# A fiscal perspective on currency crises and "original sin"[1]

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**Abstract**

Maturity and currency denomination of public debt are crucial determinants of macroeconomic dynamics in an open economy. The focus of this paper is on the dynamics of a fixed exchange rate regime in reaction to a shock that increases the real value of debt relative to government's primary surpluses, causing a fiscal imbalance. We show how monetary and fiscal policies, including maturity and denomination of debt, interact to determine the dynamic response of the economy and the magnitude of devaluation and inflation. If the government keeps the exchange rate temporarily fixed, the adjustment takes the form of a real appreciation and a current account deficit, followed by a real depreciation and a current account reversal coincident with devaluation. Our analysis suggests a broader view of: (1) fiscal causes and consequences of inflation and devaluation, (2) macroeconomic effects of fiscal shocks, and (3) interactions between fiscal and monetary policies, relative to standards in the open-economy literature.

# 1 Introduction

Why do fiscal authorities in emerging markets find it difficult to borrow in nominal terms? The literature addresses this question from different angles, but a recurrent theme is that policies guaranteeing stable prices are time inconsistent. Governments have an ex post incentive to cause inflation, any promise not to do so lacks credibility, and consequently the risk in lending in domestic currency translates into high premia.

Why is inflation fiscally beneficial? The common view is that a low inflation policy is "incredible" because a government with a fiscal problem either finds it attractive — or lacks other choices than — to finance a budget deficit by "printing money". Models of policy in emerging markets often emphasize seigniorage revenues, and this is true in particular of the literature on currency crises. According to the first-generation models (after the classic work of Krugman (1979) and Flood and Garber (1984)), uncontrollable seigniorage needs are the cause of currency instability: a fiscal imbalance must be matched with seigniorage revenues. This traditional view of speculative attacks, familiar to perhaps all economists, receives renewed attention following recent currency crises in Argentina, Brazil, East Asia, Russia and Turkey.[1]

Two developments are responsible for a recent reconsideration of fiscal benefits of inflation. The first is empirical: seigniorage revenues are moderate in several recent crisis episodes. Thus the adjustment mechanism at the center of the first-generation models is not apparent, even when crises have a striking fiscal dimension. The analysis of Burnside, Eichenbaum and Rebelo (2001a, 2001b, 2003) is a clear illustration of the fact that seigniorage is not the only mechanism through which devaluation and inflation produce fiscal revenues, and that it may be quite irrelevant empirically.

The second development is the recent rise of a general equilibrium literature that studies the link between monetary and fiscal policy regimes and price level determinacy. This literature

[1] The models of Krugman and Flood and Garber build on Salant and Henderson (1978). The first-generation literature includes, for example: Obstfeld (1986), Buiter (1987) and Calvo (1987). Buiter, Corsetti, and Pesenti (1998), Calvo (1998), Cavallari and Corsetti (2000), Flood and Marion (1999) and Jeanne (2000) are recent discussions of the literature on currency crises. Corsetti, Pesenti, and Roubini (1999a, 1999b) adopt the first-generation's setup as a starting point to interpret crises in emerging markets. In those papers, different from the Krugman model, a fiscal deficit can emerge after rather than before an exchange rate collapse.

formalizes monetary policy in terms of interest rate rules, dichotomizing fiscal policy into Ricardian and non-Ricardian — the latter case is known as the fiscal theory of the price level (FTPL).[2] The FTPL highlights the role of maturity and degree of indexation of public debt in macroeconomic dynamics. Sims (1997) observes that the FTPL and the first-generation literature are "close cousins". When one reconsiders the analysis of Krugman and Flood and Garber in an FTPL framework, the solved-forward government budget constraint by itself implies that the price level increases and the exchange rate depreciates, in such a way that the resulting wealth transfer from holders of public liabilities finances the fiscal imbalance. Unlike in the first-generation setup, one does not need to map the imbalance into a seigniorage target for the monetary authority. The analysis of how an economy adjusts to a fiscal imbalance focuses on maturity and denomination of public debt, in contrast to the emphasis on reserves and money market equilibrium in the first-generation models.

The developments outlined above have given rise to the question whether a synthesis of the FTPL and the first-generation literature can become a new framework to analyze the fiscal dimension of currency instability. Daniel (1998, 2001a) provides the first formal analysis of the link between the two literatures, interpreting a collapse of a fixed exchange rate regime as a consequence of non-Ricardian fiscal policy. Our own work (Corsetti and Maćkowiak (2000, 2003) builds a simple version of the synthetic model, developing it in several directions relative to the papers by Burnside, Eichenbaum and Rebelo and Daniel, as well as clarifying further the link between the FTPL and the classic first-generation models.

Our aim in this paper is to provide an exposition of the synthetic model, highlighting how it enhances our understanding of the effects of denomination and maturity of public debt. Our starting point is the experiment of Krugman and Flood and Garber in an economy with a fixed exchange rate and public debt (domestic- and foreign-currency, short- and long-term): we postulate an exogenous disturbance that decreases the present value of government's real primary surpluses relative to its outstanding liabilities, and analyze the dynamics of adjustment.

[2] Among papers on the FTPL are, for example: Benhabib, Schmitt-Grohé, and Uribe (2001), Cochrane (1999a, 1999b, 2001), Leeper (1991), Sims (1994, 1997, 1999) and Woodford (1994, 1995, 1996, 1998). Woodford (2000) is a recent review with further references, while Bergin (2000), Daniel (2001b), Dupor (2000), Canzoneri, Cumby, and Diba (1998) and Loyo (1998) are open-economy applications.

As in the FTPL, we model fiscal policy as non-Ricardian and monetary policy as pursuing an interest rate rule. We summarize the insights from the synthetic model as follows:

(1) Insufficient fiscal discipline can undermine currency stability *independently* of any need for seigniorage revenues. This paper contributes a simplest illustration of this point in the context of a small-open economy model with money introduced in a standard way. We show that — if the government delays devaluation in the presence of a fiscal imbalance — the present value of extra seigniorage revenues is *zero*. While the precise conclusion depends on the interest elasticity of money demand, the message is general: the role of seigniorage is akin to that of utility or technological parameters — it is *not* an essential part of the adjustment to a fiscal imbalance in an economy with public non-monetary liabilities.

(2) Disturbances that cause a collapse of a fixed exchange rate can be *nominal*, and need not imply a deterioration of government's real primary surpluses. This is because nominal shocks affect the real value of debt and are thus capable per se of causing fiscal strain. For instance, a foreign deflationary shock (like an appreciation of the dollar) can jeopardize the sustainability of a currency peg independently of changes in relative goods prices or "competitiveness" problems.

(3) Denomination of government debt determines the size of a currency crisis. In particular, small changes in the extent of "dollarization" of public liabilities can cause large differences in the magnitude of devaluation, in a nonlinear manner. The nonlinearity lets us understand why a government that borrows heavily in a foreign currency, like many emerging markets, is exposed to a devaluation of dramatic size. This is an important consequence of the "original sin" — the topic of this book (see also Eichengreen, Hausmann and Panizza (2002)).

(4) The equilibrium relation between the devaluation rate and the long-run inflation rate is *negative* — rather than positive as predicted by the first-generation models that postulate seigniorage targets. The reason for this negative relation is that higher long-run inflation implies a larger capital loss to holders of long-term nominal debt — independently of any seigniorage revenues it may generate. This is an important result in light of the observation that currency crises of striking proportions are *not* followed by chronic inflation.

