Abstract

A contingent liability is a future spending commitment that is realized with some probability. International organizations emphasize the dangers of contingent liabilities when providing advice. Why? One answer is obvious—if significant contingent liabilities are realized they commit governments to substantial fiscal costs. There is a further reason: by taking on a contingent liability the government can increase the probability of the underlying shock taking place. This paper describes how the issuance of government guarantees and the methods by which they are financed affect the probability of crises taking place. It also discusses the determinants of post-crisis inflation and depreciation.

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A contingent liability is a commitment to take on an actual liability if some economic event happens in the future.¹ There are many examples of contingent liabilities of governments: 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. 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. Furthermore, even when governments are willing to prepare themselves for contingencies, they may face difficulties in doing so: the magnitude

¹ I would like to thank the Bankard Fund for Political Economy for financial support and an anonymous referee for valuable comments. Of course, all errors are my own.
of a contingent liability may not be well known in advance and the timing of its realization may be hard to predict.

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 has no affect on 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 increases 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.”2 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 likely to incur the fiscal cost associated with bank failures. And incurring this fiscal cost, in turn, makes the probability of bank failures higher.

Section 1 of the paper presents modified and extended versions of the models in Burnside et al. (2001a, in press), to show how credible government guarantees to bank creditors can make a banking system more fragile. As in Burnside et al. (2001a), we will see that when governments issue guarantees, banks will not hedge against exchange rate risk.3 As shown in Burnside et al. (in press), this raises the specter 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 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

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2 Mishkin (1996) and Obstfeld (1998) argue that a fixed exchange rate is an implicit government guarantee of this kind. The role of the fixed exchange rate as a guarantee is emphasized by Corsetti et al. (1999), Dooley (2000) and Burnside et al. (2001a).

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

4 The role of speculators in currency crises has been emphasized by Obstfeld (1986a, 1996), Cole and Kehoe (1996), Sachs et al. (1996), Radelet and Sachs (1998) and Chang and Velasco (1999).

5 The model is thus related 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 et al. (1999), Lahiri and Végh (2000) and Burnside et al. (2001b, 2003c).
In Burnside et al. (in press), self-fulfilling speculative attacks in the absence of government guarantees are not possible in equilibrium; hence, they are less likely than they are under guarantees. This result depends on a particular form of money demand derived from a model with money in the utility function and logarithmic utility. This paper uses a more general specification—in particular one in which we can vary the interest elasticity of money demand—that allows for the possibility of self-fulfilling speculative attacks in the absence of government guarantees. In this setting, I derive explicit expressions for the likelihood of a speculative attack. I show that 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 a bank bailout. This paradox, that government guarantees make for less, not more, stability is consistent with empirical evidence in Demirgüç-Kunt and Detragiache (2000).

The second purpose of this paper is to describe how the structure of a government’s finances and budget commitments affects the probability of a speculative attack. This part of the paper relates to findings in Burnside et al. (2003a,c). Once a contingent liability has been realized, a government must take one or more of the following actions: (i) explicitly default on some portion of its debt, (ii) receive greater transfers from abroad, (iii) increase its seignorage revenue, (iv) deflating the real value of local currency debt or (v) implement fiscal reforms that result in a higher primary surplus.

In this paper I do not consider the possibility of explicit default, nor do I consider the role of foreign transfers as Jeanne and Zettlemeyer (2000) have argued that the subsidy value of official international lending in the wake of recent crises has been relatively small. Burnside et al. (2003a,c) argue that seignorage revenues increased in the wake of recent banking crises in Korea, Mexico and Turkey. However, they note that the increases in seignorage were small compared to the fiscal costs associated with bailing out banks in these crises. This suggests that deflation of nominal debt and fiscal reforms may have played important roles in these crises.

While fiscal reforms and nominal debt deflation may have been important as sources of finance, it is not clear whether the nature of fiscal reforms and the quantity of nominal debt matter for the probability of a crisis driven by self-fulfilling expectations. This paper determines whether they do.

We will see that crises of a given severity become less likely the greater the government’s existing stock of nominal debt.\footnote{With nominal debt, the model becomes consistent with work on the fiscal theory of the price level by Sims (1994), Woodford (1995), Corsetti and Mackowiak (2000), Cochrane (2001), Daniel (2001) and Dupor (2000).} The reason is straightforward: the greater the stock of nominal debt, the greater the revenue from nominal debt deflation; therefore, the less seignorage revenue is needed to finance realized contingent liabilities. The lower seignorage revenue is, the smaller the magnitude of any crisis will be. One might ask why governments don’t simply issue lots of domestic debt to reduce the impact of crises. While the answer to this question is not obvious, it may be related to why governments do not accumulate—or are not willing to lose—reserves to avoid crises: issuing nominal debt, like accumulating reserves, is expensive and requires an ex-ante fiscal outlay.
Fiscal reforms come in many shapes and sizes. In some cases, governments make explicit changes to the tax system, or cut the quantity of goods and services they purchase. In other cases, the real magnitudes of tax revenue and noninterest spending change implicitly due to changes in real output or relative prices. For example, Burnside et al. (2003a,c) argue that government revenue fell substantially after several recent crises due to sharp declines in real activity, but more importantly due to even sharper declines in the relative price of nontraded goods.

In this paper, I argue that explicit fiscal reforms reduce the magnitude of the contingent liability to be financed. Not surprisingly, this reduces the probability of a crisis of given severity. Similarly, revenue losses due to a post-crisis recession simply add to the fiscal costs to be financed some other way. Not surprisingly, the greater the potential revenue losses, the higher the probability of a self-fulfilling crisis.

To introduce the possibility of implicit fiscal reforms driven by changes in the relative price of tradable and nontradable goods, I assume that nontraded goods have sticky prices. Everything else equal, sticky prices imply a higher probability of a crisis of a given magnitude. The reason for this is somewhat complicated. Money demand is proportional to the overall price level. Since, for a given amount of depreciation, the price level will rise less in a model with sticky prices, post-crisis money demand will tend to be lower. If we hold the dollar reserve losses incurred during the crisis fixed across the two models, this means that pre-crisis money demand must also be lower in the sticky price model. Importantly, pre-crisis money demand depends negatively on (i) the probability of a crisis and (ii) the depreciation that will occur during the crisis. Since we hold the latter fixed, the probability of a crisis must be higher in the sticky price model.

Having introduced sticky prices, I show that the greater the amount of revenue that can be raised through implicit fiscal reforms, the lower the probability of a crisis of a given magnitude. The reason is simple: the larger the potential implicit fiscal reforms, the less seignorage is required to finance the budget. This implies less depreciation and inflation.

Section 1 of the paper reviews some of the evidence on the importance of debt deflation and implicit fiscal reforms in recent crisis episodes. While not an attempt to characterize these crises as examples of self-fulfilling speculative attacks, this evidence substantiates the empirical relevance of the theoretical examples explored in this paper. Section 2 of the paper explores the role of government guarantees to bank creditors in determining the probability of a self-fulfilling crisis. Section 3 of the paper explores the role of government finance in determining the probability of a self-fulfilling crisis. Section 4 concludes.

