (2001c), for a discussion of alternative rules. Also see Rebelo and Végh (2001) for a discussion of optimally chosen rules for floating.

the central bank window, this part of the return to holding money is fixed, and does not vary in proportion to money holdings. Hence we assume it has no impact on end-of-period money demand. An alternative to holding money is lending in the world market at the real net rate of interest r. The difference between the variable real rates of return on these alternative stores of value is what we will call the nominal interest rate, n_t, defined as the sum of the real interest rate, r, and the expected inflation rate.

This discussion motivates our simplifying assumption that agents' end-of-period demand for money is given by the familiar Cagan (1956) function:

$$M_t = \theta Y_t P_t \exp(-\eta n_t), \tag{1.3}$$

where Y_t denotes real activity at time t, and η represents the semi-elasticity of money demand with respect to the interest rate. For simplicity we will assume that Y_t is some constant, Y.

In any period, t, in which the fixed exchange rate regime is still in place by the end of the period, the expected inflation rate between periods t and $t+1$ is

$$\frac{E_t P_{t+1} - P_t}{P_t} = (1-q) + q\frac{S^D}{S^I} - 1 = q\left(\frac{S^D}{S^I} - 1\right).$$

If the fixed exchange rate was abandoned at or prior to date t, then expected inflation between periods t and $t+1$ is given by

$$\frac{E_t P_{t+1} - P_t}{P_t} = \frac{\gamma^{t+1-T} S^D}{\gamma^{t-T} S^D} - 1 = \gamma - 1.$$

In general we will let T denote the date at which the fixed exchange rate regime is abandoned. Our previous results mean that agents anticipate

$$P_t = \begin{cases} S^I & \text{for } t < T \\ \gamma^{t-T} S^D & \text{for } t \geq T, \end{cases} \tag{1.4}$$

and

$$n_t = \begin{cases} r + q\left(S^D/S^I - 1\right) & \text{for } t < T \\ r + \gamma - 1 & \text{for } t \geq T. \end{cases} \tag{1.5}$$

Hence, under the fixed exchange rate regime, the demand for nominal money balances would be given by

$$M^I = \theta Y S^I \exp\left\{-\eta\left[r + q\left(\frac{S^D}{S^I} - 1\right)\right]\right\} \tag{1.6}$$

whereas, under the floating exchange rate regime, the demand for nominal balances will be

$$M_t = \theta Y \gamma^{t-T} S^D \exp[-\eta(r + \gamma - 1)]. \tag{1.7}$$

1.4. Money Supply

Under the fixed exchange rate regime the government must supply a constant quantity of money, $M_t^S = M^I$ for $t < Y$. Let $M^* = M^I - \chi S^I$ denote the quantity of money left in circulation if there is a successful speculative attack at time T. We assume that the government follows a constant money growth rule for $t \geq T$, such that $M_{T+j}^S = M^* \gamma^{j+1}$, $j \geq 0$.

1.5. The Banking Sector

In this subsection we directly borrow the banking model in Burnside, Eichenbaum and Rebelo (2000).[7] We assume that banks are perfectly competitive and finance themselves by borrowing foreign currency from foreign investors. Banks, in turn lend in local currency, and are therefore exposed to exchange rate risk. But we also allow banks to hedge exchange rate risk in frictionless forward markets. Therefore, if banks take on a currency mismatch it is because they are willing to do so.

Our main focus is on banks' portfolio decisions under the fixed exchange rate regime. We show that banks will fully hedge exchange rate risk when there are no government guarantees to foreign creditors. On the other hand, banks will not hedge when there are government guarantees.[8] In fact, in the presence of guarantees, banks prefer to declare bankruptcy and minimize their residual value in the event that the currency is floated.

We assume that banks are perfectly competitive and their actions are publicly observable.[9] We let L denote the number of dollars a bank borrows from foreign investors at the beginning of a period. The bank converts these dollars into local currency at the rate S^I, and lends the LS^I units of local currency to domestic agents at a fixed gross interest rate R^a.[10] To lend $S^I L$ units of local currency, the bank incurs a real transactions cost of δL.

[7] The model we present is similar to the models in Chari, Christiano and Eichenbaum (1996) and Edwards and Vegh (1997). Other models of the role of banks in currency crises include Akerlof and Romer (1993), Caballero and Krishnamurthy (1998), and Chang and Velasco (1999).

[8] Our results mirror those in Kareken and Wallace (1978) concerning the impact of deposit insurance on bank portfolios.

[9] We view our analysis as complementary to those of McKinnon and Pill (1996, 1998) and Chinn and Kletzer (2000). These authors study the role of banks in currency crises in models where information plays a key role

[10] In some crises banks did not literally have a currency mismatch in their portfolios because they made loans to local firms in dollars. See, for example Gavin and Hausmann (1996) who write about the Chilean banking crisis of 1982. See Burnside, Eichenbaum and Rebelo (2000a) for an extension of the model to the case where banks make loans in dollars but, as a result, face credit risk that is correlated with exchange rate risk.

Banks can hedge exchange rate risk by entering into forward contracts.[11] Let F denote the one-period forward exchange rate defined as units of local currency per dollar. We assume that the forward contracts are priced risk-neutrally in a frictionless market.[12] Under these assumptions, the forward rate, F, is

$$\frac{1}{F} = (1-q)\frac{1}{S^I} + q\frac{1}{S^D}. \tag{1.8}$$

This condition implies that the expected real payoff from purchasing a forward contract is zero.[13]

Let x denote the number of units of local currency the bank sells forward. Once S, the realized value of the exchange rate, is determined the value of the bank's gross assets is

$$V^R(L, x; S) = \frac{R^a S^I L}{S} - \delta L + x(\frac{1}{F} - \frac{1}{S}). \tag{1.9}$$

The expected value of the bank's gross assets is

$$V_e^R(L, x) = \frac{R^a S^I L}{F} - \delta L. \tag{1.10}$$

This means that the bank's optimal choice of x is determined by how it affects the bank's expected liabilities to its creditors.

We use $R^b(L, x)$ to denote a competitively determined schedule of rates at which banks borrow from foreign creditors. This schedule is determined by the fact that foreign creditors require an expected gross return from lending to local banks equal to the world interest rate, $R = 1 + r$. When $V^R(L, x; S) \geq R^b(L, x)$ it is optimal for a bank to repay its creditors because it can then distribute non-negative profits $\pi(L, x; S) = V^R(L, x; S) - R^b(L, x)$ to its shareholders. On the other hand, if $V^R(L, x; S) < R^b(L, x)$ it is optimal for the bank to default by declaring bankruptcy. In this case, the bank surrenders its gross assets and pays nothing to its shareholders. We suppose that bankruptcy reduces the value of the bank's gross assets by a cost ωL, with $\omega > 0$.

[11] See Albuquerque (1999) for a more general discussion of optimal hedging strategies.

[12] See Burnside, Eichenbaum and Rebelo (2001a) for evidence on the availability of hedge instruments in countries affected by recent crises.

[13] Note that since $P_t^* = 1$, this equation implies that the expected *real* return from a forward contract is zero. This avoids Siegel's (1972) paradox, which arises when the expected *nominal* return to forward contracts is assumed to be zero.

No Government Guarantees

We first analyze the case where the government does not issue guarantees to banks' creditors. In this case, when a bank declares bankruptcy its creditors recover its gross assets net of bankruptcy costs. Let

$$I(L,x;S)=\begin{cases}0 & \text{if } V^R(L,x;S)\geq R^b(L,x)\\ 1 & \text{if } V^R(L,x;S)<R^b(L,x).\end{cases}$$

A bank's expected liabilities are given by

$$C(L,x)=\sum_{s\in\{S^I,S^D\}}\Pr(S=s)\left\{\left[1-I(L,x;S)\right]R^b(L,x)L+I(L,x;S)V^R(L,x;S)\right\}. \quad (1.11)$$

But since creditors require an expected return of R, the borrowing rate schedule will be set according to

$$RL=\sum_{s\in\{S^I,S^D\}}\Pr(S=s)\left\{\left[1-I(L,x;S)\right]R^b(L,x)L+I(L,x;S)\left[V^R(L,x;S)-\omega L\right]\right\}.$$

Thus, a bank's expected liabilities are

$$C(L,x)=RL+\sum_{s\in\{S^I,S^D\}}\Pr(S=s)I(L,x;S)\omega L.$$

It follows immediately that a bank minimizes its expected liabilities and maximizes its expected profits by avoiding bankruptcy. The optimal strategy for banks is to fully hedge by setting $x=R^aS^IL$.[14] The competitively determined equilibrium interest rate must then be $R^a=(R+\delta)F/S^I$. Banks are able to borrow from foreign creditors at the world interest rate R.