(5) Maturity of nominal government debt matters for the timing of a currency crisis, with long-term liabilities making a delay possible even without seigniorage revenues. We verify that

this insight from the FTPL continues to prevail in the absence of purchasing power parity (PPP): debt maturity remains critical for understanding *when* a given fiscal shock affects the equilibrium exchange rate. In the data a real appreciation and a current account deficit often precede a speculative attack, while a real depreciation and a current account surplus coincide with a crisis. We display an example where a qualitatively identical dynamic path arises purely as part of the adjustment to a fiscal imbalance. Thus we show that the new framework is capable of accounting for the variation in the real exchange rate and the current account around crisis episodes — independent of, say, credit market imperfections or nominal stickiness.[3]

The rest of the paper is organized as follows. The next section presents the baseline, single-good framework, then discusses shocks causing a fiscal imbalance as well as fiscal and monetary policy rules. Section 3 uses the framework to analyze the dynamic adjustment to the imbalance, discussing the determinants of the equilibrium exchange rate. Section 4 augments the baseline framework to include a traded and a nontraded good, analyzing the dynamics of the real exchange rate and the current account. Section 5 concludes, and an appendix provides details of the model with deviations from PPP.

## 2 The baseline single-good model

This section lays out a simplest fully-specified model to study the dynamic adjustment to a one-time, unanticipated fiscal imbalance in a fixed exchange rate regime. Consider a small open-economy, with a government and a representative individual who receives an endowment of a single, tradable and perishable consumption good. In the single-good world economy with costless trade, the domestic price level $P$ and the foreign (dollar) price level $P^*$ are linked by the law of one price: $P = \mathcal{E}P^*$, where $\mathcal{E}$ denotes the exchange rate. The economy takes exogenously the foreign real interest rate (equal to the dollar nominal rate). We assume that

[3] See e.g. Burstein, Eichenbaum and Rebelo (2002), Corsetti, Pesenti and Roubini (1999b) and Milesi-Ferretti and Razin (1998) for a discussion of stylized facts concerning the real exchange rate and the current account. Schneider and Tornell (2000) derive predictions for the dynamics of the real exchange rate in a setup with a credit market imperfection and a government bailout guarantee. Burnside, Eichenbaum and Rebelo (2001b) and Burstein, Eichenbaum and Rebelo (2002) present models accounting for a large real depreciation at the time of an exchange rate crisis but not for a real appreciation prior to it.

the interest rate is equal to a constant $r$ such that $(1+r)\beta = 1$, where $\beta$ is the representative individual's discount factor.

## 2.1 The representative individual's optimum problem

The representative individual pays lump-sum taxes and holds: one-period nominal bonds $B$ paying an interest rate denoted by $i_t$, nominal perpetuities $L$ selling at a price $\theta_t$, money $M$ that yields utility, and one-period dollar bonds $B^*$. We assume that $M$, $B$ and $L$ are each strictly greater than zero, issued by the domestic government and held only by the representative individual in the domestic economy, whereas dollar bonds can be traded internationally.[4]

The representative individual maximizes:

$$\sum_{t=0}^{\infty} \beta^t \ln \left[ C_t^{\eta} \left( \frac{M_t}{P_t} \right)^{1-\eta} \right] \tag{1}$$

where $0 < \eta \leq 1$, subject to:

$$\frac{\theta_t L_t}{P_t} + \frac{B_t}{P_t} + \frac{M_t}{P_t} + \frac{\mathcal{E}_t B_t^*}{P_t} \leq \frac{(1+\theta_t) L_{t-1}}{P_t} + \frac{(1+i_{t-1}) B_{t-1}}{P_t} + \frac{M_{t-1}}{P_t} + \frac{\mathcal{E}_t (1+r) B_{t-1}^*}{P_t} + Y_t - \tau_t - C_t$$

in every period, as well as to:

$$\lim_{t\to\infty} \left( \frac{1}{1+r} \right)^t \left( \frac{\theta_t L_t}{P_t} + \frac{B_t}{P_t} + \frac{\mathcal{E}_t B_t^*}{P_t} + \left( \frac{1}{1+i_t} \right) \frac{M_t}{P_t} \right) \geq 0$$

where $Y$ and $C$ denote endowment and consumption of the single good, respectively, and $\tau$ are real lump-sum taxes (or transfers, if negative).

The first order conditions with respect to $B^*$and $B$ imply that the uncovered interest rate parity holds:

$$1 + i_t = (1+r) \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \tag{2}$$

and the first order condition with respect to $L$ yields an intertemporal relationship between perpetuity prices:

$$\theta_t (1+i_t) = 1 + \theta_{t+1} \tag{3}$$

[4]The distribution of nominal claims on the government between domestic agents and foreigners matters for a welfare evaluation of a crisis, something we leave for future research.

We solve (3) forward, arriving at a relationship between the perpetuity price and future nominal interest rates:[5]

$$\theta_t = \sum_{s=0}^{\infty} \left[ \prod_{k=0}^{s} \left( \frac{1}{1 + i_{t+k}} \right) \right] \tag{4}$$

The transversality condition of the agent's problem is:

$$\lim_{t \to \infty} \left( \frac{1}{1+r} \right)^t \left( \frac{\theta_t L_t}{P_t} + \frac{B_t}{P_t} + \frac{\mathcal{E}_t B_t^*}{P_t} + \left( \frac{1}{1+i_t} \right) \frac{M_t}{P_t} \right) = 0 \tag{5}$$

Given our earlier assumption that $(1+r)\beta = 1$, the first order condition with respect to $B^*$ implies that the shadow value of the budget constraint is constant at $\lambda$. We then know that optimal consumption is constant and equal to $\eta/\lambda$. We can combine the first order conditions with respect to $B$ and $M$ to obtain a money demand relation:

$$\frac{M_t}{P_t} = \left( \frac{1-\eta}{\lambda} \right) \left( \frac{1+i_t}{i_t} \right) \tag{6}$$

## 2.2 The government budget constraint

The period-by-period government budget identity is:

$$\frac{\theta_t L_t}{P_t} + \frac{B_t}{P_t} + \frac{M_t}{P_t} + \frac{\mathcal{E}_t F_t}{P_t} = \frac{(1+\theta_t) L_{t-1}}{P_t} + \frac{(1+i_{t-1}) B_{t-1}}{P_t} + \frac{M_{t-1}}{P_t} + \frac{\mathcal{E}_t (1+r) F_{t-1}}{P_t} - \tau_t \tag{7}$$

where $F$ denotes one-period dollar bonds issued by the domestic government.[6] Notice our assumption the government can borrow in dollars at the world interest rate $r$, implying that

[5] In our forward solution, we restrict attention to competitive equilibria in which the following terminal condition holds:

$$\lim_{s \to \infty} \left[ \prod_{k=0}^{s} \left( \frac{1}{1+i_{t+k}} \right) \right] \theta_{t+s+1} = 0$$

[6] It is worth noting here that governments have many imperfectly indexed liabilities other than publicly traded bonds, including long-term spending commitments like pensions. For instance, in the aftermath of an exchange rate crisis governments sometimes freeze spending in nominal terms. Even when temporary, imperfect indexation of spending can generate large fiscal gains. A moderate change in the price level can bring about substantial wealth transfers that help resolve a fiscal crisis — in this respect, simulations on the fiscal impact of moderate inflation in Sweden by Persson, Persson and Svensson (1998) provide an instructive example. Consistent with that study, one could interpret "nominal public debt" in our model in a broad sense, redefining $\tau$ as including only items that are fully indexed to prices.

it does not default on its dollar bonds.[7] Using the individual's first order conditions and the following terminal condition:

$$\lim_{t\to\infty}\left(\frac{1}{1+r}\right)^{t}\left(\frac{\theta_t L_t}{P_t}+\frac{B_t}{P_t}+\frac{\mathcal{E}_t F_t}{P_t}\right)=0 \tag{8}$$

we obtain a solved-forward version of the government budget constraint (7):

$$\frac{(1+\theta_t)\,L_{t-1}+(1+i_{t-1})\,B_{t-1}+M_{t-1}}{P_t}+\frac{\mathcal{E}_t\,(1+r)\,F_{t-1}}{P_t}=\sum_{s=0}^{\infty}\left(\frac{1}{1+r}\right)^{s}\left[\tau_{t+s}+\left(\frac{i_{t+s}}{1+i_{t+s}}\right)\frac{M_{t+s}}{P_{t+s}}\right] \tag{9}$$

In equilibrium, the real value of public liabilities equals the present discounted value of future real primary surpluses plus interest payments avoided by maintaining real balances ("seigniorage"). In a closed economy model, this derivation would simply make use of (5) as the terminal condition — we can see this by imagining a closed economy model with an identical setup except that $B^*$ (or $F$) would denote indexed, or "real", debt. An open-economy model like ours, however, introduces a subtle problem: it is theoretically possible that, with perfect insurance markets between countries, debt of one government can grow without a bound — corresponding to an explosive growth of assets of another government. Private sector's transversality generates a terminal condition for solved-forward budget constraints of all governments taken together, rather than for the constraint of each government separately. Like Bergin (2000), Daniel (2001b) and Sims (1999), we find it realistic to consider equilibria that emerge when the government in an open economy faces a terminal condition in the form of (8).