1. The government budget after crises

This paper focuses on crises driven by the realization of contingent liabilities in the financial sector. In several recent crisis episodes, major banking crises have been associated with currency crises. In this section, I review evidence from Burnside et al. (2003a) concerning three crises: the Mexican crisis of 1994, the Korean crisis of 1997 and the Turkish crisis of 2001. The governments in these countries bore significant fiscal costs in order to recapitalize or rehabilitate banks, or to directly bail out bank creditors. Estimates of the fiscal costs vary, but I work with the following estimates: 15% of
GDP in Mexico, 24% of GDP in Korea and just over 18% of GDP in Turkey. Each country also experienced significant depreciation of its exchange rate in the first year of its crisis: $S_t$ measured in local currency units per US dollar rose 95% in Mexico, 51% in Korea and 103% in Turkey. As Table 1 indicates, each country experienced a significant decline in real GDP (measured in constant local currency units) relative to pre-crisis projections: $-9\%$ in Mexico, $-13\%$ in Korea and $-11\%$ in Turkey. Finally, each country experienced a sharp decline, relative to trend, in the ratio of the GDP deflator, $P_t$, to the exchange rate, $S_t$. In Mexico, this was on the order of 32%, in Korea 43% and in Turkey 21%.

In first generation models of speculative attacks, large fiscal costs trigger large depreciations if the government finances them with seignorage revenue. As Table 1 indicates there is little evidence that seignorage revenue increased sharply in the wake of the three crises mentioned above. Instead, debt deflation and implicit changes in government budgets played a much bigger role in post-crisis government finance. I will not provide details of Burnside et al.’s (2003a) methodology for constructing the estimates in Table 1. However, the basic approach is to first estimate changes in government revenue and expenditure flows, measured in dollars that occurred as the result of the crisis. These changes are decomposed into three components: (i) changes due to declines in real activity, (ii) changes due to declines in the relative price of nontraded goods and (iii) a residual term ascribed to explicit fiscal reform.

### Table 1
Changes in output, relative prices and budgets after recent crises

<table>
<thead>
<tr>
<th>Date of the crisis</th>
<th>Mexico</th>
<th>Korea</th>
<th>Turkey</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/94</td>
<td>15.0</td>
<td>24.0</td>
<td>18.2</td>
</tr>
<tr>
<td>Changes in real GDP after the crisis (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 1</td>
<td>$-9.2$</td>
<td>$-13.0$</td>
<td>$-10.5$</td>
</tr>
<tr>
<td>Year 2</td>
<td>$-7.6$</td>
<td>$-10.0$</td>
<td>$-7.2$</td>
</tr>
<tr>
<td>Changes in $P_t/S_t$ after the crisis (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 1</td>
<td>$-32.0$</td>
<td>$-43.4$</td>
<td>$-21.0$</td>
</tr>
<tr>
<td>Year 2</td>
<td>$-29.6$</td>
<td>$-38.4$</td>
<td>$-10.9$</td>
</tr>
<tr>
<td>Changes in government budgets after the crisis (% GDP)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fiscal cost of banking crisis</td>
<td>15.0</td>
<td>24.0</td>
<td>18.2</td>
</tr>
<tr>
<td>Explicit fiscal reforms</td>
<td>$-2.5$</td>
<td>11.9</td>
<td>3.3</td>
</tr>
<tr>
<td>Change in revenue due to recession</td>
<td>$-6.5$</td>
<td>$-10.2$</td>
<td>$-4.4$</td>
</tr>
<tr>
<td>Net fiscal cost to be financed</td>
<td>24.0</td>
<td>22.3</td>
<td>19.2</td>
</tr>
<tr>
<td>Increase in seignorage</td>
<td>1.7</td>
<td>1.7</td>
<td>1.8</td>
</tr>
<tr>
<td>Debt deflation</td>
<td>1.7</td>
<td>3.5</td>
<td>7.3</td>
</tr>
<tr>
<td>Change in primary balance due to change in $P_t/S_t$</td>
<td>9.1</td>
<td>4.4</td>
<td>1.2</td>
</tr>
<tr>
<td>Amount as yet unpaid</td>
<td>11.4</td>
<td>12.7</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Source: All estimates from Burnside et al. (2003a).

Changes in real GDP and $P_t/S_t$ are measured in percent relative to pre-crisis projections, where $P_t$ is the GDP deflator and $S_t$ is the exchange rate in local currency units per dollar. Years 1 and 2 are 1995–1996 for Mexico, 1998–1999 for Korea and 2001–2002 for Turkey. Changes in government budget flows are present values measured in percent of crisis-year GDP, from the 1995 (for Mexico), 1998 (for Korea) and 2001 (for Turkey) through 2002. See Burnside et al. (2003a) for details.
In the model presented in Section 2, the relevant fiscal cost for determining the magnitude of a currency crisis is the fiscal cost not financed explicitly through cuts in the quantity of government purchases of goods and services or increases in tax rates. So, in Table 1, we net any explicit fiscal reforms made by the three governments from the costs of their banking sector bailouts. Table 1 also adds to the fiscal costs any implicit changes in government revenue due to the recessions that followed the crises. Since each country experienced a sharp recession after its crisis, these revenue losses were significant. Once we net out explicit fiscal reforms and recession costs, we get an estimate of the fiscal cost that would need to be financed either through printing money, debt deflation or implicit fiscal reforms driven by changes in \( \frac{P_t}{S_t} \). In all three cases, this fiscal cost is around 20% of GDP.

Seignorage has played a small role, providing less than 10% of the total financing in each case. Debt deflation was modest in Mexico, which had little domestic debt denominated in pesos prior to the crisis, was somewhat more important in Korea, but was very important in Turkey, which had substantial stocks of domestic debt prior to its crisis in 2001. In Mexico and Korea, which experienced the largest real exchange rate movements of the three countries, the most significant sources of new revenue were implicit fiscal reforms driven by changes in relative prices. It is this evidence, that debt deflation and implicit fiscal reforms are more important than seignorage, that motivates the extended model in Section 3.

2. Guarantees and fragility

Consider a simple partial equilibrium model of a small open economy. There is a single good, no trade barriers and purchasing power parity holds: \( P_t = S_t P^*_t \), where \( P_t \) and \( P^*_t \) denote the domestic and foreign price levels, respectively, and \( S_t \) is the exchange rate defined as units of domestic currency per unit of foreign currency. For simplicity, let \( P^*_t = 1 \) for all \( t \).

The economy consists 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. To highlight the role that guarantees play in making the banking system more fragile, I allow for only one source of uncertainty: changes in agents’ beliefs.

2.1. Beliefs

To analyze a potential currency crisis at time \( t \), I assume that a fixed exchange rate regime has been in effect for all periods \( s < t \). That is, I assume that \( S_t = S^t \) for \( s < t \). Holders of domestic currency coordinate on an i.i.d. signal, \( Q_t \), observed at the beginning of each period, where

\[
Q_t = \begin{cases} 
0 & \text{with probability } 1 - q \\
1 & \text{with probability } q. 
\end{cases}
\]
If $Q_t = 1$, agents anticipate that the exchange rate regime will be abandoned within the period, and that $S_{t+j} = S^D_j$, $j \geq 0$, for some $S^D \geq S^I$ and $\gamma_i \geq 1$. If $Q_t = 0$, agents anticipate that $S_t = S^I$ and that in period $t+1$ their beliefs will be determined by a further i.i.d. draw from the same probability distribution.

2.2. Timing assumptions and the Central Bank’s threshold rule

The model’s timing assumptions for a period, $t$, that begins under the fixed exchange rate regime are as follows. There is a unit measure of identical holders of domestic currency that come into period $t$ with $M_{t-1}$ units of money. The following sequence of events takes place.

1. Agents coordinate their beliefs based on the signal, $Q_t$, as described above.
2. If they wish to, agents adjust their money holdings at the central bank window.
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 $\gamma$ units of foreign currency, it floats the exchange rate and closes its foreign exchange window permanently.\(^7\) If the total requests for foreign currency are less than $\gamma$, the central bank honors them and does not float the exchange rate.
4. The money and goods markets open simultaneously. Markets clear. Holders of domestic money determine their end-of-period money holdings, $M_t$.