Government Guarantees

Now we consider the case where the government guarantees foreign creditors against bank default in the devaluation state, $S=S^D$. In this case, foreign creditors are willing to lend to a bank that defaults only when $S=S^D$ at the world interest rate. If a bank fully hedges, its expected liabilities are $C(L,x)=RL$, as before. But if a bank is solvent when $S=S^I$ and defaults when $S=S^D$, (1.11) implies that the bank's expected liabilities are

$$C(L,x)=(1-q)RL+qV^R(L,x;S^D).$$

[14]Notice that by setting x equal to R^aS^IL, the value of the bank's gross assets are invariant to S: $V^R(L,R^aS^IL;S)=(R^aS^I/F-\delta)L$ for both values of S.

As long as $\omega < R$, it is optimal for banks to declare bankruptcy when $S = S^D$, by selling dollars forward. Given our assumptions about forward prices, banks must always be able to honor their forward contracts, so that $V^R(L, x; S^D) \geq \omega L$.[15] So the minimized value of $V^R(L, x; S^D) = \omega L$,

$$C(L, x) = [(1 - q)R + q\omega]L$$

and

$$R^a = \frac{F}{S^I}\left[(1 - q)R + q\omega + \delta\right].$$

1.6. The Government

We assume that under the fixed exchange rate regime the government has a constant real primary deficit given by d. We have already seen that during the fixed exchange rate regime, the government keeps the money supply constant at the level M^I. This prevents the government from raising seignorage. So, under the fixed exchange rate regime the government's flow budget constraint is

$$f_t = Rf_{t-1} - d, \tag{1.12}$$

where f_t is the government's net real asset position at the end of period t.[16] We assume that for $t < T$, $f_t = \bar{f} = d/(R - 1)$, so that the government's asset position is constant.

Now consider the possibility that there is a successful speculative attack against the currency at date T. Given our description of the speculative attack, this means that in its immediate aftermath, the government's net asset position is $Rf_{T-1} - \chi$.[17] We will let Γ denote the value of any contingent liabilities that the government realizes as a result of this event. Obviously, if the government does not issue guarantees to bank creditors, $\Gamma = 0$. On the other hand, when the government does issue guarantees, $\Gamma = RL$. For simplicity, we assume that the demand for loans is entirely driven by technology, not prices, so that L is invariant to the interest rate, R^a. We also assume that the government pays for its contingent liabilities in period T.

[15] If we did not impose this condition, then presumably there would be substantial defaults associated with forward contracts, and forward prices would vary significantly across firms. This does not appear to be the case in the real world where forward contracts are heavily collateralized. See Sercu and Uppal (1995), Chapter 4.

[16] Our analysis is a straightforward application of the classic work on the effects of monetary policy by Sargent and Wallace (1981). As in their basic models, for the moment we assume that money is the only government obligation denominated in units of local currency.

[17] Here we are assuming that the government receives all the interest on f_{T-1} and then loses χ dollars during the speculative attack.

Immediately after the attack, the money supply is M^*. By the end of period T it is $M^*\gamma$. So the government raises real revenue from seignorage equal to $(\gamma - 1)M^*/S^D$ in period T. Finally, given that we will allow for fiscal reforms that lower the fiscal deficit, we will let the primary deficit at time T be d_T. So the government's flow budget constraint during the period of the speculative attack ($t = T$) is:

$$f_T = Rf_{T-1} - \chi - \Gamma + (\gamma - 1)M^*/S^D - d_T \tag{1.13}$$

For $t > T$ the government raises seignorage revenues given by

$$\frac{M_t - M_{t-1}}{P_t} = \frac{M^*\gamma^{t-T+1} - M^*\gamma^{t-T}}{\gamma^{t-T}S^D} = (\gamma - 1)M^*/S^D.$$

Hence, it's flow budget constraint for $t > T$ is

$$f_t = Rf_{t-1} + (\gamma - 1)M^*/S^D - d_t. \tag{1.14}$$

If we iterate on (1.14) and combine it with (1.13), notice that

$$\chi + \Gamma = Rf_{T-1} + \frac{R}{R-1}(\gamma - 1)\frac{M^*}{S^D} - \sum_{j=0}^{\infty} R^{-j} d_{T+j}.$$

Noting that $f_{T-1} = \bar{f} = d/(R-1)$, we obtain the government's intertemporal budget constraint

$$\chi + \Gamma = \frac{R}{R-1}(\gamma - 1)\frac{M^*}{S^D} + \sum_{j=0}^{\infty} R^{-j}(d - d_{T+j}). \tag{1.15}$$

This equation simply states that seignorage revenues, plus the present value of the government's fiscal reforms, must equal the value of the government's contingent liabilities, Γ, plus the reserves lost during the speculative attack, χ.

1.7. A Sustainable Fixed Exchange Rate

It is obvious that there is always an equilibrium in which $q = 0$, i.e. agents simply never believe that the exchange rate regime is going to collapse. In this equilibrium, the government's contingent liabilities are irrelevant because they are contingent on a zero probability event. The government's level of debt remains constant at the level $\bar{f}$, forever. Given an arbitrary initial value for the exchange rate, S^I, the money supply remains constant at the level $M^I = \theta Y S^I e^{-\eta r}$, forever. The hedging behavior of banks is also irrelevant as there is no exchange rate risk.

1.8. Equilibria with Speculative Attacks

Equilibrium in our model is summarized by two conditions: the government satisfies its lifetime budget constraint and the money supply always equals money demand. We also require that agents beliefs be rational.

We treat the central bank's threshold rule as an exogenous parameter χ. Furthermore, we take the present value of any fiscal reforms, $\Delta \equiv \sum_{j=0}^{\infty} R^{-j}(d - d_{T+j})$, as a exogenous parameter. The key equilibrium conditions for the model are as follows. It follows that the government must then choose γ so that (1.15) is satisfied. Below, we will see that the equilibrium value of γ depends on whether or not the government has issued guarantees to bank creditors.

We have already imposed the condition that money supply should equal money demand under the fixed exchange rate regime—this is how the government keeps the exchange rate fixed at the level S^I. Later it will be convenient to have an expression for real balances, $m_t = M_t/P_t$, under the fixed exchange rate regime. Given (1.6), for $t < T$, $m_t = m^I$, where

$$m^I = \theta Y \exp\left\{-\eta\left[r + q\left(\frac{S^D}{S^I} - 1\right)\right]\right\}. \tag{1.16}$$

Next, we must impose the condition that money supply should equal money demand under the floating exchange rate regime. We have shown that for $t \geq T$ money demand is given by (1.7), while money supply is given by $M_t^S = \gamma^{t-T+1}M^* = \gamma^{t-T+1}(M^I - \chi S^I)$. Equating supply and demand we obtain

$$m^I = \chi + \frac{S^D}{S^I}\theta Y \exp[-\eta(r + \gamma - 1)]/\gamma. \tag{1.17}$$

If we equate the expressions for m^I, given in (1.16) and (1.17) we obtain the equilibrium condition:

$$\theta Y \exp\left\{-\eta\left[r + q\left(\frac{S^D}{S^I} - 1\right)\right]\right\} = \chi + \frac{S^D}{S^I}\theta Y \exp[-\eta(r + \gamma - 1)]/\gamma. \tag{1.18}$$

Given χ, and the value of γ that satisfies (1.15), it is clear that (1.18) determines either the size of the devaluation associated with the speculative attack, S^D/S^I, taking the probability of the speculative attack, q, as given, or vice versa. For rational speculative attacks to occur in equilibrium, we must verify whether both $0 < q < 1$ and $S^D/S^I > 1$ are consistent with our equilibrium conditions.

With Contingent Liabilities

To solve for the equilibrium value of γ, we first examine the case where the government has taken on a contingent liability by issuing a guarantee to bank creditors. This means that $\Gamma = RL > 0$. Given our previous analysis, (1.15) can be rewritten as

$$\chi + \Gamma - \Delta = \frac{R}{R-1}(\gamma - 1)\theta Y \exp[-\eta(r + \gamma - 1)]/\gamma. \tag{1.19}$$

As stated above, this equation determines the equilibrium money growth rate, γ, in terms of χ, the size of the contingent liability, Γ, and the size of the fiscal reform, Δ.

The right-hand side of this expression is the present value of seignorage revenue. In the appendix we show that seignorage is a continuous function of γ, and is maximized at

$$\bar{\gamma} = \frac{1}{2} + \frac{1}{2}\sqrt{1 + 4/\eta}.$$

Since seignorage is zero for $\gamma = 1$ and $\gamma = \infty$, two solutions to (1.19) exist if and only if

$$\frac{R}{R-1}(\bar{\gamma} - 1)\theta Y \exp[-\eta(r + \bar{\gamma} - 1)]/\bar{\gamma} > \chi + \Gamma - \Delta. \tag{1.20}$$

One solution is less than $\bar{\gamma}$, while the other is greater than $\bar{\gamma}$. We assume that the government chooses the smaller of these two values. This is equivalent to assuming that the government only operates on the upward sloping part of the seignorage Laffer curve.