### 2.3 Equilibrium

A competitive equilibrium in this small open-economy is a specification for a time path of the vector $\{Y, r, C, B^*, B, M, L, F, \tau, i, \theta, \mathcal{E}, P^*, P\}$ such that: (1) when the representative individual takes the $\{Y, r, \tau, i, \theta, \mathcal{E}, P^*, P\}$ part of the path as given, $\{C, B^*, B, L, M\}$ solves her optimum

[7] It is not realistic to rule out the possibility of government default, but there is a good reason for doing so in a simple model. Outright default and the kind of implicit default on nominal government liabilities that occurs via unanticipated inflation are different phenomena. A holder of a government bond on which outright default is possible is exposed not just to to aggregate default uncertainty, but also to negotiation and legal costs as well as additional uncertainty over which creditors would bear the default cost. See Sims (1997) for a discussion.

problem; (2) the solved-forward government budget constraint (9) holds.[8]

### 2.4 On the present value of seigniorage in equilibrium

The classic first-generation papers focus on seigniorage as *the* adjustment mechanism to a fiscal imbalance. It is not evident that the role of seigniorage revenues is as important as that literature suggests. We mention an empirically motivated objection in the introduction. At a theoretical level, it is apparent that — in the presence of nominal public debt — seigniorage need not play *any* role in financing a fiscal imbalance. In this model for instance, with money introduced in a standard way, *the present value of seigniorage* in equilibrium, which we denote with $\Omega$, *is independent of the path of nominal interest rates*:

$$\Omega = \sum_{s=0}^{\infty} \left(\frac{1}{1+r}\right)^s \left(\frac{i_{t+s}}{1+i_{t+s}}\right) \frac{M_{t+s}}{P_{t+s}} = \left(\frac{1+r}{r}\right)\left(\frac{1-\eta}{\lambda}\right) \tag{10}$$

If the government delays devaluation in the presence of a fiscal imbalance, the present value of extra seigniorage revenues is zero — anticipated money growth fails to produce any fiscal gains. What matters for this conclusion is the interest elasticity of money demand: depending on its value, it is even possible for net seigniorage revenues to be negative — adding to, rather than offsetting a fiscal imbalance.[9]

We take this result as an illustration of the fact that the role of seigniorage is akin to that of utility or technological parameters — it is *not* an essential part of the adjustment to a fiscal imbalance in an economy with nominal debt. For this reason, the rest of our analysis abstracts from money altogether setting $\eta = 1$. In effect, we study devaluation scenarios in which no portion of an imbalance is financed by anticipated money growth, and all of it is financed by unanticipated wealth transfers from holders of nominal liabilities. With $M = 0$ we think of the price level, $P$, as the rate at which a newly issued, one-period nominal bond trades for the real commodity. Analogously, of the nominal interest rate as the rate at which the domestic

[8] Recall that we postulate (9) as an additional equilibrium condition. In a closed economy model, an equivalent condition would be implied by (7) and private sector's optimization. Note also that in this open-economy model $F$, determined by government supply, need not equal $B^*$.

[9] Lahiri and Vegh (1998) study in detail how the present value of seigniorage depends in first-generation models on the interest elasticity of money demand.

government exchanges old, one-period nominal bonds for new ones; and of the perpetuity as an asset promising one unit of short-term bonds in every period from now on.

### 2.5 Policy rules and shocks causing a fiscal imbalance

Suppose that the foreign price level is equal to a constant, $P^*_\alpha$, and that the government fixes the exchange rate at $\overline{\mathcal{E}}$. For a fixed exchange rate to be sustainable, fiscal policy must be consistent with the government's solved-forward budget constraint (9) holding at $\overline{\mathcal{E}}$. Let $\{\overline{\tau}_{t+s}\}_{s=0}^{s=\infty}$ be a path of primary surpluses such that (9) holds given $P^*_\alpha$ and initial debt ($B_{t-1}$, $L_{t-1}$ and $F_{t-1}$) with the exchange rate *permanently* fixed at $\overline{\mathcal{E}}$, that is $\mathcal{E}_{t+s} = \overline{\mathcal{E}}$, $s \geq 0$. By definition, then, $\{\overline{\tau}_{t+s}\}_{s=0}^{s=\infty}$ is a sequence such that:

$$\sum_{s=0}^{\infty} \left(\frac{1}{1+r}\right)^s \overline{\tau}_{t+s} = \frac{(1+1/r)\, L_{t-1} + (1+r)B_{t-1}}{\overline{\mathcal{E}} P^*_\alpha} + \frac{(1+r)\, F_{t-1}}{P^*_\alpha} \tag{11}$$

To satisfy the above condition, a sequence of $\tau$'s must eventually imply a strong feedback from debt to $\tau$'s. In response to shocks hitting the economy, policy must set a path of $\tau$'s so as to insure that primary surpluses fully back debt, given $\overline{\mathcal{E}}$. The FTPL literature refers to this fiscal policy as *passive* or *Ricardian*.

Recent contributions begin, in the spirit of Krugman, by assuming that the government fails to stick to Ricardian policy. The motivation of e.g. Corsetti, Pesenti and Roubini (1999a) and Burnside, Eichenbaum and Rebelo (2001a) is the arrival of news about a bailout of private companies. As a complement to focusing directly on a deterioration of primary surpluses, it is appealing to motivate a fiscal imbalance as a consequence of an external shock.[10] Most economists would probably find it intuitive that a change in real international prices exogenous to a small economy, like the terms-of-trade or the world real interest rate, can result in fiscal slippage. What is not readily apparent and what this model makes clear, is that a foreign *nominal* shock can also lead to a fiscal imbalance with critical consequences for a fixed exchange rate policy.

[10] There is a vector-autoregressive literature documenting that a substantial fraction of macroeconomic variation in small economies originates abroad (e.g. Calvo, Leiderman and Reinhart (1993), Canova (2003), Cushman and Zha (1997) and Maćkowiak (2001)).

Suppose the foreign price level changes in period $t$ to a new, permanent level $P^*_\beta$ where $P^*_\beta \leq P^*_\alpha$. Provided the inequality is strict, the shock increases on impact the real value of both nominal and dollar debt. Foreign deflation increases the quantity of the real commodity the government promises to bondholders, regardless of whether their claims are denominated in domestic or in foreign currency. Given the definition of $\{\overline{\tau}_{t+s}\}_{s=0}^{s=\infty}$, we now write the solved-forward government budget constraint (9) in period $t$ as follows:

$$\frac{(1+\theta_t)\,L_{t-1}+(1+r)\,B_{t-1}}{\mathcal{E}_t P^*_\beta}+\frac{(1+r)\,F_{t-1}}{P^*_\beta}=\left[\sum_{s=0}^{\infty}\left(\frac{1}{1+r}\right)^s\overline{\tau}_{t+s}\right]-\Delta \qquad (12)$$

where $\mathcal{E}_t$ may or may not equal $\overline{\mathcal{E}}$ in equilibrium. In the above expression, $\Delta$ is a measure of the extent of fiscal adjustment the government undertakes in reaction to the shock, with $\Delta < 0$ corresponding to reform and $\Delta > 0$ to deterioration beyond the immediate effect of the shock.[11] A restriction we place on $\Delta$ is that it satisfies:

$$\Delta > \left[\sum_{s=0}^{\infty}\left(\frac{1}{1+r}\right)^s\overline{\tau}_{t+s}\right]-\left[\frac{(1+1/r)\,L_{t-1}+(1+r)B_{t-1}}{\overline{\mathcal{E}}P^*_\beta}+\frac{(1+r)\,F_{t-1}}{P^*_\beta}\right]$$

Thus we in effect assume that the shock coincides with fiscal policy becoming *active* or *non-Ricardian*, in the terminology of the FTPL literature.