2.3. Money demand and money supply

Agents’ end-of-period demand for money is given by the familiar Cagan (1956) function:

$$M_t = \theta Y_t P_t \exp(-\eta n_t),$$ \hspace{1cm} (2)

where $Y_t$ denotes real activity at time $t$, $n_t$ is the nominal interest rate and $\eta$ represents the semi-elasticity of money demand with respect to the interest rate. The Cagan specification can be justified if agents hold money for liquidity services proportional to the value of transactions and money is a store of value, which earns no interest.\(^8\)

Assume $Y_t = Y$ for simplicity. Let $r$ be the dollar rate of interest in world markets. The nominal interest rate, $n_t$, is the sum of the real interest rate, $r$, and the expected depreciation rate, $E_t(S_{t+1} - S_t)/S_t$. In any period, $t$, in which the fixed exchange rate regime is still in

\(^7\) 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 et al. (2001b) for a discussion of alternative rules. Also see Rebelo and Ve´gh (2002) for a discussion of optimally chosen rules for floating.

\(^8\) Agents with $M_t \geq \gamma$ expect to make arbitrage profits of $\gamma(1 - S^I/S^D)$ in the event that $Q_{t+1} = 1$, but, because of the nature of the central bank window, this part of the return to holding money is fixed, and does not vary in proportion to $M_t$. Hence, it has no impact on end-of-period money demand.
place by the end of the period, $E_t(S_{t+1} - S_t)/S_t = q(S^D/S^I - 1)$. If the fixed exchange rate was abandoned at or prior to date $t$, then $E_t(S_{t+1} - S_t)/S_t = \gamma - 1$.

Let $T$ denote the date at which the fixed exchange rate regime is abandoned. Our previous results mean that agents anticipate

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

and

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

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

$$M_t = 0Y e^{-\eta[r+q(S^D/S^I-1)]}$$

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

$$M_t = 0Y e^{-\eta[r+\gamma-1]}.$$ 

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

2.4. The banking sector

In this subsection, I use the banking model developed in Burnside et al. (in press). 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. Banks can 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.

The focus here is on banks’ portfolio decisions under the fixed exchange rate regime. It turns out 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

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The model is similar to those in Chari et al. (1995) and Edwards and Végh (1997). Other models of the role of banks in crises include Akerlof and Romer (1993), Caballero and Krishnamurthy (1998) and Chang and Velasco (1999).
government guarantees, a result similar to Kareken and Wallace’s (1978) finding regarding the impact of deposit insurance. 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.

Banks are perfectly competitive and their actions are publicly observable. 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 $R^a$. To lend $SL$ units of local currency, the bank incurs a real transactions cost of $\delta L$.

Banks can hedge exchange rate risk by entering into forward contracts. Let $F$ denote the one-period forward exchange rate defined as units of local currency per dollar. Forward contracts are priced risk-neutrally in a frictionless market. Under these assumptions, the forward rate, $F$, is given by

$$1/F = (1 - q)/S^I + q/S^D.$$  

(7)

Thus, the expected real payoff from purchasing a forward contract is zero.

Let $x$ denote the number of units of local currency the bank sells forward. Once $S$ is determined the value of the bank’s gross assets is

$$V^R(L, x; S) = R^a S^I L/S - \delta L + x(1/F - 1/S).$$  

(8)

The expected value of the bank’s gross assets is

$$V^e_c(L) = R^a S^I L/F - \delta L.$$  

(9)

I use $R^b(L, x)$ to denote a competitively determined schedule of rates at which banks borrow from foreign creditors. This schedule, which is derived below, is consistent with the fact that foreign creditors require an expected gross return equal to the world interest rate, $R = 1 + r$. When $V^b(L, x; S) \geq R^b(L, x)L$ it is optimal for a bank to repay its creditors because it can then distribute non-negative profits $V^R(L, x; S) - R^b(L, x)L$ to its shareholders. On the other hand, if $V^b(L, x; S) < R^b(L, x)L$, 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. Bankruptcy is assumed to reduce the value of the bank’s gross assets by a cost $\omega L$, with $\omega > 0$.

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10 In some crises, banks did not have direct currency exposures because they borrowed and made loans in dollars. See, for example, Gavin and Hausmann (1996) regarding the Chilean crisis of 1982. See Burnside et al. (2001a) for an extended model in which banks lend in dollars but face credit risk that is correlated with exchange rate risk.


12 Since the expected dollar return from a forward contract is zero, we avoid Siegel’s (1972) paradox, which arises when the expected nominal return to forward contracts is assumed to be zero.
Banks choose $L$ and $x$ to maximize the expected payoff to their shareholders:

$$V(L, x) = \sum_{s \in [S^I, S^D]} \Pr(S = s)[1 - I(L, x; s)][V^R(L, x; s) - R^b(L, x)L].$$  \hfill (10)

The function $I(\cdot)$ is an indicator function that takes on the value 1 if the bank is insolvent:

$$I(L, x; S) = \begin{cases} 
0 & \text{if } V^R(L, x; S) \geq R^b(L, x)L \\
1 & \text{if } V^R(L, x; S) < R^b(L, x)L.
\end{cases}$$  \hfill (11)

Some simple rearrangement of Eq. (10) implies that

$$V(L, x) = V^R_e(L) - C(L, x),$$  \hfill (12)

where

$$C(L, x) = \sum_{s \in [S^I, S^D]} \Pr(S = s)[1 - I(L, x; s)]R^b(L, x)L + I(L, x; s)V^R(L, x; s)].$$  \hfill (13)

I refer to $C(L, x)$ as a bank’s expected cost of borrowing, because $R^bL$ is what a bank pays to its creditors if it is solvent, and $V^R$ is its gross assets, which it hands to the bankruptcy court if it is insolvent. Notice that Eq. (12) implies that the bank’s optimal choice of $x$ is determined solely in terms of its effect on the bank’s expected cost of borrowing. I.e., we can find the optimal $x$ by minimizing $C(L, x)$.

2.4.1. No government guarantees

I 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. Since creditors require an expected return of $R$, the borrowing rate schedule will be set according to

$$RL = \sum_{s \in [S^I, S^D]} \Pr(S = s)[1 - I(L, x; s)]R^b(L, x)L + I(L, x; s)V^R(L, x; s)].$$  \hfill (14)

Combining Eq. (14) with Eq. (13), we see that a bank’s expected cost of borrowing is

$$C(L, x) = RL + \sum_{s \in [S^I, S^D]} \Pr(S = s)I(L, x; s)oL.$$  \hfill (15)

It follows immediately that a bank minimizes its expected cost of borrowing by avoiding bankruptcy. The optimal strategy for banks is to fully hedge by setting $x = R^aS^I/L$. By doing this it makes its gross assets invariant to $S$, since $V^R(L, R^aS^I/L; S) = (R^aS^I/F - \delta)L$ for all $S$, and it can borrow at the risk free rate, $R^b = R$, so $C(L, x) = RL$.
It follows, from Eqs. (9) and (12), that the banks’ shareholders’ expected payoff is \( V = [R^aS^1/F - (R + \delta)]L \). Hence, the competitively determined equilibrium interest rate must be \( R^e = (R + \delta)F/S^1 \).

### 2.4.2. Government guarantees

Suppose the government gives foreign creditors the following guarantee: if a bank fails when \( S = S^D \), the government will pay its creditors

\[
\Gamma = \min \{ RL - [V^R(L, x; S^D) - \omega L], RL \}. \tag{16}
\]

The foreign creditors therefore obtain total proceeds equal to \( V^R(L, x; S^D) - \omega L + \Gamma \). Notice that, if \( V^R(L, x; S^D) \geq \omega L \), this means the creditors’ total proceeds are \( RL \), whereas if \( V^R(L, x; S^D) < \omega L \), the creditors’ total proceeds are \( V^R(L, x; S^D) - \omega L + RL < RL \). This effect of the upper limit on the government’s payout to creditors specified in Eq. (16), plays a role, below, in limiting banks’ losses if they default.