Formally, we define a *speculative attack equilibrium with government guarantees* to be a pair (γ, q) that satisfies (1.18) and (1.19) given values of χ, $S^D/S^I > 1$, Γ, Δ and the other model parameters.

Equilibrium without Contingent Liabilities

When the government does not take on contingent liabilities this means that $\Gamma = 0$. The two necessary conditions become

$$\chi - \Delta = \frac{R}{R-1}(\gamma - 1)\theta Y \exp[-\eta(r + \gamma - 1)]/\gamma. \tag{1.21}$$

When there are two solutions to (1.21) we assume that the government always chooses the smaller of the two values of γ.

Formally, we define a *speculative attack equilibrium without government guarantees* to be a pair (γ, q) that satisfies (1.18) and (1.21) given values of χ, $S^D/S^I > 1$, Δ and the other model parameters.

The Effect of Contingent Liabilities on Equilibrium Outcomes

In this section we consider the impact of government guarantees on equilibrium. Our first result regards the effect of government guarantees on the inflation rate for the post speculative attack period, $t \geq T$.

Proposition 1. Consider two economies, one with government guarantees and the other without government guarantees. Assume that the economies share the same model parameters, and common values of χ, S^D/S^I and Δ. Conditional on *speculative attack equilibria* existing for both economies, the post-attack inflation rate in the economy with guarantees will be higher than the post-attack inflation rate in the economy without guarantees.
Proof: The result is fairly straightforward. Equations (1.19) and (1.21) pin down the post-attack inflation rates in the two economies. Holding χ and Δ constant, it is clear that the present value of seignorage must be higher in the economy with guarantees. Since we have assumed that the government only operates on the upward sloping part of the seignorage Laffer curve, the inflation rate in the economy with guarantees must be larger in order to raise more seignorage.■

Our next result concerns the probability with which speculative attacks occur in equilibrium.
Proposition 2. Consider two economies, one with government guarantees, the other without. Assume that the economies share the same model parameters, and common values of χ, S^D/S^I and Δ. Conditional on *speculative attack equilibria* existing for both economies, a speculative attack is more likely in the economy with guarantees.
Proof: Let (q_g, γ_g) and (q_n, γ_n) be the equilibrium values of q and γ in the economies with and without guarantees. We know, from Proposition 1, that $\gamma_g > \gamma_n$. Now solve (1.18) for the probability of a speculative attack by rearranging it:

$$q = -\left(r + \eta^{-1} \ln \left\{ \frac{\chi}{\theta Y} + \frac{S^D}{S^I} \exp[-\eta(r+\gamma-1)]/\gamma \right\}\right) / \left(\frac{S^D}{S^I} - 1\right) \tag{1.22}$$

Notice that

$$\frac{\partial q}{\partial \gamma} = \frac{(1+\eta\gamma)\frac{S^D}{S^I}\exp[-\eta(r+\gamma-1)]}{\eta\gamma\left\{\gamma\frac{\chi}{\theta Y} + \frac{S^D}{S^I}\exp[-\eta(r+\gamma-1)]\right\}\left(\frac{S^D}{S^I} - 1\right)} > 0.$$

Since $\gamma_g > \gamma_n$ this implies that $q_g > q_n$.■

Propositions 1 and 2 provide our main message from this section of the paper. Here we have shown that conditional on a crisis of a given magnitude, in terms of the jump in the exchange rate at the time of the crisis, S^D/S^I, in an economy with guarantees, long-term inflation will be higher than in an economy without guarantees. Second, we have shown that crises of a given magnitude are strictly more likely in economies with guarantees than they are in economies where the government has not taken on a contingent liability to bank creditors.

2. How Does Financing Affect Speculative Attacks?

In this section, we consider variants of the model presented in the previous section. Our first step will be to consider a numerical example of our model in which there are government guarantees to bank creditors. Given calibrated values of the model parameters, we will determine the implied equilibrium values of γ and q. Then we will extend our analysis by considering variants of the model in which we explicitly allow for the possibility that the government issues nominal debt. We will also consider examples in which we abstract from PPP.

2.1. A Benchmark Example

Here we construct a numerical example of the model outlined in the previous section. We must set values for several of the model's parameters—in particular we must choose values for any parameters appearing in equations (1.18) and (1.19). First, we will normalize $Y = 1$ and $S^I = 1$. We set $\theta = 0.1$, implying that real balances will represent less than 10 percent of GDP in equilibrium—a typical value for the ratio of the monetary base to GDP in middle income countries. We set $\eta = 0.6$, a value consistent with the range of estimates of money demand elasticities in developing countries provided by Easterly, Mauro and Schmidt-Hebbel (1985). We set the world real interest rate, r, to 5 percent.

The remaining parameters are χ, Γ, Δ, and S^D. To calibrate χ we would need to decide how many of its reserves a country is typically willing to lose before it floats a fixed exchange rate. One way to do this would be to look at the quantity of reserves lost in recent crises. Since data on reserves are frequently misleading due to reporting errors, an alternative would be look at the typical decline in nominal money balances immediately prior to observed speculative attacks. One thing to note is that we must set χ to be a sufficiently small value such that the equilibrium level of real balances under the fixed exchange rate, m^I, is greater than χ. If we do not do this, the supply of domestic money will be exhausted. For simplicity we use $\chi = 0.005$ in our simulations. This choice will imply an approximately 5 percent reduction in nominal balances immediately prior to the speculative attack. We let $\Gamma = 0.2$, or 20 percent of GDP. Several recent banking crises are estimated to have resulted in costs of roughly this magnitude.[18] Initially we let $\Delta = 0$.

Finally, we let S^D/S^I be variable. We compute the equilibrium value of q for several different values of S^D/S^I, as illustrated in Figure 2. The figure shows that self-fulfilling speculative attacks are possible over a fairly narrow range of values for S^D/S^I. We also see that q is a decreasing function of S^D/S^I. There are two reasons for this. First, holding S^I fixed, the higher is S^D/S^I, the higher expected inflation is in the pre-attack world, and therefore, the lower the demand for nominal balances in the pre-attack world. Second, holding S^I fixed, the higher S^D/S^I is, the higher S^D is, which raises the demand for nominal balances in the post-attack world. Both of these effects make the jump in nominal money demand at the time of the attack smaller in magnitude. But the jump in money demand has to be χS^I which is fixed. Therefore, q must fall by enough to actually raise the demand for nominal balances in the pre-attack world.

The largest devaluation that can occur in equilibrium can be found by taking the limit as $q \to 0$. From (1.22) we see that this is

$$\left(\frac{S^D}{S^I}\right)_{\max} = \frac{\theta Y \exp(-\eta r) - \chi}{\theta Y \exp[-\eta(r+\gamma-1)]/\gamma} = \frac{\theta Y \exp(-\eta r) - \chi}{\theta Y \exp[-\eta(r+\gamma-1)]/\gamma} \tag{2.1}$$

Given our parameter values, the equilibrium value of $\gamma \approx 1.12$, so that the post-attack inflation rate is 12 percent. This implies $\left(S^D/S^I\right)_{\max} \approx 1.144$.

Given the parameter values above, speculative attacks cannot occur in equilibrium in the absence of government guarantees. The reason for this is that given our parameter values the left hand side of (1.21) is quite small. Therefore, the post-attack inflation rate, γ, does cause a sufficient decline in money demand to be consistent with the drop in money demand that is required in equilibrium at the time of the speculative attack.

How do fiscal reforms affect the equilibrium outcomes? As the fiscal reform, Δ, becomes larger, γ becomes smaller—less seignorage revenue is required to finance the banking sector bailout. But, as we saw above $\partial q/\partial \gamma > 0$, implying that $\partial q/\partial \Delta < 0$. Thus, fiscal reforms

[18] For a variety of estimates of the costs of banking crises over the past 20 years see Caprio and Klingebiel (1996) and Frydl (1999).

lower the probability of a speculative attack associated with a specific amount depreciation of the currency, S^D/S^I. In our experiments we found that fiscal reforms of close to three-quarters of the fiscal cost of the bailout, eliminate the possibility of speculative attacks in equilibrium.

2.2. Extending the Model

Our results in the previous section indicate that a significant amount of inflation would result from a speculative attack. In the period of the attack, inflation would be somewhere between 8 and 15 percent, and in the long-run there would an increase of inflation to about 12 percent. Furthermore, in equilibrium, after a small decline in the money supply during the speculative attack, money growth after the attack is also about 12 percent.