The fiscal implications of nominal shocks have not been noted by previous contributions on speculative attacks. Yet two realistic scenarios make the case $P^*_\beta < P^*_\alpha$ interesting. The first is deflation in the euro area or in the United States, or an appreciation of the dollar that decreases dollar prices of commodities traded in the world market. Second, we are motivated by the role of Brazil's devaluation in 1999 in the recent crisis in Argentina. A devaluation in Brazil decreases international prices faced by Argentina. While this is an improvement in Argentina's terms-of-trade or a relative price change, the impact of the shock on the real value of Argentina's public debt is equivalent to that of a decrease in $P^*$ or a purely nominal shock.[12]

[11] For example, one can assume that from time $T_d$ onwards primary surpluses change by a constant $d$:

$$\Delta \equiv \frac{(1+r)\,d}{r}\left(\frac{1}{1+r}\right)^{T_d-t}$$

Letting $T_d \geq t$ allows for the possibility that primary surpluses change at a future date.

[12] A more realistic model, with a nominal rigidity, might predict a decrease in Argentina's output in reaction to Brazil's devaluation, and a consequent deterioration in Argentina's primary surpluses. See e.g. Hausmann

While we think of the case $P^*_\beta < P^*_\alpha$ as a realistic example, our analysis allows for the possibility that $P^*_\beta = P^*_\alpha$ because we do not want to specialize to only one source of a fiscal imbalance. An adverse shock underlying $\Delta$ can stem from a variety of external and domestic sources. Once this disturbance occurs, the government may attempt to adjust the path of its budgets in an effort to reverse the negative impact of the shock. What we assume is that the government cannot (or is not willing to) implement reforms such that its debt continues to be backed fully with real taxes, and (9) holds with the exchange rate permanently fixed at $\overline{\mathcal{E}}$. Thus $\Delta$ is defined as the net change in the present value of real primary surpluses *after* the government has taken all measures it deemed feasible to reverse the impact of the shock. Note that the restriction on $\Delta$ implies that $\Delta > 0$ so long as $P^*_\beta = P^*_\alpha$.

Having described fiscal policy, we complete the model by specifying an interest rate rule for monetary policy. So long as the exchange rate is fixed at $\overline{\mathcal{E}}$, the nominal interest rate is determined by the uncovered interest rate parity (2) evaluated at $\mathcal{E}_t = \overline{\mathcal{E}}$. In the event of a devaluation, we assume that the interest rate is set according to the reaction function:

$$1 + i_{\widetilde{T}+s} = \phi_0 + \phi_1 \frac{\mathcal{E}_{\widetilde{T}+s}}{\mathcal{E}_{\widetilde{T}+s-1}} \tag{13}$$

where $\widetilde{T} \geq t$ is the period of devaluation, and $s \geq 0$. According to this rule, the (gross) nominal interest rate is a linear function of the (gross) depreciation rate. We assume that $\beta\phi_1 < 1$, i.e. policy makes $i$ react weakly to depreciation (or inflation) — this is an instance of *passive* monetary policy familiar from the FTPL literature.[13] To derive closed-form solutions, we specialize to a simple interest rate peg such that $i_{\widetilde{T}+s} = i^p$ (that is, $\phi_1 = 0$ and $\phi_0 - 1 = i^p$), $s \geq 0$ (Corsetti and Maćkowiak (2003) examine the general rule (13)). Note that the choice of $i^p$ determines the rate of chronic depreciation in the post-devaluation period.

and Velasco (2002) for an analysis of the crisis in Argentina, including a discussion of the impact of Brazil's devaluation on its neighbor.

[13] We also assume that $\beta\phi_0 \geq 1 - \beta\phi_1$ so that the post-devaluation (gross) chronic depreciation rate converges to a number greater than or equal to 1. This assumption is inessential for substantive results of this paper, but allows us to rule out persistent deflation after devaluation.

# 3 Adjustment to a fiscal imbalance

We now use our framework to analyze the adjustment to a given fiscal imbalance, a classic topic since Krugman's work. To build intuition, we initially carry out the analysis under the assumption that the government abandons the peg in the same period in which the imbalance appears — thus causing an unanticipated jump in the exchange rate at $t$. We subsequently consider the case in which the parity is abandoned at some later date $\widetilde{T} > t$.

## 3.1 Devaluation with foreign nominal shocks and shocks to primary surpluses

An immediate, unanticipated devaluation in period $t$ reduces the real value of $B$ and $L$, resulting in a wealth transfer, while the post-devaluation interest rate rule determines $\theta_t$. A higher rate of chronic post-devaluation inflation reduces $\theta_t$ — by (4) — creating an additional wealth transfer. In equilibrium, the wealth transfers due to jumps in the exchange rate and the price of perpetuities finance the fiscal imbalance. Formally, once policy chooses the post-collapse nominal interest rate $i_{t+s} = i^p$, $s \geq 0$, the equilibrium condition (4) yields the perpetuity price $\theta_t = (1/i^p)$. To solve for the equilibrium devaluation rate $\left(\mathcal{E}_t/\overline{\mathcal{E}}\right)$, we make use of the solved-forward government budget constraint — combining (11) with (12) we obtain the unique solution:

$$\frac{\mathcal{E}_t}{\overline{\mathcal{E}}} = \frac{\dfrac{\left[1 + (1/i^p)\right] L_{t-1} + (1+r)\, B_{t-1}}{\overline{\mathcal{E}} P_\beta^*}}{\dfrac{\left[1 + (1/r)\right] L_{t-1} + (1+r)\, B_{t-1}}{\overline{\mathcal{E}} P_\alpha^*} - \dfrac{\left(P_\alpha^* - P_\beta^*\right)(1+r)\, F_{t-1}}{P_\alpha^* P_\beta^*} - \Delta} \tag{14}$$

The equation (14) highlights several properties of the equilibrium devaluation rate $\left(\mathcal{E}_t/\overline{\mathcal{E}}\right)$. First, the jump in the exchange rate is increasing in the size of the fiscal imbalance: $\left(\mathcal{E}_t/\overline{\mathcal{E}}\right)$ is decreasing in $P_\beta^*$ and increasing in $\Delta$. The exchange rate change is determined both by the size of the shock and by the policy reaction to it. Second, for any given imbalance, dollar debt acts as leverage — the higher the fraction of debt denominated in dollars, the larger the devaluation rate. An economy in which the government borrows heavily in dollars, like many emerging markets, sees a larger jump in the exchange rate for a given fiscal imbalance.