Given the government’s guarantee, it is clear that foreign creditors are willing to lend at the world interest rate to a bank that either (i) fully hedges or (ii) defaults only when \( S = S^D \) and sets \( \omega = (\omega + \delta - R^eS^1/S^D)L/(1/F - 1/S^D) \), the bank achieves \( V^R(L, x; S^D) = \omega L \) and

\[
C(L, x) = (1 - q)RL + qV^R(L, x; S^D). \tag{17}
\]

Now banks have an incentive to make \( V^R(L, x; S^D) \) as small as possible. As long as \( \omega < R \), banks can choose any value of \( x \) consistent with \( \omega L \leq V^R(L, x; S^D) < RL \). By setting \( x = (\omega + \delta - R^eS^1/S^D)L/(1/F - 1/S^D) \), the bank achieves \( V^R(L, x; S^D) = \omega L \) and

\[
C(L, x) = [(1 - q)R + q\omega]L. \tag{18}
\]

This is lower than \( RL \) as long as \( \omega < R \).

It follows, from Eqs. (9) and (12), that the banks’ shareholders’ expected payoff is \( V = [R^aS^1/F - (1 - q)R - \delta]L \). Hence, the competitively determined equilibrium interest rate must be \( R^e = [(1 - q)R + q\omega + \delta]/S^1 \).

Would banks ever try to set \( V^R(L, x; S^D) < \omega L \)? If they did so, notice that they would no longer be able to borrow at the rate \( R \), given the limit on the government’s guarantee. Their borrowing rate would be determined by

\[
RL = (1 - q)R^b(L, x)L + q[V^R(L, x; S^D) - \omega L + RL], \tag{19}
\]

while the expected cost of borrowing would be

\[
C(L, x) = (1 - q)R^b(L, x)L + qV^R(L, x; S^D). \tag{20}
\]
Putting these two expressions together notice that \( C(L,x) = [(1 - q)R + qo]L \). This implies that banks would be indifferent between a strategy where they set \( V^R(L,x;S^D) < oL \) and a strategy where they set \( V^B(L,x;S^D) = oL \). Hence, I assume that they set \( V^B(L,x;S^D) = oL \).

### 2.5. The government

As in Sargent and Wallace (1981), the government is assumed to issue only real, or dollar, debt. Let \( f_t \) be the government’s net real asset position at the end of period \( t \). The government runs a primary deficit, \( d_t \), denominated in dollars. As above, the end-of-period money supply is given by \( M_t \). Hence, the government’s flow budget constraint in local currency terms is given by

\[
S_t f_t = S_t (R f_{t-1} - d_t) + M_t - M_{t-1}
\]  
(21)

We will see, below, that we must slightly modify Eq. (21) for periods in which speculative attacks occur.

Under the fixed exchange rate regime, the government has a constant real primary deficit given by \( \bar{d} \). Recall that the government sets \( M_t = M^1 \) for \( t < T \). So, under the fixed exchange rate regime the government’s flow budget constraint (Eq. (21)) reduces to

\[
f_t = R f_{t-1} - \bar{d}.
\]  
(22)

Assume that for \( t < T \) the government’s pre-crisis asset position is constant, so that \( f_t = \bar{f} = \bar{d}/r \).

Now consider the possibility that there is a successful speculative attack against the currency at date \( T \). Assuming that the government receives all the interest on \( f_{T-1} \), in the immediate aftermath of the speculative attack, the government’s net asset position is \( R f_{T-1} - \gamma \). Let \( \Gamma \) 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, assume that the demand for loans is entirely driven by technology, not prices, so that \( L \) is invariant to the interest rate, \( R^a \).

Immediately after the attack, the money supply is \( M^* \). By the end of period \( T \) it is \( M^*/\gamma \). So the government raises seignorage revenue equal to \( (\gamma - 1)M^* \) in period \( T \). Finally, given the possibility of fiscal reforms—after the speculative attack—that lower the fiscal deficit, let the primary deficit at time \( T \) be \( d_T \). The government’s flow budget constraint during the period of the speculative attack \((t = T)\) is then given by:

\[
f_T = R f_{T-1} - \gamma - \Gamma - d_T + (\gamma - 1)M^*/S^D
\]  
(23)

For \( t > T \), the government raises seignorage revenues given by \( M_t - M_{t-1} = (\gamma - 1)\gamma^t - T M^* \) and \( S_t = \gamma^t - T S^D \). Hence, the flow budget constraint for \( t > T \) is

\[
f_t = R f_{t-1} - d_t + (\gamma - 1)M^*/S^D.
\]  
(24)
Iterating on Eq. (24) and combining it with Eq. (23), notice that

\[ v + G = R f T / C_0 + \frac{R}{r} (c - 1) \frac{M^*}{S^0} - \sum_{j=0}^{\infty} R^{-j} d_{T+j}. \]  

(25)

Noting that \( f T / C_0 = \tilde{f} = \tilde{d} / r \), the government’s intertemporal budget constraint is

\[ v + \Gamma = \frac{R}{r} (c - 1) \frac{M^*}{S^0} + \sum_{j=0}^{\infty} R^{-j} (\tilde{d} - d_{T+j}). \]  

(26)

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, \( \Gamma \), plus the reserves lost during the speculative attack, \( \chi \).

2.6. A sustainable fixed exchange rate

There is always an equilibrium with \( q = 0 \), in which agents believe \( S_t = S^f \), forever. In this equilibrium, the government’s contingent liabilities are irrelevant because they are contingent on a zero probability event. The government’s assets remain constant at \( \tilde{f} \), forever. Given an arbitrary initial value for the exchange rate, \( S^f \), the money supply is \( M^f = 0 Y S^f e^{-w} \), forever. The hedging behavior of banks is irrelevant as there is no exchange rate risk.

2.7. Equilibria with speculative attacks

Equilibrium in the model is summarized by two conditions: the government satisfies its lifetime budget constraint and the money supply always equals money demand. Also, agents beliefs must be rational.

Treat the central bank’s threshold rule as an exogenous parameter \( \chi \). Furthermore, take the present value of any fiscal reforms, \( \Delta = \sum_{j=0}^{\infty} R^{-j} (\tilde{d} - d_{T+j}) \), as an exogenous parameter. It follows that the government must choose \( \gamma \) so that Eq. (26) is satisfied. Below, we will see that the equilibrium value of \( \gamma \) depends on whether or not the government has issued guarantees to bank creditors.

We have 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 \( S^f \). 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 Eq. (5),

\[ m_t = m^f = 0 Y e^{-q (r + q (S^0 / S^{t-1}) \mid, \text{ for } t < T.} \]  

(27)

Money supply should also equal money demand under the floating exchange rate regime. Above, we saw that for \( t \geq T \) money demand is given by Eq. (6), while money
supply is given by \( M_t^S = r - T + 1 M^* = r - T + 1 (M^1 - \chi S^1) \). Equating supply and demand, we obtain:

\[
M^1 = \frac{S^D}{S^1} \frac{\theta Y e^{-\eta(r+\gamma-1)}}{\gamma}.
\]  

(28)

Equating the expressions for \( M^1 \) given in Eqs. (27) and (28) leads to the equilibrium condition:

\[
\theta Y e^{-\eta(r+q(S^D/S^1-1))} = \frac{S^D}{S^1} \frac{\theta Y e^{-\eta(r+\gamma-1)}}{\gamma}.
\]  

(29)

Given \( \chi \), and the value of \( \gamma \) that satisfies Eq. (26), Eq. (29) determines either the size of the devaluation associated with the speculative attack, \( S^D/S^1 \), taking the probability of the speculative attack, \( q \), as given, or vice versa. For rational speculative attacks to occur in equilibrium, the equilibrium conditions must imply \( 0 < q < 1 \) for \( S^D/S^1 > 1 \).