After the recent Asian crises, domestic prices rose slowly. However, there were substantial depreciations of the local currencies. Also, there was no immediate acceleration in money growth. This suggests at least two shortcomings of our analysis: (i) our assumption of PPP is counterfactual, and (ii) we put too much emphasis on seignorage revenue as a method of financing the costs of a banking sector bailout.[19]

In this section we extend the framework outlined above to address these shortcomings. Our first step is to introduce nonindexed government liabilities. If there is a significant stock of outstanding government liabilities at the time of a speculative attack, these obligations will diminish in value, providing a source of revenue to the government.[20] Our second step is to eliminate the assumption of PPP. This will allow for deviations between the behavior of the aggregate price index and the exchange rate in the aftermath of a speculative attack.

Nonindexed Government Liabilities

Here we extend the model by introducing domestic bonds, B, issued under the fixed exchange rate regime. In particular, we assume that under the fixed exchange rate regime the government issues 1-period bonds that pay $N_t = 1 + n_t$ units of local currency at the end of period $t + 1$. Given risk neutral investors, the local currency price of one of these bonds, at time t, is 1 unit of local currency.

[19] See Burnside, Eichenbaum and Rebelo (2001b,c) for discussions of relevant facts about the Asian crisis. We should point out that we do not think of the model in this paper as a model of the Asian crisis, per se.

[20] By assuming that there is a stock of nominal debt, our analysis becomes consistent with work on the fiscal theory by Cochrane (2000), Sims (1994) and Woodford (1995). Applications to open economy models include Corsetti and Mackowiak (2000), Daniel (2000) and Dupor (2000).

Let B_t be the end-of-period t stock of these nominal bonds. We will assume that the government net asset position at the end of period t is given by $f_t = -b_t - B_t/S_t$, where b_t is government net dollar-denominated debt.

From (1.5) we have

$$N_{t-1} = N^I = 1 + r + q\left(S^D/S^I - 1\right)$$

for $t \leq T$. Hence, for $t < T$, the government's flow budget constraint is

$$b_t + B_t/S^I = Rb_{t-1} + N^I B_{t-1}/S^I + d. \tag{2.2}$$

We assume that for all $t < T$, $b_t = \bar{b}$ and $B_t = \bar{B}$, so that

$$d = -(R-1)\bar{b} - \left(N^I - 1\right)\bar{B}/S^I. \tag{2.3}$$

We assume that for $t \geq T$, the government issues only real debt. This is an innocuous assumption in that for $t \geq T$, there is no remaining uncertainty. The government's flow budget constraint for $t = T$ is given by

$$b_T = R\bar{b} + \frac{N^I \bar{B}}{S^D} + \chi + \Gamma - (\gamma - 1)\frac{M^*}{S^D} + d_T. \tag{2.4}$$

For $t > T$ the government's budget constraint, as before, is

$$b_t = Rb_{t-1} - (\gamma - 1)M^*/S^D + d_t. \tag{2.5}$$

If we iterate on (2.5) and combine it with (2.4) we get

$$R\bar{b} + \frac{N^I \bar{B}}{S^D} + \chi + \Gamma = \frac{R}{R-1}(\gamma - 1)\frac{M^*}{S^D} - \sum_{j=0}^{\infty} R^{-j} d_{T+j}$$

Letting $\Delta = \sum_{j=0}^{\infty} R^{-j}(d - d_{T+j})$, as before, using (2.3), and substituting in the expression this can be rewritten as

$$\chi + \Gamma - \Delta = \frac{R}{R-1}(\gamma - 1)\theta Y \exp[-\eta(r + \gamma - 1)]/\gamma + \left(\frac{R}{R-1}\frac{N^I - 1}{N^I}\frac{S^D}{S^I} - 1\right)\frac{N^I \bar{B}}{S^D}. \tag{2.6}$$

Given that $N^I > R$, and $S^D > S^I$, the last term, which represents net revenue from the deflation of nominal debt, is strictly positive.

To examine the impact of nominal debt on equilibrium outcomes, we leave our parameters other than $\bar{B}$ unchanged. Using (1.18) and (2.6), and given a value of q, we compute the equilibrium values of S^D/S^I and γ for the case where $\bar{B} = 0$—this is our benchmark case.

Then we compute the equilibrium values of S^D/S^I and γ for the case where $\bar{B} > 0.3$, or 30 percent of GDP.

Our results are summarized in Figure 3. In equilibria where the probability of a speculative attack against the currency is small (less than 10 percent), the deflation of nominal debt brings in between 3 and 6 percent of GDP. Compared to the model without nominal debt, inflation is considerably lower, both in the period of the attack, and in subsequent periods. In low probability attacks, S^D/S^I is lower by about 5 to 6 percentage points, while steady state inflation, γ, is lower by between 2 and 4 percentage points. Most (between 65 and 80 percent) of the government's new revenue still comes from seignorage and, of course, we still have the problem that purchasing power parity holds.

Our example is only valid for the case where there is one period debt. In Burnside, Eichenbaum and Rebelo (2001a) we examine a different model, and consider the case where pre-existing nominal debt is in the form of nominal consols. In this case, debt deflation can be an more significant source of revenue to the government, because it lasts for more than one period. Obviously, here, we could get more bang-for-the-buck if we had multi-period debt.

Deviations from Purchasing Power Parity

So far we have only considered models in which PPP holds. Here we will consider deviations from PPP. To do this we will introduce nontraded goods into the analysis. This will have 3 effects which we will analyze incrementally. First, we will assume that nontraded goods prices do not respond immediately to any movement in the exchange rate. In other words, in period T we will assume that nontraded goods prices remain at their pre-crisis levels. On the other hand, for $t > T$ we will assume that nontraded goods prices increase at the same rate as traded goods prices. This, in and of itself, will allow us to capture deviations between movements in local prices and the exchange rate. Second, we will allow for implicit fiscal reforms that occur when the government has spending commitments that are not denominated in dollars, but are commitments to quantities of tradable and nontradable goods. Third, we will introduce distribution costs for tradable goods.

Nontradable Goods

In the presence of nontradable goods we let the consumer price index (CPI)—the relevant price index for money demand—be given by:

$$P_t = (P_t^T)^\omega (P_t^N)^{1-\omega}, \tag{2.7}$$

where P_t^N is the price of nontradable goods, P_t^T is the price of tradable goods and $0 < \omega < 1$. We initially maintain the assumption of PPP for tradable goods, so that $P_t^T = S_t$ for all t. We assume that under the fixed exchange rate regime $P_t = P_t^N = P_t^T = S^I$. Furthermore, we assume that $P_T^N = S^I$, that is, nontradable goods prices do not rise in the period in which the speculative attack takes place. For $t > T$, we assume that all prices share the common inflation rate, γ.

To consider the effect of these assumptions on our model we modify the analysis of the previous section. First, we must modify the formulas for nominal interest rates to account for the new definition of P_t. Under the fixed exchange rate regime, the price level is given by $P_t = S^I$. Thus, there is probability $1 - q$ that the price level will remain at that level in the next period, i.e. $P_{t+1} = S^I$. On the other hand, there is a probability q that tradables prices will jump to S^D, while nontradables prices will remain at the level S^I for one more period, implying $P_{t+1} = (S^D)^\omega (S^I)^{1-\omega} = (S^D/S^I)^\omega S^I$. So expected inflation for $t < T$ is

$$\frac{E_t P_{t+1} - P_t}{P_t} = (1-q) + q(S^D/S^I)^\omega - 1 = q[(S^D/S^I)^\omega - 1].$$

As before, expected inflation for $t \geq T$, is simply given by γ.

So

$$P_t = \begin{cases} S^I & \text{for } t < T \\ \gamma^{t-T}(S^D/S^I)^\omega S^I & \text{for } t \geq T, \end{cases} \tag{2.8}$$

and

$$n_t = \begin{cases} r + q[(S^D/S^I)^\omega - 1] & \text{for } t < T \\ r + \gamma - 1 & \text{for } t \geq T. \end{cases} \tag{2.9}$$

Under the fixed exchange rate regime, the demand for money balances would be given by

$$M^I = \theta Y S^I \exp\left(-\eta\left\{r + q[(S^D/S^I)^\omega - 1]\right\}\right) \tag{2.10}$$

whereas, under the floating exchange rate regime, the demand for nominal balances is

$$M_t = \theta Y \gamma^{t-T}(S^D/S^I)^\omega S^I \exp[-\eta(r + \gamma - 1)]. \tag{2.11}$$

We still have the money supply rule $M_t^S = \gamma^{t-T+1}(M^I - \chi S^I)$. Combining this with (2.10) and (2.11) we get a modified version of the equilibrium condition (1.18):

$$\theta Y \exp\left(-\eta\left\{r + q[(S^D/S^I)^\omega - 1]\right\}\right) = \chi + \theta Y (S^D/S^I)^\omega \exp[-\eta(r+\gamma-1)]/\gamma. \tag{2.12}$$

For the government budget constraint, where we do our accounting in dollars, we now obtain

$$\begin{aligned}\chi + \Gamma - \Delta \quad = \quad & \frac{R}{R-1}(\gamma-1)\theta Y \left(\frac{S^D}{S^I}\right)^{\omega-1} \exp[-\eta(r+\gamma-1)]/\gamma + \\ & \left(\frac{R}{R-1}\frac{N^I-1}{N^I}\frac{S^D}{S^I} - 1\right)\frac{N^I \bar{B}}{S^D}.\end{aligned} \tag{2.13}$$

where $N^I = 1 + r + q[(S^D/S^I)^\omega - 1]$. We assume that movements in the real exchange rate have no implicit impact on the government's dollar budget deficit, d_t.