Third, post-devaluation interest rate policy influences $\left(\mathcal{E}_t/\overline{\mathcal{E}}\right)$, because the post-collapse path of interest rates determines the long-term bond price. Specifically, a higher $i^p$ implies a larger jump in $\theta_t$, and consequently a smaller one-time devaluation rate $\left(\mathcal{E}_t/\overline{\mathcal{E}}\right)$. Thus a currency crisis followed by little long-run inflation, like in some recent episodes, is associated with a larger initial exchange rate adjustment. In fact, setting $i^p = r$ implies that the depreciation rate in the post-devaluation steady state is zero. If no further shocks hit the economy, the dynamics involve a (relatively larger) one-time jump in the exchange rate to a new, constant level.[14]

The post-devaluation regime in the classic first-generation models exhibits chronic depreciation. Real money decreases, because a standard money market equilibrium relation makes the quantity of real money a negative function of the chronic depreciation rate. It is well known that those predictions are inconsistent with facts: some real-world post-devaluation regimes do not exhibit ongoing inflation or low money balances. Our setup makes it clear that a fiscal imbalance causes a one-time devaluation. Post-devaluation policy can set the nominal interest rate at *any* desired level, not necessarily switching to a regime of chronic depreciation. Money supply adjusts consistent with that policy, and there is no implication that real money decreases relative to the fixed exchange rate period.

It is straightforward to check that the unique solution to the solved-forward government budget constraint satisfies the other equilibrium conditions, and therefore is the unique equilibrium exchange rate. In particular, given $i^p$ and $\mathcal{E}_t$, the uncovered interest rate parity (2) determines the rate of depreciation $(\mathcal{E}_{t+1}/\mathcal{E}_t)$. The result that non-Ricardian fiscal policy and passive monetary policy deliver a uniquely determinate price level and a stationary inflation rate is familiar from the FTPL literature.[15]

Subsequent algebraic derivations are easier to follow if we assume that $P^*_\beta = P^*_\alpha$. The solution for $\left(\mathcal{E}_t/\overline{\mathcal{E}}\right)$ makes it clear that this assumption does not affect generality of the argument — we can simply think of $\Delta$ as a complete measure of the fiscal impact of the shock, whatever such shock may have been. So long as $P^*_\beta = P^*_\alpha$, we can normalize $P^*$ to 1, thinking of the

[14] We assume that $i^p$ is chosen so that $\mathcal{E}_t > \overline{\mathcal{E}}$.

[15] To determine the equilibrium level of consumption, so long as $P^*_\beta < P^*_\alpha$, we would need to make an arbitrary assumption regarding the small economy's net international asset position in dollar bonds.

domestic price level as synonymous with the exchange rate. Given our earlier assumption that $(1+r)\beta = 1$, the first order condition with respect to $B^*$ now implies that consumption is constant in equilibrium.

### 3.2 Determinants of the rate of devaluation: the new "shadow exchange rate"

Expression (14) is the equilibrium exchange rate conditional on devaluation at time $t$. After Flood and Garber, economists refer to equilibrium exchange rates conditional on abandoning the peg as *shadow* rates.[16] This section characterizes the shadow rate (analogous to expression (14)), if the peg is not abandoned at the time when the fiscal imbalance materializes.

Can the government choose to delay devaluation until some period $\widetilde{T} > t$? For a delay to be consistent with equilibrium, the solved-forward government budget constraint must hold with $\mathcal{E}_t = \overline{\mathcal{E}}$ exclusively by virtue of a wealth transfer from holders of nominal *long-term* debt, due to an unanticipated jump in $\theta_t$. Thus a delay is consistent with equilibrium only if $L$ is of sufficient size relative to the imbalance; otherwise, the exchange rate must jump immediately in equilibrium. While the model considers perpetuities for simplicity, the point is general: abstracting from seigniorage, the government can postpone devaluation only if it has a large enough stock of nominal debt of sufficient maturity. This is a condition emerging markets are less likely to satisfy than developed economies.

Assuming that this condition holds in our economy, we combine (11) and (12) with $\mathcal{E}_t = \overline{\mathcal{E}}$ to solve for the equilibrium perpetuity price in period $t$:

$$\theta_t = \frac{1}{r} - \Delta \frac{\overline{\mathcal{E}}}{L_{t-1}} > 0 \tag{15}$$

$\theta_t$ is uniquely defined, because the jump in the bond price must guarantee that the solved-forward government budget constraint holds with $\mathcal{E}_t = \overline{\mathcal{E}}$. Letting $\widetilde{T} > t$ denote the date at which the government abandons the peg, we use (2) and (3) as well as the policy rule $i_{\widetilde{T}+s} = i^p$,

[16] See Cavallari and Corsetti (2000) for a generalization of the concept to first- and second-generation models.

$s \geq 0$ to obtain an intertemporal relationship between perpetuity prices in periods $t$ and $\widetilde{T}$:

$$\theta_t = \frac{1}{r} + \left(\frac{1}{1+r}\right)^{\widetilde{T}-t-1} \left(\frac{1+(1/i^p)}{(1+r)\left(\mathcal{E}_{\widetilde{T}}/\overline{\mathcal{E}}\right)} - \frac{1}{r}\right) \tag{16}$$

Putting together (15) and (16), we arrive at the unique solution for the equilibrium devaluation rate $\left(\mathcal{E}_{\widetilde{T}}/\overline{\mathcal{E}}\right)$:[17]

$$\frac{\mathcal{E}_{\widetilde{T}}}{\overline{\mathcal{E}}} = \frac{\left(L_{t-1}/\overline{\mathcal{E}}\right)}{\left(\frac{i^p}{1+i^p}\right)\left(\frac{1+r}{r}\right)\frac{L_{t-1}}{\overline{\mathcal{E}}} - \left(\frac{i^p}{1+i^p}\right)\Delta\,(1+r)^{\widetilde{T}-t}} \tag{17}$$

This expression together with (14) establishes properties of the shadow rate: (1) A larger imbalance $\Delta$ requires a larger jump in the bond price and a larger devaluation rate at any date. (2) A larger $L$ acts as a cushion for the government, being associated with a smaller jump in the bond price and a smaller devaluation rate. (3) An increase in post-devaluation interest rates (or in long-run inflation) decreases the devaluation rate. (4) Delaying the collapse further into the future (i.e. an increase in $\widetilde{T}$) raises the equilibrium devaluation rate.[18]

Numerical examples of the model's solution in figure 1 illustrate its empirically relevant, nonlinear nature. The top graph shows $\left(\mathcal{E}_t/\overline{\mathcal{E}}\right)$ as a function of the portion of public debt denominated in foreign currency. A relatively small change in the extent of "dollarization" can lead to large differences in the magnitude of a crisis. For example, the impact of a combination of 10% of foreign deflation and a fiscal imbalance of $\Delta = 0.1$ (10% of GDP, in present value) more than doubles when the share of dollar debt increases from 80 to 90%. (E.g. Levy (2002) reports for Argentina a share of dollar bonds in public debt of 87-98% between 1997 and 2001.) The bottom graph illustrates rapid increases in the shadow devaluation rate $\left(\mathcal{E}_{\widetilde{T}}/\overline{\mathcal{E}}\right)$ as the government delays devaluation (i.e. $\widetilde{T} - t$ increases).[19]

[17] An expression similar to (17) is at the center of the contributions by Daniel (1998, 2001a). (She also obtains an expression similar to (14), setting $P^*_\alpha = P^*_\beta$ and $B = 0$.) Daniel's interpretation is that monetary policy can choose (subject to equilibrium behavior of private agents) two of the three variables: the magnitude of the devaluation, its timing and the post-collapse inflation rate.

[18] Following our discussion of devaluation in period $t$, it should be evident that the unique solution for $\left(\mathcal{E}_{\widetilde{T}}/\overline{\mathcal{E}}\right)$ satisfies the other equilibrium conditions.

[19] Both numerical examples assume that public debt is 50% of GDP, $i^p = r = 5\%$; the second in addition sets the share of long-term debt in total nominal debt equal to 50%.