2.7.1. Equilibrium with contingent liabilities

To solve for the equilibrium value of \( \gamma \), I first examine the case where the government has taken on a contingent liability by issuing guarantees. This means \( G = RL > 0 \) so that Eq. (26) can be rewritten as

\[
\chi + \Gamma - \Delta = \frac{R}{r} \frac{\gamma - 1}{\gamma} \theta Y e^{-\eta(r+\gamma-1)}.
\]  

(30)

As stated above, this equation determines the equilibrium money growth rate, \( \gamma \), in terms of \( \chi \), the size of the contingent liability, \( \Gamma \), and the size of the fiscal reform, \( \Delta \).

The right-hand side of Eq. (30) is the present value of seignorage revenue. It is straightforward to show that seignorage is maximized at \( \gamma = \left( 1 + \sqrt{1 + 4/\eta} \right)/2 \). Since seignorage is zero for \( \gamma = 1 \) and \( \gamma = \infty \), two solutions to Eq. (30) exist if and only if

\[
\frac{R}{r} \frac{\gamma - 1}{\gamma} \theta Y e^{-\eta(r+\gamma-1)} > \chi + \Gamma - \Delta.
\]  

(31)

One solution is less than \( \gamma \), while the other is greater than \( \gamma \). I assume that the government chooses the smaller of these two values.

Formally, a speculative attack equilibrium with government guarantees is a pair \( (\gamma, q) \) that satisfies Eqs. (29) and (30) given values of \( \chi, S^D/S^1 > 1, \Gamma, \Delta \) and the other model parameters.

2.7.2. Equilibrium without contingent liabilities

When the government does not take on contingent liabilities \( \Gamma = 0 \), its budget constraint becomes

\[
\chi - \Delta = \frac{R}{r} (\gamma - 1) \theta Y e^{-\eta(r+\gamma-1)} / \gamma.
\]  

(32)

Again, if there are two solutions to Eq. (32), I assume that the government chooses the smaller value of \( \gamma \).
Formally, a speculative attack equilibrium without government guarantees is a pair \((\gamma, q)\) that satisfies Eqs. (29) and (32) given values of \(\delta, S^D/S^I > 1, \Delta\) and the other model parameters.

2.7.3. The effect of contingent liabilities on equilibrium outcomes

In this section, I consider the impact of government guarantees on equilibrium. The first result pertains to the effect of 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. Assume that the economies share the same model parameters, and common values of \(\delta, S^D/S^I\) and \(\Delta\). 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.** Eqs. (30) and (32) pin down the post-attack inflation rates in the two economies. Holding \(\delta\) and \(\Delta\) constant, it is clear that the present value of seignorage must be higher in the economy with guarantees. Since the government always chooses the smallest \(c\) consistent with its budget constraint, the inflation rate in the economy with guarantees must be larger in order to raise more seignorage.

The 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 \(\delta, S^D/S^I\) and \(\Delta\). Conditional on speculative attack equilibria existing for both economies, a speculative attack is more likely in the economy with guarantees.

**Proof.** Let \((q_g, \gamma_g)\) and \((q_n, \gamma_n)\) be the equilibrium values of \(q\) and \(\gamma\) in the economies with and without guarantees. From Proposition 1, \(\gamma_g > \gamma_n\). Solve Eq. (29) for the probability of a speculative attack by rearranging it:

\[
q = -\left\{r + \eta^{-1}\ln\left[\frac{\delta^D}{\delta^I}S^D e^{-\eta(r+\gamma-1)} \right] / \gamma \right\} / \left(\frac{S^D}{\delta^I} - 1\right)
\]

(33)

Notice that

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

(34)

Since \(\gamma_g > \gamma_n\) this implies that \(q_g > q_n\).

What intuition stands behind Proposition 2? Recall, from Proposition 1, that other things equal, the economy with guarantees has a higher post-crisis rate of inflation.
This means that post-crisis money balances are lower in the economy with guarantees. Since the drop in money balances that induces the crisis, $\gamma S^I$, and the jump in the exchange rate at the time of the crisis, $S^D/S^I$, are assumed to be the same for the two economies, this means that pre-crisis money balances also have to be lower in the economy with guarantees. This is true if pre-crisis expected depreciation, which depends on $q$ and $S^D/S^I$ is higher in the economy with guarantees. Since $S^D/S^I$ is held fixed, $q$ must be higher.

Propositions 1 and 2 provide the main message from this section of the paper. Conditional on a crisis of a given magnitude, as measured by $S^D/S^I$, in an economy with guarantees long-term inflation will be higher than in an economy without guarantees. Also, crises of a given magnitude are strictly more likely in economies with guarantees than in economies without them.

3. How does financing affect speculative attacks?

This section considers variants of the model presented in Section 2. The first step will be to consider a numerical example of the model in which there are government guarantees to bank creditors. Given calibrated values of the model parameters, we will determine the equilibrium values of $c$ and $q$. The analysis will be extended by considering variants of the model which explicitly allow for the possibility that the government issues nominal debt, and that PPP fails to hold, so that changes in relative prices can induce implicit fiscal reforms.

3.1. A benchmark example

Here I construct a numerical example of the model outlined in Section 2. Values for several model parameters must be chosen—in particular, values for any parameters appearing in Eqs. (29) and (30). First, normalize $Y=1$ and $S^I=1$. Let $\theta=0.1$, implying that real balances will represent just less than 10% of GDP in equilibrium—a typical value for the ratio of the monetary base to GDP in middle income countries. Let $\eta=0.6$, a value consistent with the range of estimates of money demand elasticities in developing countries provided by Easterly et al. (1995). Let $r=0.05$.

The remaining parameters are $\chi$, $\Gamma$, $\Delta$ and $S^D$. To calibrate $\chi$ requires an estimate of 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 $\chi$ must be a sufficiently small value such that the equilibrium level of real balances under the fixed exchange rate, $m^I$, is greater than $\chi$. Otherwise, the supply of domestic money would be exhausted in a speculative attack. I use $\chi=0.005$ in the simulations. This choice will imply an approximately 5% reduction in nominal balances immediately prior to the speculative attack. Let $\Gamma=0.2$, or 20% of GDP. Several recent banking crises are estimated to have
resulted in costs of roughly this magnitude. Initially, I assume there is no fiscal reform so $\Delta = 0$.