To see the impact of these changes we repeat the analysis of the previous section with $\bar{B} = 0.3$ and set $\omega = 0.5$. We find that accounting for nontradable goods in this way has a significant impact one aspect of the equilibrium, as illustrated in Figure 4. For small probability speculative attacks, the amount of currency depreciation during the speculative attack is higher by about 10 percentage points, while there is almost no impact on the inflation rate. Both the immediate inflation rate and the steady state inflation rate fall by small amounts. For small probability speculative attack equilibria, the amount of revenue raised via seignorage declines to between 13 and 15 percent of GDP, as compared to between 14 and 17 percent of GDP with PPP holding, and over 20 percent of GDP, in the absence of nominal debt.

So, overall there is little change in the amount of inflation induced by the currency crisis. On the other hand, there is now a large wedge between inflation and depreciation in the year of the crisis. We have simplified the analysis by assuming that this wedge only lasts for one year. Of course, we could have considered other examples in which prices were sticky for longer than a year.

Implicit Fiscal Reforms

Suppose that under the fixed exchange rate, the government's real primary deficit, d, is the result of the following spending and revenue operations by the government.

1. Spending on tradable and nontradable goods denoted by $P_t^T x_t^T$ and $P_t^N x_t^N$, respectively.

2. Taxation of economic activity yields revenues equal to $P_t^T \tau_t^T$ and $P_t^N \tau_t^N$, respectively, from tradables and nontradables. Here we can think of τ_t^T as being the product of a tax rate on tradables activity times tradables activity.

Suppose that $x_t^T = x^T$, $x_t^N = x^N$, $\tau_t^T = \tau^T$ and $\tau_t^N = \tau^N$ for all t, so that in the fixed exchange rate regime, the dollar value of the government's primary deficit is

$$d = x^T + x^N - \tau^T - \tau^N.$$

Now consider d_t for $t \geq T$. Notice that it will be given by

$$d_t = x^T + \frac{P_t^N}{S_t} x^N - \tau^T - \frac{P_t^N}{S_t} \tau^N = d + \left(\frac{P_t^N}{S_t} - 1 \right) (x^N - \tau^N).$$

If the government's initial spending on nontradables is greater than its revenue derived from taxing them, then because of deviations from PPP, the government will benefit from an implicit fiscal reform: d_t will be lower than d as long as $P_t^N < S_t$.

In order to measure the impact of implicit fiscal reforms on our equilibrium, we do not need to change (2.12) from the previous section. We need to change (2.13) by noting that Δ no longer represents explicit fiscal reforms. In fact, we will assume that there are no explicit fiscal reforms, and that

$$\Delta = \sum_{j=0}^{\infty} R^{-j} \left(1 - \frac{P_t^N}{S_t} \right) (x^N - \tau^N) \tag{2.14}$$

Given that $P_t^N = S^I \gamma^{t-T}$ and $S_t = S^D \gamma^{t-T}$ for $t \geq T$, this means $\Delta = \left(1 - S^I/S^D\right)(x^N - \tau^N)R/(R-1)$.

We illustrate the effects of this modification to our model by assuming that $x^N - \tau^N = 0.02$; that is, the government's spending on nontradables exceeds its revenue from nontradables by 2 percent of GDP. We maintain the assumptions of the previous subsection regarding the rest of the model's parameters. The computed equilibria are illustrated in Figure 5. The results are quite striking. In the period of the speculative attack, for equilibria with low probabilities of a speculative attack ($q \leq 0.1$), inflation is now about 5 percent and in the steady state it is between 6 and 7 percent, as opposed to about 10 percent in both cases for our previous example. On the other hand, we now have less depreciation of the exchange rate during the speculative attack than before, at about between 9 and 12 percent as opposed to around 15 to 20 percent in the previous example. Still, there is still substantially more depreciation than inflation.

We also see that there is a significant reduction in the importance of seignorage. It now accounts for new revenues of about 11 to 12 percent of GDP. Debt deflation becomes somewhat less important, accounting for between 4 and 6 percent of GDP, and implicit fiscal reforms make up the rest of the new revenue at around 4 to 5 percent of GDP.

Distribution Costs

We can induce a larger wedge between inflation and depreciation if we allow the local retail price of a tradable good to deviate from the price implied by PPP. One way to do this is to introduce distribution costs in the tradable goods sector, as in Burstein, Neves and Rebelo (2000). We assume that δ units of nontradables are required to distribute tradable goods. As in their paper we assume that PPP holds for the import prices but not for the retail prices of tradable goods. This assumption implies that $P_t^T = S_t + \delta P_t^N$, and that the CPI is given by:

$$P_t = (S_t + \delta P_t^N)^{\omega} (P_t^N)^{1-\omega}.$$

As in previous sections, we continue to assume that $P_t^N = S^I \gamma^{t-T}$ for $t \geq T$. We must modify both of our equilibrium conditions to take account of this change to the model.

Under the fixed exchange rate regime, the price level is given by $P_t = S^I (1+\delta)^{\omega}$. Thus, there is probability $1-q$ that the price level will remain at that level in the next period, i.e. $P_{t+1} = S^I (1+\delta)^{\omega}$. On the other hand, there is a probability q that tradables prices will jump to $S^D + \delta S^I$, while nontradables prices will remain at the level S^I for one more period, implying $P_{t+1} = (S^D + \delta S^I)^{\omega} (S^I)^{1-\omega} = (S^D/S^I + \delta)^{\omega} S^I$. So expected inflation for $t < T$ is

$$\frac{E_t P_{t+1} - P_t}{P_t} = q \left[\left(\frac{S^D/S^I + \delta}{1+\delta} \right)^{\omega} - 1 \right].$$

As before, expected inflation for $t \geq T$, is simply given by γ.

So

$$P_t = \begin{cases} S^I (1+\delta)^{\omega} & \text{for } t < T \\ \gamma^{t-T} (S^D/S^I + \delta)^{\omega} S^I & \text{for } t \geq T, \end{cases} \tag{2.15}$$

and

$$n_t = \begin{cases} r + q \left[\left(\frac{S^D/S^I + \delta}{1+\delta} \right)^{\omega} - 1 \right] & \text{for } t < T \\ r + \gamma - 1 & \text{for } t \geq T. \end{cases} \tag{2.16}$$

Under the fixed exchange rate regime, the demand for money balances would be given by

$$M^I = \theta Y S^I (1+\delta)^{\omega} \exp \left(-\eta \left\{ r + q \left[\left(\frac{S^D/S^I + \delta}{1+\delta} \right)^{\omega} - 1 \right] \right\} \right) \tag{2.17}$$

whereas, under the floating exchange rate regime, the demand for nominal balances is

$$M_t = \theta Y \gamma^{t-T}(S^D/S^I + \delta)^\omega S^I \exp[-\eta(r+\gamma-1)]. \tag{2.18}$$

We still have the money supply rule $M_t^S = \gamma^{t-T+1}(M^I - \chi S^I)$. Combining this with (2.17) and (2.18) we get a modified version of the equilibrium condition (1.18):

$$\theta Y(1+\delta)^\omega \exp\left(-\eta\left\{r+q\left[\left(\frac{S^D/S^I+\delta}{1+\delta}\right)^\omega - 1\right]\right\}\right) = \chi + \theta Y(S^D/S^I+\delta)^\omega \exp[-\eta(r+\gamma-1)]/\gamma. \tag{2.19}$$

For the government budget constraint, where we do our accounting in dollars, we now obtain

$$\begin{aligned}\chi + \Gamma \quad = \quad & \frac{R}{R-1}(\gamma-1)\theta Y\left(\frac{S^D}{S^I}+\delta\right)^\omega \frac{S^I}{S^D}\exp[-\eta(r+\gamma-1)]/\gamma + \\ & \left(\frac{R}{R-1}\frac{N^I-1}{N^I}\frac{S^D}{S^I} - 1\right)\frac{N^I\bar{B}}{S^D} + \sum_{j=0}^{\infty} R^{-j}(d - d_{T+j}).\end{aligned}$$

where $N^I = 1 + r + q\{[(S^D/S^I+\delta)/(1+\delta)]^\omega - 1\}$. To evaluate $\Delta = \sum_{j=0}^{\infty} R^{-j}(d - d_{T+j})$, we assume that the government's transactions involving tradables occur at the wholesale level, so that the relevant price of tradables for the government is S_t. This implies that

$$d_t = x^T - \tau^T + \frac{P_t^N}{S_t}(x^N - \tau^N)$$

as in the previous section. Hence we can continue to use the expression (2.14) for Δ.