### 3.3 The timing of devaluation

Our framework shares the basic feature of the first-generation models: the emergence of a fiscal imbalance implies that the currency depreciates in finite time. To see this, note that, when calculating $\left(\mathcal{E}_{\widetilde{T}}/\overline{\mathcal{E}}\right)$, we have assumed that the fiscal imbalance $\Delta$ is no larger than the present value of the maximum wealth transfer from long-term bond holders:

$$\Delta(1+r)^{\widetilde{T}-t} < \frac{L_{t-1}}{\overline{\mathcal{E}}}\left(\frac{1+r}{r}\right) \tag{18}$$

The above formula suggests that a currency collapse must occur before the passage of time changes the sign of the above inequality, i.e. before $\widehat{T}$ such that:

$$\widehat{T} = t + \frac{\log\left[\frac{L_{t-1}}{\overline{\mathcal{E}}}\left(\frac{1+r}{r}\right)\right] - \log\Delta}{r} \tag{19}$$

Thus, conditional on $L_{t-1}$ and $\Delta$, there exists a finite upper bound $\widehat{T}$ to the date of devaluation — note the implication that the government can borrow to defend the peg until $\widehat{T}$. Following Grilli (1986), we refer to $\widehat{T}$ as the time of a *natural collapse* of the exchange rate. In more general specifications, the natural collapse date will depend on utility and technological parameters as well as on *seigniorage* (perhaps most important from the viewpoint of the first-generation literature), but will remain finite. An increase in the present value of seigniorage will give the government more resources to back its debt, decreasing the shadow exchange rate much like an increase in $i^p$ in this model (Maćkowiak (2002)).[20]

While a fiscal imbalance makes devaluation inevitable, the model fails to pin down the date of the collapse — any period between $t$ and $\widehat{T}$ can be the devaluation date. This is an important difference relative to the first-generation model, with its uniquely defined date of a speculative attack.[21]

[20]If the government attempted to delay the devaluation past $\widehat{T}$, its solved-forward budget contraint would fail to hold with $\mathcal{E}_t = \overline{\mathcal{E}}$, and the peg would collapse in period $t$. Lahiri and Vegh (2000) introduce a government bond that is assumed to have utility value – its price is therefore not determined exclusively by the uncovered interest parity. The government can borrow by issuing such bonds at increasing interest rates. Buiter (1987) directly assumes an upward-sloping supply schedule for reserves. Those considerations do not matter for the substance of our argument – they merely act to decrease $\widehat{T}$ as borrowing increases.

[21]Corsetti and Maćkowiak (2003) show that an interest rate rule pursued by monetary policy determines a

# 4 Adjustment with deviations from PPP

The framework laid out above assumes — like the classic first-generation literature — a single-good world economy with the law of one price, shifting the focus from reserves and the monetary base to public debt and interest rate rules. In the framework, the adjustment to a fiscal imbalance depends on maturity of debt denominated in domestic currency. But if prices deviate from purchasing power parity, there may exist another adjustment mechanism — independent of debt maturity — via which *price level* inflation brings about a fiscal transfer consistent with a temporary *exchange rate* stability.

To address this issue, we consider a small-open economy with a traded and a nontraded good. We verify whether there is an equilibrium in which, when a fiscal imbalance appears, the price of nontradables rises in such a way that the resulting decrease in the real value of nominal public debt finances the imbalance. The government could then choose to postpone devaluation, without any long-term liabilities outstanding or without having recourse to seigniorage revenues. The adjustment mechanism would involve a real appreciation in anticipation of a speculative attack. Different from the single-good model, there would be real effects of anticipated devaluation, consisting of fluctuations in the real exchange rate and possibly the current account.

Note that, if such an equilibrium could be constructed, the augmented framework would account *qualitatively* for important empirical regularities that models with PPP cannot match. The stylized facts are that a currency crisis is often preceded by a real appreciation and a current account deficit, and coincides with a real depreciation and a current account surplus. As we will argue below, these facts could reflect, at least in part, an adjustment to a fiscal imbalance rather than "competitiveness problems".

## 4.1 The framework augmented to include a traded and a nontraded good

Consider the augmented framework — to save space, we do not restate expressions that are either unchanged or changed in obvious ways relative to the single-good model. In the new

unique timing for a devaluation in the new framework. They also explain how thinking in terms of that interest rate rule resolves paradoxes of the classical model concerning the dynamics of a speculative attack.

setup, the representative agent receives endowments of an internationally traded and a non-traded good, and maximizes:

$$\sum_{t=0}^{\infty} \beta^t G_t \ln C_t$$

where $G$ is government spending and $C$ is the Cobb-Douglas composite of consumption of the traded good, $C_T$, and the nontraded good $C_N$:

$$C = \frac{C_T^{\gamma} C_N^{1-\gamma}}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}} \tag{20}$$

$0 < \gamma < 1$. The reason why we introduce utility-providing $G$ will become apparent shortly.

The period-by-period budget constraint of the individual takes the form:

$$\frac{B_t}{P_t} + \frac{\mathcal{E}_t B_t^*}{P_t} = \frac{(1+i_{t-1})\,B_{t-1}}{P_t} + \frac{(1+r)\,B_{t-1}^* \mathcal{E}_t}{P_t} + \frac{P_{T,t} Y_{T,t}}{P_t} + \frac{P_{N,t} Y_{N,t}}{P_t} - \tau_t - C_t$$

We drop the long-term bond from the menu of available assets in order to rule out the adjustment mechanism dependent on debt maturity. The price level depends on the price of the traded good, equal to $\mathcal{E} P_T^*$ because of the law of one price, and on the price of the nontraded good $P_N$:

$$P = (\mathcal{E} P_T^*)^{\gamma}\, P_N^{1-\gamma}$$

When $(1+r)\,\beta = 1$, intertemporal conditions in the agent's problem simplify to the uncovered interest rate parity (2) and to a condition relating the path of marginal utility of consumption to the paths of the exchange rate and the price level:

$$\frac{G_t / C_t}{G_{t+1} / C_{t+1}} = \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \frac{P_t}{P_{t+1}} \tag{21}$$

The agent's *intra*temporal optimization is governed by the condition:

$$C_T \mathcal{E} P_T^* = \left( \frac{\gamma}{1-\gamma} \right) C_N P_N \tag{22}$$

The period-by-period government budget identity is:

$$\frac{B_t}{P_t} = \frac{(1+i_{t-1})\,B_{t-1}}{P_t} - \tau_t + G_t \tag{23}$$

where $\tau$ now denotes real lump-sum taxes (*not* the primary surplus, which equals $\tau - G$). Since we solve a local linear approximation about this model's steady state, and since we already know that the most interesting effect of dollar debt is due to a nonlinearity, we assume here that all public debt is nominal. From among a number of possibilities, we consider a simple assumption regarding the composition of government spending. Namely, $G$ is an index of traded and nontraded goods identical to $C$:[22]

$$G = \frac{G_T^{\gamma} G_N^{1-\gamma}}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}}$$

The current account identity is:

$$B_t^* = (1+r)\, B_{t-1}^* + P_{T,t}^* \left(Y_{T,t} - C_{T,t} - G_{T,t}\right)$$

and the equilibrium in the market for nontradables:

$$Y_N - G_N = C_N \tag{24}$$

It is convenient to study the dynamics of adjustment in a two-period version of this model (we denote the periods with $t$ and $t+1$). Consider a steady state with a constant $P_T^*$ in which the government fixes the exchange rate permanently at $\overline{\mathcal{E}}$, pursuing a Ricardian fiscal policy. We log-linearize the model around this steady state, using the standard notational convention according to which $\overline{X}_t$ denotes the value of the variable $X$ in the steady state in period $t$, while a lower case $x_t$ denotes the percentage deviation of $X_t$ from $\overline{X}_t$, i.e. $x_t = \log X_t - \log \overline{X}_t$.

We assume that the external shock to the log-linearized model consists of an exogenous decrease in the international price of tradables: $p_{T,t}^* < 0$ (allowing the shock to be temporary, i.e. $p_{T,t+1}^* = 0$, or persistent). Holding the exchange rate parity fixed ($e_t = 0$), the law of one price then implies a decrease in the domestic price of traded goods ($p_{T,t} < 0$), raising the real value of government debt. We suppose that fiscal policy switches to non-Ricardian coincident with the shock, i.e. the path of primary surpluses fails to adjust fully to match the new, higher value of debt. Since we are interested in the dynamics of adjustment, we also suppose that policy keeps the exchange temporarily fixed, $e_t = 0$, letting the currency depreciate in period $t+1$ ($e_{t+1} > 0$).