Finally, I let $S^D/S^I$ be variable. I compute the equilibrium value of $q$ for different values of $S^D/S^I$, as illustrated in Fig. 1(a). The figure shows that self-fulfilling speculative attacks are possible over a narrow range of values for $S^D/S^I$. Also, $q$ is a decreasing function of $S^D/S^I$, i.e. speculative attacks with big depreciations are less likely than speculative attacks with small depreciations. 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 is 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 $\chi S^I$, which is fixed. Therefore, 

Fig. 1. The probability of a speculative attack in four versions of the model. The results labeled “(a) Benchmark Model” were obtained for the model presented in Section 3.1 by solving for $q$ (the probability of the crisis) and $\gamma$ (the post-crisis money growth rate) taking each value of $S^D/S^I$ (the depreciation that occurs during the crisis) as given. The results labeled “(b) Nominal debt” were obtained in the same way for the model presented in Section 3.2. The results labeled “(c) Sticky prices” were obtained in the same way for the first model presented in Section 3.3. The results labeled “(d) Implicit Fiscal Reforms” were obtained in the same way for the second model presented in Section 3.3.

\[13\] For a variety of estimates of the costs of banking crises over the past 20 years, see Caprio and Klingebiel (1996) and Frydl (1999).
as $S^D/S^I$ rises, $q$ must fall 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 Eq. (33), this is

$$ (S^D/S^I)_{\text{max}} = \gamma e^{(1-\nu)} (1 - e^{\nu} Y/\theta Y) $$

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

Given the parameter values above, speculative attacks cannot occur in equilibrium in the absence of government guarantees. The reason for this is that given the assumed parameter values the left hand side of Eq. (32) is quite small. Therefore, the post-attack inflation rate, $\gamma$, does not cause a sufficient decline in money demand to be consistent with the drop, $\chi S^I$, that is required at the time of the speculative attack.

How do fiscal reforms affect the equilibrium outcomes? As the fiscal reform, $\Delta$, becomes larger, $\gamma$ 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 lower the probability of a speculative attack associated with a specific amount depreciation of the currency, $S^D/S^I$. In further experiments not reported here, I found that fiscal reforms of close to three-quarters of the fiscal cost of the bailout eliminate the possibility of speculative attacks in equilibrium.

3.2. Extending the model: nominal debt

This section extends the framework outlined above by introducing nonindexed government liabilities. If there is an outstanding stock of such liabilities at the time of a speculative attack, they will diminish in dollar value, providing a source of revenue to the government.

In this section, I extend the model by introducing bonds denominated in units of domestic currency. Specifically, let $B_t$ denote the quantity of one-period bonds issued by the government at the end of period $t$. Suppose that these bonds pay $N_t = 1 + n_t$ units of local currency at the end of period $t+1$, where $n_t$ is defined in Eq. (4), above. Given risk neutral investors, the time-$t$ price of each bond will be one unit of local currency.

The government net asset position at the end of period $t$ is now defined as $f_t = b_t - B_t/S_t$, where $b_t$ is government net dollar-denominated debt. The government’s flow budget constraint denominated in units of local currency is now:

$$ S_t b_t + B_t = S_t (R b_{t-1} + d_t) + N_{t-1} B_{t-1} - (M_t - M_{t-1}). $$

Under the fixed exchange rate regime, from Eq. (4), the net nominal interest rate is $n^l = r + q(S^D/S^I - 1)$. Hence, if we maintain the assumption that the government runs a constant primary deficit, $d^N$, under the fixed exchange rate regime, then for $t < T$ its flow budget constraint reduces to

$$ b_t + B_t/S^I = R b_{t-1} + N^l B_{t-1}/S^I + d^N $$

where $N^l = 1 + n^l$. 

I assume, as in Section 2, that the government is “born” with a certain net asset position \( \bar{f} \), and that under the fixed exchange rate regime it keeps its asset position constant at this level. The government’s debt management strategy is to also keep \( b_t \) and \( B_t \) constant, for \( t < T \), at the levels \( \bar{b} \) and \( \bar{B} \), respectively. Hence, \( \bar{f} = \bar{b} - \bar{B}/S^1 \). Given these assumptions, Eq. (37) implies

\[
d\bar{N} = -r\bar{b} - n^1\bar{B}/S^1.
\]

(38)

For a given level of \( \bar{f} \), notice that \( d\bar{N} \) is smaller the larger is \( \bar{B}/S^1 \) because Eq. (38) can be rewritten as

\[
d\bar{N} = r\bar{f} - (n^1 - r)\bar{B}/S^1
\]

(39)

and \( n^1 - r = q(S^D/S^1 - 1) > 0 \). Hence, a government that issues a greater fraction of its debt in local currency must be more fiscally conservative for given values of \( \bar{f}, q \) and \( S^D/S^1 \).

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 \( t = T \) reduces to

\[
b_T = Rb_T + \frac{N^1\bar{B}}{S^D} + \chi + \gamma - (\gamma - 1)\frac{M^*}{S^D} + d_T.
\]

(40)

For \( t > T \), the government’s budget constraint, as before, reduces to

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

(41)

Iterating on Eq. (41) and combining it with Eq. (40), we obtain:

\[
Rb_T + \frac{N^1\bar{B}}{S^D} + \chi + \gamma = R \left( \frac{\gamma - 1}{S^D} \right) M^* - \sum_{j=0}^{\infty} R^{-j} d_{T+j}
\]

(42)

Letting \( \Delta = \sum_{j=0}^{\infty} R^{-j}(d^N - d_{T+j}) \), using Eq. (38) and substituting in the expression for \( M^*/S^D \), we can rewrite Eq. (42) as

\[
\chi + \gamma - \Delta = \frac{R}{r} \left( \frac{\gamma - 1}{\gamma} \right) \theta Y e^{-q(\gamma+\gamma-1)} + \left( \frac{R}{r} n^1 \frac{\bar{B}}{S^1} - \frac{N^1\bar{B}}{S^D} \right).
\]

(43)

Given that \( n^1 > r \) and \( S^D/S^1 \), the last term is strictly positive. It is easy to verify that when uncovered interest parity holds exactly, the last term is the sum of two components. The first of these is the difference between the pre-crisis expected dollar value of the domestic debt, \( [(1-q)/S^1 + q/S^D]N^1\bar{B} \), and its post-crisis value \( N^1\bar{B}/S^D \). The second component is the present value of savings due to the post-crisis reduction in the government’s risk premium: \( (R/r)(n^1 - r)\bar{B}/S^1 \). In practice, I refer to the sum of these terms as debt deflation, though strictly speaking one might want to refer only to the first component in this way.

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14 Uncovered interest parity implies that \( R = [(1-q)/S^1 + q/S^D]n^1 \).
To examine the impact of nominal debt on equilibrium outcomes, I leave all parameters other than $\hat{B}$ unchanged relative to the benchmark case. Using Eqs. (29) and (43), and given a value of $S^D/S^I$, I compute the equilibrium values of $q$ and $\gamma$ for the case where $\hat{B} \in (0, 0.6)$, or up to 60% of GDP. These can be compared to the $q$’s and $\gamma$’s we obtained from the benchmark model.

Does nominal debt matter for the probability of a crisis? For the benchmark model, where $\hat{B} = 0$, we found that speculative attacks were possible in approximately the range $S^D/S^I \in (1.085, 1.144)$. Fig. 2 illustrates that jumps of the exchange rate of this magnitude are strictly less likely with nominal debt. Furthermore, the greater the stock of nominal debt, the lower the probability of a speculative attack of any given magnitude.

The intuition for this result is straightforward. With nominal debt, less seignorage revenue is needed to finance contingent liabilities. This means post-crisis money growth and inflation will be lower, implying higher post-crisis money balances. But recall that money balances must fall by a fixed amount, $\gamma S^I$, to trigger the crisis. Other things equal, therefore, money balances before the crisis must also be higher: this requires the probability of the speculative attack to be smaller.

Fig. 1(b) illustrates the same phenomenon while focusing on a specific case, $\hat{B} = 0.3$. If one holds the likelihood of the speculative attack fixed, the size of the speculative attack is much smaller when $\hat{B} = 0.3$. To focus on other aspects of how the equilibrium of the model is affected by introducing nominal debt, I focus on the case where $\hat{B} = 0.3$, and speculative attacks occur with probability $q = 0.1$.