In Figure 6 we display equilibria that result from assuming $\delta = 1$.[21] Other than this change, we maintain the assumptions of the previous subsection. Once again, we will focus on equilibria with small probabilities of speculative attacks. Now we see substantial differences between depreciation and inflation. In the period of the speculative attack, the currency depreciates by 12 to 15 percent, while inflation is between 3 and 4 percent. Steady state inflation is also only around 4 percent. So while the government induces the currency crisis, in a sense, by printing more money, it does not need to print nearly as much money or generate nearly as much inflation as in our previous examples. Seignorage now accounts for about half the new revenue the government needs to finance the banking sector bailout. Debt deflation and implicit fiscal reforms account for roughly equal shares of the rest.

[21] This value of δ is consistent with the evidence presented in Burstein, Neves and Rebelo (2000).

3. Conclusions

In this paper we have explored two aspects of crises driven by agents' self-fulfilling expectations of a devaluation. First, we have shown that a crisis of a given magnitude, as measured by the amount of depreciation of the currency, is more likely in equilibrium, if the government has issued guarantees to the creditors of banks. This is because the size of a depreciation is driven by the magnitude of the fiscal costs associated with a crisis—the larger these costs, the larger the depreciation. We have seen that when guarantees are not issued to bank creditors, banks will choose more cautious portfolios and will not fail conditional on a devaluation. This reduces the fiscal cost of a currency crisis, and makes a crisis of a given magnitude less likely. Importantly, in our numerical examples, we found that absent a banking sector bailout, speculative attacks could not occur with positive probability.

Second, we have shown that the crises driven by the government's need to resort to seignorage-like revenue, do not have to be associated with rampant inflation, and the rapid printing of money. When the government has nominal liabilities, when its spending is more skewed towards nontradables than its revenue, when nontradables prices are temporarily sticky, and when there are distribution costs associated with locally purchased tradables, large depreciations can be associated with relatively small inflation rates, and relatively slow money growth rates. Debt deflation and implicit fiscal reforms can pay for substantial portions of the fiscal costs associated with a crisis.

The model we used in our analysis was very stylized and we did not explore the full range of equilibria that are possible within this framework. In particular, we assumed that prices were sticky for only one period, and that post-crisis money growth was constant. Neither of these assumptions was necessary, and we might have found richer results had we explored the model more generally. Furthermore, we only considered crises driven by agents' self-fulfilling expectations. We did not include the possible effects of real uncertainty. We intend to pursue these issues in subsequent work.

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4. Appendix

The expression for the present value of seignorage in (**??**) is

$$\frac{R}{R-1}(\gamma-1)\theta Y \exp[-\eta(r+\gamma-1)]/\gamma. \tag{4.1}$$

To know what the maximal value of seignorage is, it is useful to maximize the expression in (4.1) with respect to γ. This is equivalent to finding the value of γ that maximizes

$$f(\gamma) = (1-\gamma^{-1})\exp(-\eta\gamma).$$

Here, we note that $f(1) = 0$, $f(\gamma) > 0$ for $\gamma > 1$ and $\lim_{\gamma\to\infty} f(\gamma) = 0$. Also, $f(\gamma)$ is continuous and differentiable for $\gamma \geq 1$. We also have

$$f'(\gamma) = (\gamma^{-2} + \eta\gamma^{-1} - \eta)\exp(-\eta\gamma).$$

There is a unique point $\bar{\gamma} \geq 1$ at which $f'(\gamma) = 0$. This is

$$\bar{\gamma} = \frac{1}{2} + \frac{1}{2}\sqrt{1+4/\eta} > 1.$$

Given the other properties we have listed for the function f, this means $\bar{\gamma}$ is a global maximum of f in the set $[1,\infty)$. Therefore, $\bar{\gamma}$ also maximizes (4.1).