[22] Assuming that $G$ is entirely on nontradables gives the same qualitative results concerning equilibrium paths of the real exchange rate and the current account.

The appendix lists all equations of the log-linearized model. An equilibrium is a vector:

$$(c_t, c_{t+1}, c_{T,t}, c_{T,t+1}, c_{N,t}, c_{N,t+1}, p_t, p_{t+1}, p_{N,t}, p_{N,t+1}, i_t, e_t, e_{t+1})$$

that solves the equations listed in the appendix for given values of $p^*_{T,t}$ and $p^*_{T,t+1}$. The following two subsections discuss the main results and the intuition, while the details of the solution are in the appendix.

## 4.2 Long-term debt and delayed devaluation

Suppose we rule out changes in taxation and spending, by setting $\tau_t = \tau_{t+1} = g_t = g_{t+1} = 0$, which is equivalent to $\Delta = 0$. It is easy to show that a foreign deflationary shock ($p^*_{T,t} < 0$) implies an immediate devaluation ($e_t > 0$), like in the single-good model, without any change in the real exchange rate. Put differently, an equilibrium with a delayed devaluation ($e_t = 0$) fails to exist, against our conjecture of an adjustment mechanism involving real appreciation at the given exchange rate parity.

Our nonexistence result is related to Uribe's (2002) analysis of the "price-consumption puzzle of currency pegs". Uribe points out that, in standard optimizing models, an anticipated real appreciation must be accompanied by a declining path of consumption. In a similar fashion, a real depreciation in period $t + 1$ in our model implies a relatively high real rate of return and a decreasing path for the marginal utility of consumption. On the other hand, the adjustment mechanism we conjecture involves a current account deficit in period $t$ followed by a surplus at the time of a delayed crisis at $t + 1$, implying a declining path for consumption. Those two implications contradict each other, if there is a monotone decreasing relationship between consumption and its marginal utility, resulting in nonexistence.

Thus the introduction of nontraded goods per se does not overturn the key result from the single-good specification — that, without long-term debt, the equilibrium involves an immediate devaluation. We interpret this finding as a confirmation that — so long as one uses an optimizing model like the one laid out thus far — debt maturity is critical for understanding *when* a given fiscal shock affects the equilibrium exchange rate.

### 4.3 Dynamics of the current account and the real exchange rate

Our result above suggests that, for our model to have an equilibrium with $e_t = 0$, marginal utility of consumption at the time of an exchange rate crisis must be relatively low. In this respect, observe that, by the first order condition (21), a declining path of consumption may be consistent with intertemporal optimality for a relatively small value of $(G_{t+1}/G_t)$. Consider then a decrease in government spending at the time of the crisis ($g_{t+1} < 0$), capable of decreasing marginal utility of consumption even if consumption itself is also low. The idea is that a reduced supply of public goods (e.g. police and judicial services that guarantee private property) decreases the enjoyment of any given quantity of private goods. This modeling strategy is a way to break the monotone relationship between consumption and its marginal utility at the center of the nonexistence result in the previous subsection.

With $g_{t+1} < 0$ an equilibrium with $e_t = 0$ exists, but is not unique, as the appendix discusses. To obtain a unique solution, we must introduce a feedback from pre-devaluation endogenous variables to post-crisis fiscal policy. The FTPL literature by now recognizes that uniqueness of equilibrium in models like ours depends on how the buildup of debt before the crisis affects the scale of fiscal reform after the abandonment of the peg (Maćkowiak (2002)). The reason is that an increase in $i_t$ drives up debt and, with insufficient post-devaluation reform, can cause a self-fulfilling increase in the equilibrium exchange rate.[23] While such self-fulfilling equilibria may be interesting per se, we prefer to rule them out by restricting fiscal reform so that the size of the decrease in $G$ at the time of a crisis depends on the pre-devaluation interest rate. Specifically, we add $g_{t+1}$ to the vector of endogenous variables, appending $g_{t+1} = \alpha_0 + \alpha_1 i_t$ (with $\alpha_1 < 0$) to the list of equations in the appendix. A feedback from devaluation expectations to the size of the fiscal retrenchment eliminates the possibility that the magnitude of the crisis be determined by self-fulfilling expectations.[24]

[23] Our single-good model has a uniquely defined exchange rate only because, once a fiscal imbalance appears, the exchange rate depends on $\widetilde{T}$ but not on the stock of debt or the interest rate.

[24] It is plausible that a crisis prompts some fiscal reform, and that the extent of the reform is related to the size of the crisis. Crises and reform are costly, and reform may be delayed in a heterogeneous society until a "crisis" makes it evident that costs of further fiscal inaction are sufficiently high. The political economy literature has formalized the idea that crises are beneficial for economic reforms (for example, Drazen and Grilli (1993) and

Numerical simulations of the unique equilibrium, in figure 2, suggest conclusions concerning the dynamics of the real exchange rate and the current account around the time of a currency crisis.[25] Our model provides examples in which a foreign deflationary shock leads to an abandonment of a fixed exchange rate regime, but devaluation is delayed. As the price of the nontraded good increases in the runup to the crisis, the country experiences a real appreciation, a current account deficit and an increase in consumption. A subsequent devaluation coincides with a real depreciation, a current account surplus and a decrease in consumption. Thus the model matches the dynamics of the real exchange rate and the current account in the data, purely as part of the fiscal adjustment to a foreign shock — not as a result of, say, credit market imperfections or changes in output.

To an observer unaware of the fiscal implications of foreign deflation, the real appreciation in period $t$ may suggest that the country is experiencing "competitiveness problems", and that they are responsible for the current account deficit. The same observer may feel that she is proven right by the subsequent sharp correction in the nominal and the real exchange rate, accompanied by declining prices for nontradables and a surplus in the current account.

It is remarkable that the adjustment to a fiscal imbalance is consistent with domestic price level *deflation* in period $t$. This is because, while the price of the nontraded good unambiguously increases, the price of tradables must fall as a consequence of foreign deflation. The latter effect on the aggregate price level is stronger in a relatively more open economy. It is also worth noting that, by causing a real depreciation at the time of the crisis, the fiscal adjustment increases the costs of servicing debt denominated in tradables. These costs are relatively lower in the runup to the crisis.

Zarazaga (1997)). It is also plausible that fiscal "reform" in the context of a crisis begins with cuts in funding for law enforcement that decrease marginal utility of private consumption.

[25] The figure is drawn for the case where foreign deflation is temporary, $p^*_{T,t} = -0.01$ and $p^*_{T,t+1} = 0$ — conclusions from an analysis of a permanent shock are substantively the same. Thick lines in the figure correspond to $\gamma = 0.2$, whereas thin lines to a relatively more open economy with $\gamma = 0.6$. The real exchange rate is defined as the price of the traded good divided by the price of the nontraded good, so that an increase in the ratio corresponds to real depreciation. Endowments of income are assumed to be constant, so that an increase in consumption of the traded good signifies a movement toward a current account deficit.

# 5 Concluding remarks

Maturity and currency denomination of public debt are crucial determinants of macroeconomic dynamics in an open economy. The focus of this paper is on the dynamics of a fixed exchange rate regime in reaction to a shock that increases the real value of debt relative to government's primary surpluses, causing a fiscal imbalance. We show how monetary and fiscal policies, including maturity and denomination of debt, interact to determine the dynamic response of the economy and the magnitude of devaluation and inflation. If the government keeps the exchange rate temporarily fixed, the adjustment takes the form of a real appreciation and a current account deficit, followed by a real depreciation and a current account reversal coincident with devaluation. Our analysis suggests a broader view of: (1) fiscal causes and consequences of inflation and devaluation, (2) macroeconomic effects of fiscal shocks, and (3) interactions between fiscal and monetary policies, relative to standards in the open-economy literature.