Table 2 shows that for speculative attacks with $q = 0.1$, the initial depreciation of the currency and initial inflation are much lower with nominal debt (6.9%) than in the benchmark model (13.4%). Steady state inflation after the speculative attack, which is determined by $\gamma$, is lower by about 4 percentage points. Because the government raises

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Fig. 2. The effects nominal debt on the probability of a crisis. The model in Section 3.2 was solved for $q$ (the probability of the crisis) and $\gamma$ (the post-crisis money growth rate, not shown) taking each value of $S^D/S^I$ (the depreciation that occurs during the crisis) and $\hat{B}$ (the quantity of outstanding nominal debt) as given.
revenue from deflating the value of its nominal debt, in this case about 30% of its total financing, it does not need to raise as much seignorage revenue once the currency is floated: hence, $c$ is lower.

Given these findings, would a government in the pre-crisis period want to issue nominal rather than real debt? The framework used in this paper does not allow welfare assessments, but there are clear trade-offs involved in the decision to issue nominal debt. The greater the portion of the government’s debt that is issued in local currency the lower the risk of a speculative attack of a given magnitude, and the lower the rate of post-crisis inflation. However, as we saw above, issuing nominal debt comes at a cost in the pre-crisis period. For a given level of overall debt, the government must run a smaller primary deficit.

### 3.3. Extending the model: implicit fiscal reforms

The model, so far, is based on the assumption that PPP holds. But, as we saw in Section 1, after the Korean, Mexican and Turkish crises, domestic prices rose slower than exchange rates depreciated. We also saw that this change in relative prices appears to have significantly affected government finance in the crisis countries. So far our model does not allow for this possibility.

This subsection extends the model by introducing nontraded goods, and by assuming that PPP only holds for tradables at the producer level. This allows for deviations between the behavior of the aggregate price index and the exchange rate in the aftermath of a speculative attack. A shortcoming of this extended model is that it will not determine the price of nontraded goods in equilibrium. Instead, for simplicity, I will make assumptions about the path of nontraded goods prices and solve for the exchange rate and traded goods prices.\(^{15}\) In particular, I will assume that nontraded goods prices do not rise immediately when the currency crisis happens. In other words, in period $T$, I will assume that nontraded

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\(^{15}\) See Burstein et al. (2002) for a model in which nontraded goods prices are determined in general equilibrium.
goods prices remain at their pre-crisis levels. On the other hand, for \( t > T \), I will assume that nontraded goods prices increase at the same rate as traded goods prices. After introducing nontradables, I rewrite the government budget constraint to allow for implicit fiscal reforms. These reforms occur when the government has spending commitments to quantities of goods and taxes economic activity in both sectors. These changes to the model have implications for equilibrium outcomes.

3.3.1. Nontraded goods with sticky prices

The exchange rate, \( S_t \), is governed by the same set of beliefs described above. Assume that PPP holds for tradable goods at the producer level. I.e. the producer price of tradables, denoted \( \bar{P}_t^T \), is given by:

\[
\bar{P}_t^T = S_t
\]

for all \( t \). Like Burstein et al. (in press), assume that \( d \) units of nontradables are required to distribute tradable goods at the retail level. This, along with perfect competition, implies that the retail price of tradables is:

\[
P_t^T = \bar{P}_t^T + dP_t^N,
\]

where \( P_t^N \) is the price of nontradable goods.

Assume that under the fixed exchange rate regime \( P_t^N = S_t \). Furthermore, assume that \( P_t^N = S_t \), that is, nontradable goods prices do not rise in the period in which the speculative attack takes place. For \( t > T \), assume that all prices share the common inflation rate, \( \gamma \).

The money demand specification (Eq. (2)) does not need to be changed with our new assumptions. However, we must define a new price index relevant for money demand. A natural choice is to define a consumer price index (CPI) given by:

\[
P_t = (P_t^T)^\omega (P_t^N)^{1-\omega},
\]

where \( 0 < \omega < 1 \) represents the weight of tradable goods in household purchases.

Given the behavior of traded and nontraded goods prices, we have

\[
P_t = \begin{cases} (1 + \delta)\omega S_t & \text{for } t < T \\ \gamma^{t-T}(S^D/S^t + \delta)^\omega S_t & \text{for } t \geq T. \end{cases}
\]

Under the fixed exchange rate regime, the demand for money balances is

\[
M_t = \theta Y S_t^\omega (1 + \delta)\omega e^{-\eta(r+\gamma(S^D/S^t-1))}
\]

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

\[
M_t = \theta Y S_t^{\omega-\gamma-T}(S^D/S^t + \delta)^\omega e^{-\eta(r+\gamma-1)}.
\]

The money supply rule is still \( M_t^S = \gamma^{-T+1}(M_t^1 - \chi S_t^1) \). Combining this with Eqs. (46) and (47), the modified version of the equilibrium condition (29) is:

\[
\ddot{\theta}Ye^{-\eta[r+\gamma(S^D/S^t-1)]} = \chi + \ddot{\theta}Y \left( \frac{S^D/S^t + \delta}{1 + \delta} \right)^\omega e^{-\eta(r+\gamma-1)} / \gamma,
\]

where \( \ddot{\theta} = \theta(1 + \delta)^\omega \).
At this stage, we do not change the government’s flow budget constraint, so the lifetime budget constraint is:

\[
\gamma + \Delta = \frac{R}{r} \gamma \left( \frac{S_D}{S_I + \delta} \right) \alpha \frac{S_I}{S_D} e^{-\eta (r + \gamma - 1)} + \left( \frac{R}{r} \frac{n^I}{N^I} \frac{S_D}{S_I} - 1 \right) \frac{N^I \tilde{B}}{S_D}. 
\]

The difference between Eqs. (43) and (49) reflects changes in the expression for the dollar value of seignorage revenue, given the new specification of money demand.

To see the impact of these changes, I repeat the analysis of Section 2 with \( \tilde{B} = 0.3 \), while setting \( \omega = 0.5 \) and \( \delta = 1 \).\(^\text{16}\) Previously we set \( \theta = 0.1 \). But notice that if we keep the same value of \( \theta \), the new specification of money demand will imply that money balances are a larger fraction of GDP in the pre-crisis period for fixed values of \( \bar{h}, S_I, S_D, r, \) and \( q \).

Hence, I recalibrate the model so that \( \theta = 0.1 \).

Accounting for nontradable goods has a significant impact on equilibrium outcomes. Fig. 1(c) illustrates the fact that introducing sticky nontradables prices significantly raises the probability of a speculative attack of a given magnitude for all \( S_D/S_I \). What explains this phenomenon?

In the new model, money demand prior to the crisis is given by

\[
\tilde{\bar{h}} Y S_I e^{-\frac{(r + q (S_D/S_I) - 1)}{C_0}}.
\]

Since we have calibrated \( \tilde{\bar{h}} \) so that it equals our previous value for \( \bar{h} \), this expression is identical to the expression for pre-crisis money demand in the single good model. So, the dollar value of money demand prior to the crisis, which appears on the left-hand side of Eq. (48), is the same for the two models.

The models have differing implications for post-crisis money demand. In the new model, period \( T \)'s money demand, from Eq. (47), is

\[
M_T = \tilde{\bar{h}} Y S_I \left( \frac{S_D}{S_I + \delta} \right)^{\alpha} e^{-\frac{(r + q (S_D/S_I) - 1)}{C_0}}.
\]

Notice that this expression—divided by \( S_I \)—appears on the right-hand side of Eq. (48). For a given set of parameter values, it is smaller for the new model than the equivalent expression for the single good model, which is \( M_T = \tilde{\bar{h}} Y S_I (S_D/S_I) e^{-\frac{(r + q (S_D/S_I) - 1)}{C_0}} \). This reflects the fact that money balances are proportional to the price level, not the exchange rate. So, in the new model, where nontradable prices are sticky for one period, nominal money balances after the crisis are lower. This implies that nominal balances prior to the crisis must also be lower, and that \( q \) must be higher for given \( S_D/S_I \) and \( \gamma \).