FIGURE 1

BELIEFS AND THE PATH OF THE EXCHANGE RATE

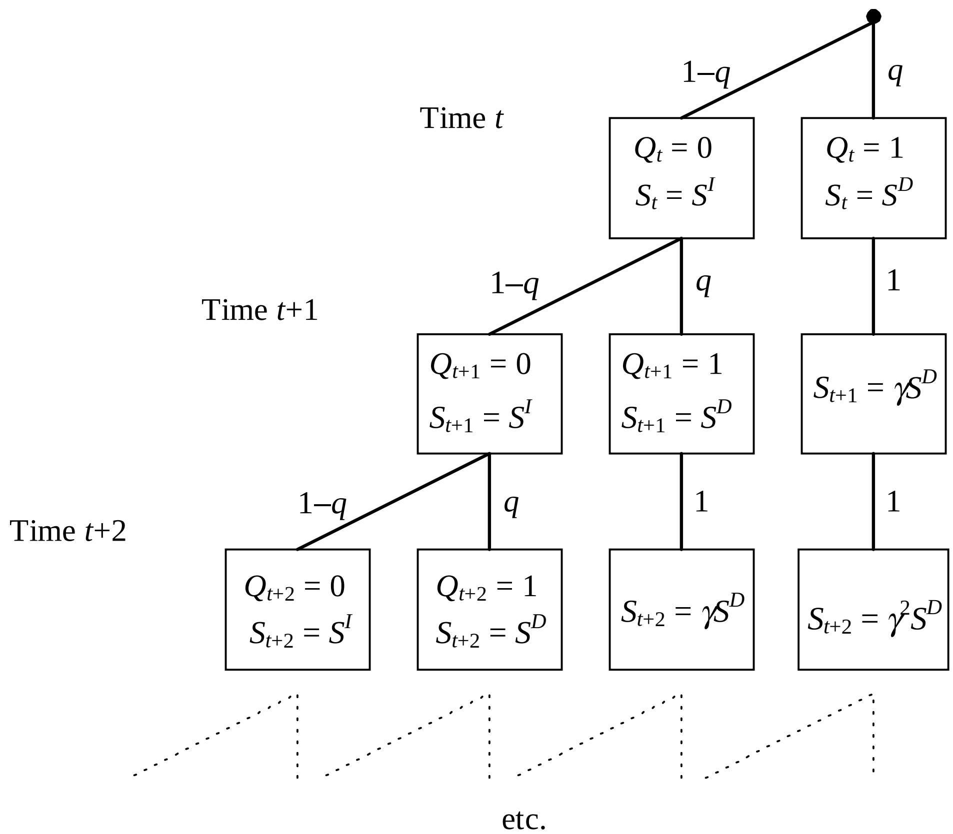


FIGURE 2

THE PROBABILITY OF A SPECULATIVE ATTACK IN THE BENCHMARK MODEL

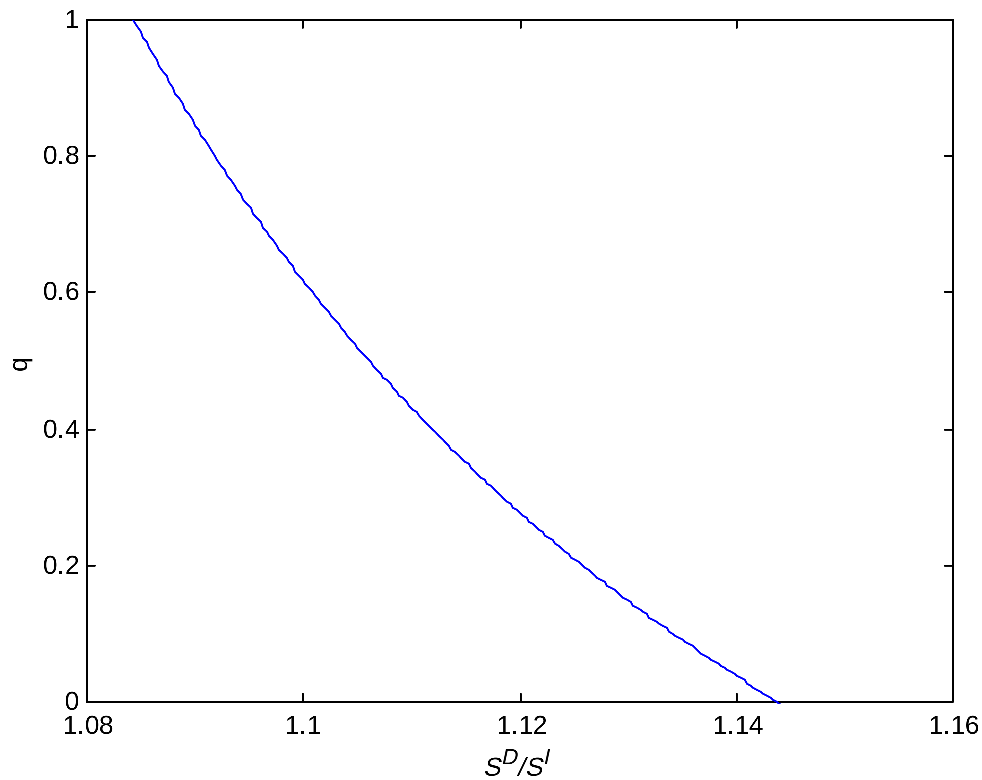
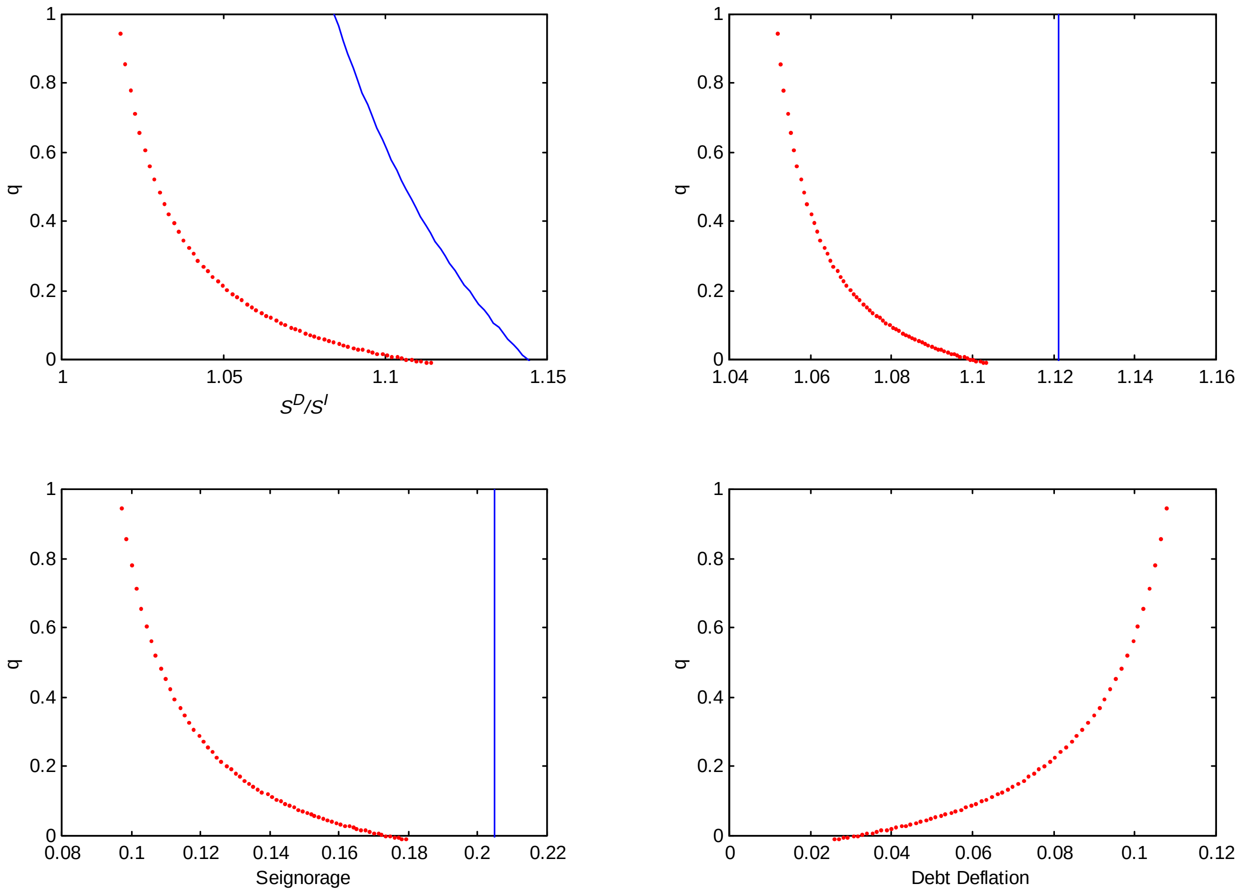


FIGURE 3

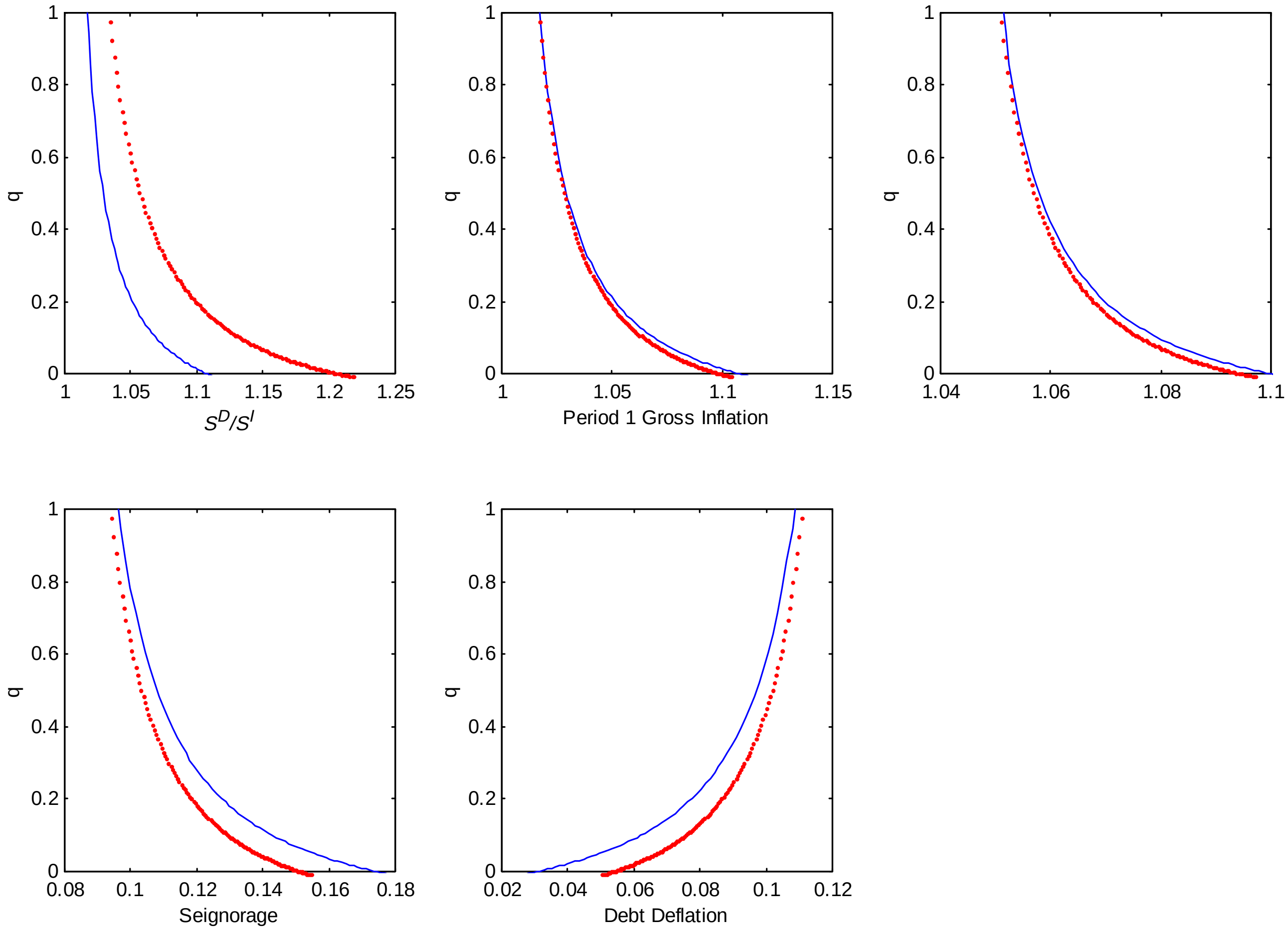
The Effects of Nominal Debt Deflation



Notes: The solid lines represent equilibria of our benchmark model, with $B = 0$. The dotted lines represent equilibria of our model allowing for nominal debt, with $B = 0.3$.

FIGURE 4

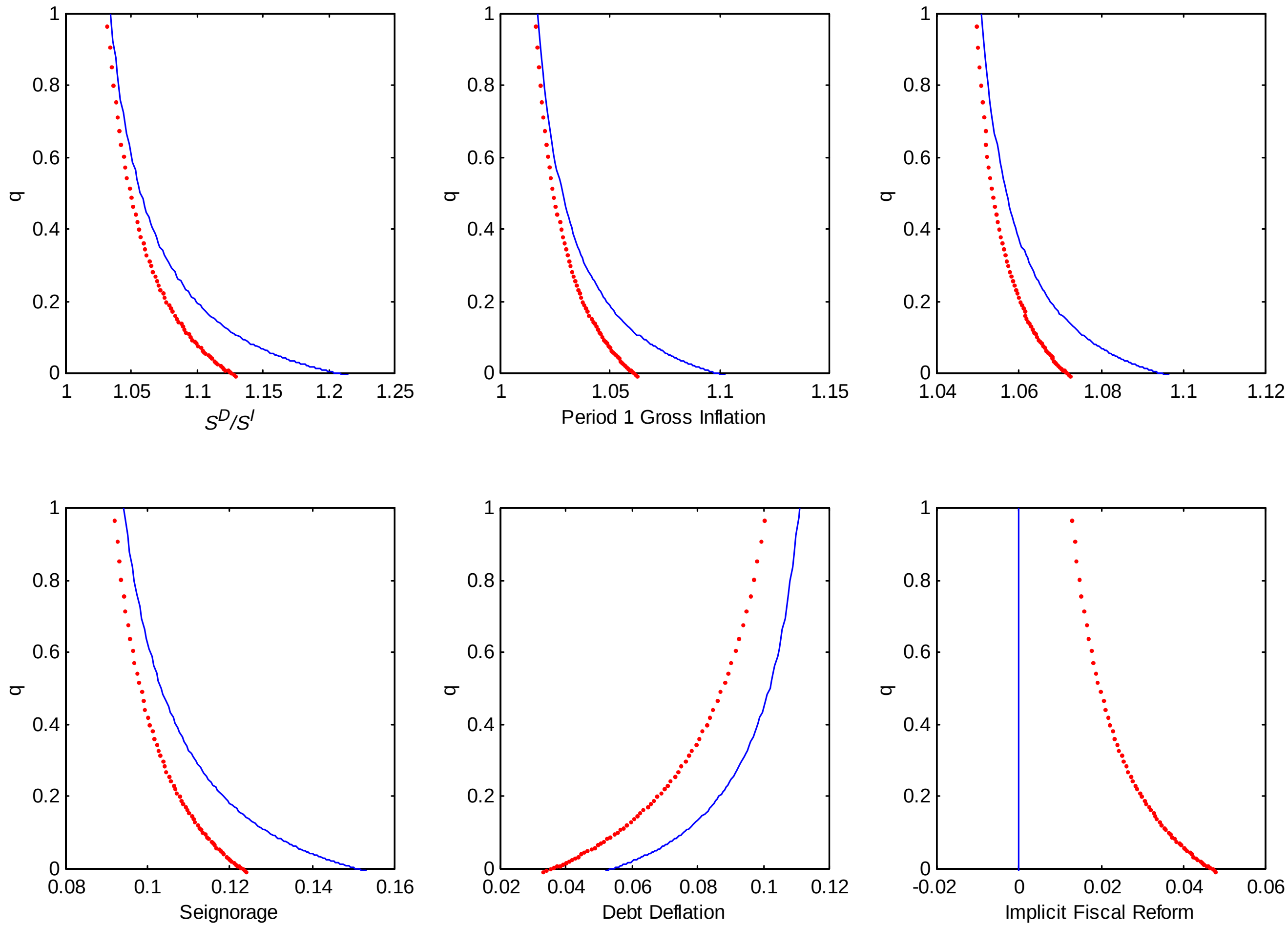
DEVIATIONS FROM PPP: NONTRADABLES PRICES ARE STICKY FOR ONE PERIOD



Notes: The solid lines represent equilibria of our model allowing for nominal debt, with *B* = 0.3. The dotted lines represent equilibria of the same model in which nontradables prices are sticky for one period.

FIGURE 5

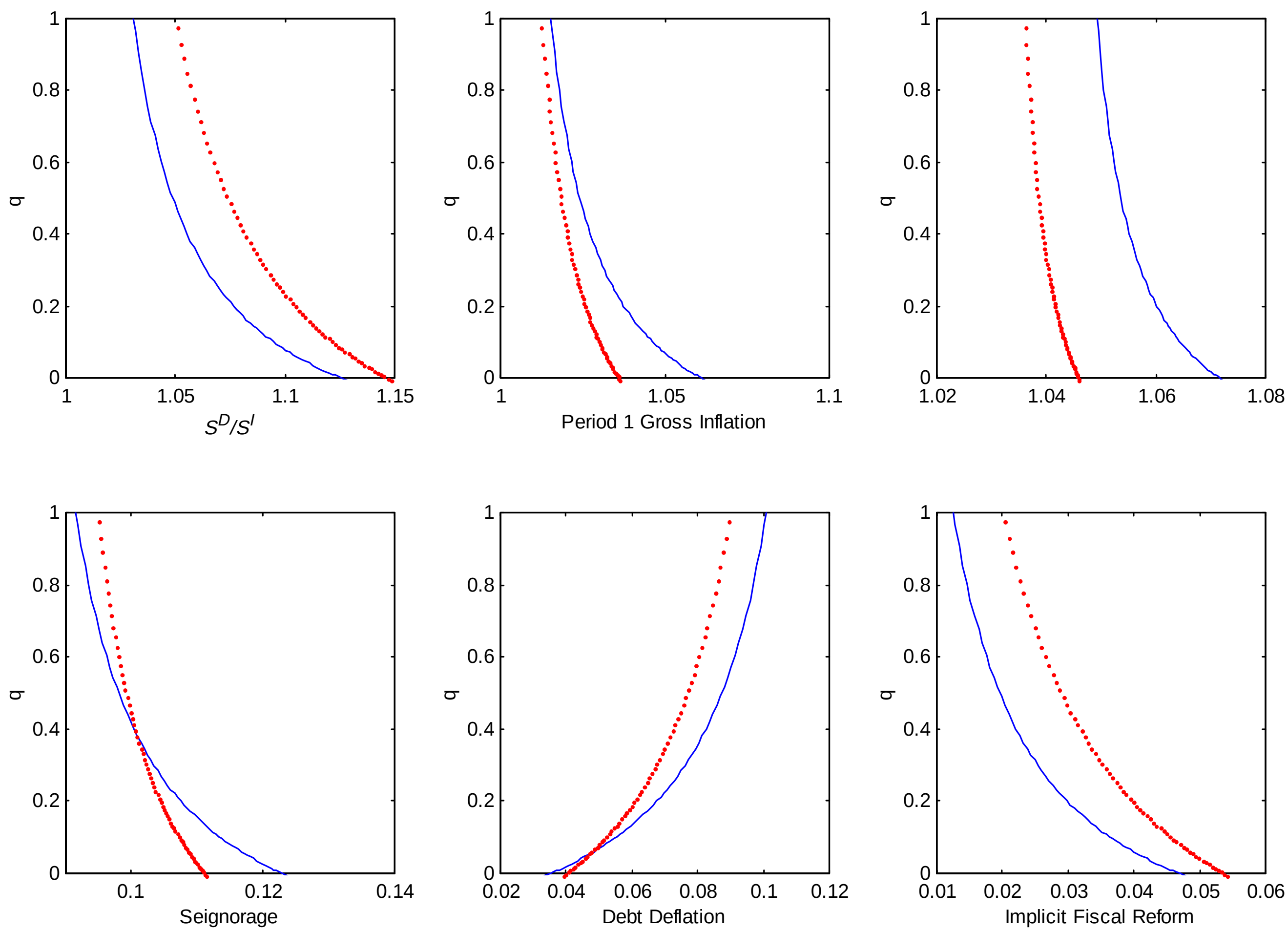
STICKY NONTRADABLES PRICES AND IMPLICIT FISCAL REFORMS



Notes: The solid lines represent equilibria of our model allowing for nominal debt and sticky nontradables prices, with $B = 0.3$, $\omega = 0.5$. The dotted lines represent equilibria of the same model with the added feature of implicit fiscal reforms. The difference between the government's spending on and revenue from nontradables is set at 2 percent of GDP, i.e. $x^N - \tau^N = 0.02$.

FIGURE 6

DISTRIBUTION COSTS FOR TRADABLES GOODS



Notes: The solid lines represent equilibria of our model allowing for nominal debt, sticky nontradables prices, and implicit fiscal reforms with $B = 0.3$, $\omega = 0.5$, $x^N - \tau^N = 0.02$. The dotted lines represent equilibria of the same model with the added feature of distribution costs with $\delta = 1$.