This effect can be reinforced once we consider two effects of sticky prices on the government budget constraint. First, for a given value of \( S_D/S_I \), we have shown that the probability of a crisis, \( q \), will be higher in the new model. But this means the pre-crisis nominal interest rate, \( n^I = r + q (S_D/S_I - 1) \), will also be higher. Notice that this means revenue from debt deflation will be greater.

\(^{16}\) This value of \( \delta \) is consistent with the evidence presented in Burstein et al. (2001).
Second, notice that for any given values of $S^D/S^I > 1$ and $\gamma$ the expression for the present value of seignorage, in Eq. (49), is smaller than the expression for seignorage in earlier versions of the model, as in Eq. (43). The reason for this is straightforward: money demand is proportional to the price level not the exchange rate. Since, in the new version of the model, the crisis induces a permanent decline in the ratio of $P_T$ to $S$, the dollar value of post-crisis seignorage is smaller.

Other things equal, holding $S^D/S^I$ fixed, the equilibrium value of $\gamma$ will rise or fall depending on whether the increase in revenue from debt deflation is smaller or larger than the decrease in seignorage revenue. A higher value of $\gamma$ would lower post-crisis money demand. Using the same argument as above, this would require pre-crisis money demand to be lower as well and this would mean $q$ would have to be larger.

Table 2 (row c) shows further results, where, as before, we focus on speculative attacks that occur with probability 0.1. Given the above discussion, it is not surprising to find that introducing sticky nontradables prices makes the amount of depreciation associated with the crisis larger (12.2% versus 6.9% in the model with nominal debt). On the other hand, inflation in the period of the speculative attack is actually lower. This reflects the fact that nontradables, which do not move in the period of the attack, are the dominant effective component of the CPI.

Post-crisis steady-state inflation, which is determined by $\gamma$, is lower by about 2 percentage points. Above, we argued that $\gamma$ would be higher for a fixed value of $S^D/S^I$. However, because $S^D/S^I$ ends up higher for a fixed value of $q$, sufficient additional revenue is raised through debt deflation that $\gamma$ actually ends up smaller than before.

### 3.3.2. Implicit fiscal reforms

Suppose that government spending, measured in local currency units, is $P^T x^T + P^N x^N$, where $x^T$ and $x^N$ are quantities of tradable and nontradable goods purchased by the government. Suppose, further, that tax revenues, measured in local currency units, are $P^T \tau^T + P^N \tau^N$, where $\tau^T$ can be thought of as the product of a tax rate and the volume of production in sector $j$, for $j = T, N$. Here, I am implicitly assuming that the government purchases goods at producer prices and that it taxes the value of production.

Suppose that $x^T = x, x^N = x^N, \tau^T = \tau^T$ and $\tau^N = \tau^N$ for all $t$. This implies that, in the fixed exchange rate regime, the dollar value of the government’s primary deficit, $d_t$, is $d = x^T + x^N - \tau^T - \tau^N$. For $t \geq T$,

$$d_t = x^T - \tau^T + (P^N / S)(x^N - \tau^N) = d + (P^N / S)(x^N - \tau^N). \quad (51)$$

If the government’s initial spending on nontradables, $x^N$, is greater than its revenue derived from taxing them, $\tau^N$, 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 $P^N < S$.\(^{17}\)

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\(^{17}\) The empirical evidence in Section 1 is consistent with the notion that $x^N > \tau^N$, since it appears that governments in crisis countries have benefitted from implicit fiscal reforms.
In order to measure the impact of implicit fiscal reforms on the equilibrium, no modification of Eq. (48) from Section 2 is needed. Eq. (49) must be changed by noting that $D$ no longer represents explicit fiscal reforms. In fact, I will assume that there are no explicit fiscal reforms, so that $D = P_l j = 0 R / C_0 j (1 / C_0 P_N t S_I / S_D) (x_N / C_0 s_N) R / r$.

To illustrate the effects of this modification of the model, I assume that $x_N / C_0 s_N = 0.02$; that is, the government’s spending on nontradables exceeds its revenue from nontradables by 2% of GDP. The assumptions of Section 3.3.1 regarding the rest of the model’s parameters are maintained.

Since we did not change Eq. (48), $q$ will not change if we hold $S_D / S_I$ and $\gamma$ fixed. However, notice that with $x_N > \tau_N$, the government will raise revenue through implicit fiscal reforms. Therefore, it needs less seignorage revenue after the crisis. This implies a smaller value of $\gamma$, which raises post-crisis money demand. To raise pre-crisis money demand and maintain equality of the two sides of Eq. (48), we must also lower $q$. So crises of a given magnitude become less likely. This is revealed in Fig. 1(d).

Table 2 (row d) shows further results, where, as before, we focus on speculative attacks that occur with probability 0.1. Given the above discussion it is not surprising to find that introducing implicit fiscal reforms reduces the amount of depreciation associated with the crisis (9.0% versus 12.2% in the basic sticky price case). Inflation in the period of the speculative attack is also lower.

Steady-state inflation after the speculative attack, which is determined by $\gamma$, is slightly lower. This reflects the fact that with a new source of revenue, from implicit fiscal reforms, the government needs less seignorage revenue. The reduction in $\gamma$ is not dramatic, however, because the lower value of $S_D / S_I$ implies less revenue from debt-deflation than before.

The possibility of a post-crisis recession has been omitted from the model, but it is easy to guess what would happen. If taxes were proportional to real activity, tax revenue would decline in the post-crisis period. Other things equal, this would require more seignorage revenue and a higher post-crisis money growth rate, and would lower post-crisis money demand. The lower level of real activity would directly dampen money demand. Anything that lowers post-crisis money demand must be compensated, in equilibrium, by something that lowers pre-crisis money demand. For a given value of $S_D / S_I$, we would need an increase in $q$, the probability of a speculative attack.

4. Conclusions

This paper has explored two aspects of crises driven by agents’ self-fulfilling expectations of a devaluation. First, we have seen 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. Also 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 numerical examples, absent a banking sector bailout, speculative attacks cannot occur with positive probability.

Second, we have seen that the likelihood of a crisis of a given magnitude is affected by how the government finances itself in the post-crisis period. Our findings can be summarized as follows:

(i) the larger the government’s explicit fiscal reforms, the less likely a crisis of a given magnitude becomes;
(ii) the more nominal debt a government issues prior to the crisis, the less likely a crisis of a given magnitude becomes;
(iii) if there are nontraded goods with sticky prices, crises of a given magnitude become more likely;
(iv) if the government can raise revenue through implicit fiscal reforms, crises of a given magnitude become less likely.

The first, second and fourth results reflect the fact that if the government relies less on seignorage revenue, post-crisis money growth rates will be smaller and money demand will be higher. Since a fixed amount of money is traded at the central bank window during the crisis, this also implies that pre-crisis money demand must be higher. This can only be true if the probability of a crisis is smaller.

The third result reflects the fact that sticky prices suppress post-crisis nominal money demand. Since a fixed amount of money is traded at the central bank window during the crisis, this also implies that pre-crisis money demand must be lower. This is true if the probability of a crisis is larger.

The model used in the analysis was very stylized and I did not explore the full range of equilibria that are possible within this framework. In particular, I assumed that prices were sticky for only one period, all nominal debt was one-period debt, and post-crisis money growth was constant. I only considered crises driven by agents’ self-fulfilling expectations, and I ignored the effects of real uncertainty. None of these assumptions was necessary, and we might expect richer results from a more general exploration of the model.

References


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