Our framework moves away from a partial view of the adjustment to a fiscal imbalance, focused on seigniorage and therefore having little to say about the role of the "original sin" in the dynamics of currency instability. While we do not solve for currency and maturity structure of debt (they are given initial conditions in our model), our results suggest that fiscal benefits of inflation are increasing in the stock of non-indexed nominal debt. An important topic for future research is the study of time-consistent equilibria, in which the "original sin" emerges as an endogenous equilibrium feature.

Other aspects of our analysis likewise need additional research. For instance, we do not explicitly model factors that constrain fiscal reform and monetary policy after an adverse shock. Political economy and concerns about financial stability are promising areas of analysis. Finally, many devaluations coincide with both fiscal stress and sharp changes in output. Clearly, our contribution should be regarded as a building block toward future models that will simultaneously account for both aspects of actual crises.

# A Appendix

We list equations of the model with a traded and a nontraded good log-linearized about its steady state:

$$-c_t - p_t = g_{t+1} + e_{t+1} - c_{t+1} - p_{t+1} \tag{25}$$

$$e_{t+1} = i_t$$

$$c_t = \gamma c_{T,t} + (1-\gamma) c_{N,t} \tag{26}$$

$$c_{t+1} = \gamma c_{T,t+1} + (1-\gamma) c_{N,t+1}$$

$$p_t = \gamma p^*_{T,t} + (1-\gamma) p_{N,t}$$

$$p_{t+1} = \gamma e_{t+1} + \gamma p^*_{T,t+1} + (1-\gamma) p_{N,t+1}$$

$$g_t = \gamma g_{T,t} + (1-\gamma) g_{N,t} = 0$$

$$g_{t+1} = \gamma g_{T,t+1} + (1-\gamma) g_{N,t+1}$$

$$c_{T,t} + p^*_{T,t} = c_{N,t} + p_{N,t}$$

$$c_{T,t+1} + e_{t+1} + p^*_{T,t+1} = c_{N,t+1} + p_{N,t+1}$$

$$-\overline{G}_{N,t} g_{N,t} = \overline{C}_{N,t} c_{N,t}$$

$$-\overline{G}_{N,t+1} g_{N,t+1} = \overline{C}_{N,t+1} c_{N,t+1}$$

$$-\overline{R}_t \overline{P}_t \left(\overline{\tau}_t - \overline{G}_t\right) p_t = \overline{P}_{t+1} \left(\overline{\tau}_{t+1} - \overline{G}_{t+1}\right) p_{t+1} - \overline{R}_t \overline{B}_t e_{t+1} - \overline{G}_{t+1} \overline{P}_{t+1} g_{t+1}$$

$$\overline{P}^*_{T,t} \left(\overline{Y}_{T,t} - \overline{C}_{T,t} - \overline{G}_{T,t}\right) p^*_{T,t} - \overline{P}^*_{T,t} \overline{C}_{T,t} c_{T,t} =$$

$$= -\beta \overline{P}^*_{T,t+1} \left(\overline{Y}_{T,t+1} - \overline{C}_{T,t+1} - \overline{G}_{T,t+1}\right) p^*_{T,t+1} + \beta \overline{P}^*_{T,t+1} \overline{C}_{T,t+1} c_{T,t+1} + \beta \overline{P}^*_{T,t+1} \overline{G}_{T,t+1} g_{T,t+1}$$

We suppose that the government sets:

$$g_T = \frac{1}{2\gamma} g$$

$$g_N = \frac{1}{2(1-\gamma)} g$$

We consider an exogenous shock $p^*_{T,t} < 0$ and assume that policy sets $e_t = 0$ and $\tau_t = \tau_{t+1} = g_t = 0$. We assume the following values of parameters and steady state variables: $\alpha_0 = 0$, $\alpha_1 = -1$, $\beta = 1$, $\overline{R}_t = 1$, $\overline{G}_t = \overline{G}_{t+1} = 0.3$, $\overline{G}_{T,t} = \overline{G}_{T,t+1} = \overline{G}_{N,t} = \overline{G}_{N,t+1}$, $\overline{\tau}_t = \overline{\tau}_{t+1} = 0.6$, $\overline{B}_{t-1} = 0.6$, $\overline{B}_t = 0.3$, $\overline{C}_{T,t} = \overline{C}_{T,t+1} = 1$, $\overline{C}_{N,t} = \overline{C}_{N,t+1} = 1$, $\overline{\mathcal{E}}_t = \overline{\mathcal{E}}_{t+1} = 1$, $\overline{P}_{N,t} = \overline{P}_{N,t+1} = 1$, $\overline{P}^*_{T,t} = \overline{P}^*_{T,t+1} = 1$, $\overline{Y}_{T,t} = \overline{Y}_{T,t+1} = \overline{C}_{T,t} + \overline{G}_{T,t} = \overline{C}_{T,t+1} + \overline{G}_{T,t+1}$.

We first show that, if $g_{t+1} = 0$, then there is no solution with $e_t = 0$. To see why, suppose that $e_t = 0$ in equilibrium. With the price of tradables falling together with the foreign price, i.e. $p_{T,t} = p^*_{T,t} < 0$, the solved-forward government budget constraint requires that the price of the nontraded good must increase ($p_{N,t} > 0$) so as to reduce the real value of debt consistent with an unchanged path of primary surpluses. Since in equilibrium there is no change in consumption of the nontraded good, $c_{N,t} = 0$, nominal spending on this good must increase ($c_{N,t} + p_{N,t} > 0$). But spending on the traded good is proportional to spending on nontradables, so it too must increase ($c_{T,t} + p^*_{T,t} > 0$). For $c_{T,t} + p^*_{T,t}$ to be positive with $p^*_{T,t} < 0$ it must be the case that domestic agents consume more of the traded good, moving the current account toward a deficit. By (26), aggregate consumption increases ($c_t > 0$). In period $t+1$, by contrast, aggregate consumption decreases ($c_{t+1} < 0$): the nontraded goods equilibrium still implies that $c_{N,t+1} = 0$, but the current account must move toward a surplus so that $c_{T,t+1} < 0$. This argument establishes that, if a solution with $e_t = 0$ exists, it exhibits a downward sloping path for consumption, $c_{t+1} - c_t < 0$. Elements responsible for this conclusion are: valuation of public debt, intratemporal optimization and the current account.

The crucial observation for establishing nonexistence with $e_t = 0$ is that a decreasing path for consumption is inconsistent with intertemporal optimality. The argument above implies a real depreciation in period $t+1$ ($e_{t+1} - (p_{t+1} - p_t) > 0$), but a real depreciation is consistent with intertemporal optimization, (25), only if the marginal utility of consumption follows a decreasing path. This in turn implies that $c_{t+1} - c_t > 0$, generating a contradiction.

We reconsider our experiment under the assumption that an exchange rate crisis at $t+1$ coincides with a decrease in utility-providing government spending ($g_{t+1} < 0$). We begin by setting $g_{t+1}$ equal to a unique value such that all equilibrium conditions hold with $e_t = 0$. This amendment implies that the marginal utility of consumption decreases in period $t+1$, even if consumption itself follows a declining path. With $g_{t+1} < 0$, there is a unique value of $p_{N,t}$ consistent with equilibrium. However, there are a continuum of solutions for the interest rate in period $t$ and the price level at $t+1$. In fact, changes in $i_t$ affect the outstanding stock of debt, and therefore can cause self-fulfilling changes in $e_{t+1}$ and $p_{N,t+1}$. Setting $g_{t+1} = \alpha_0 + \alpha_1 i_t$ (with $\alpha_1 < 0$) we solve the model numerically, obtaining a unique solution depicted in figure 2.

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Figure 1: Numerical examples of the single-good model

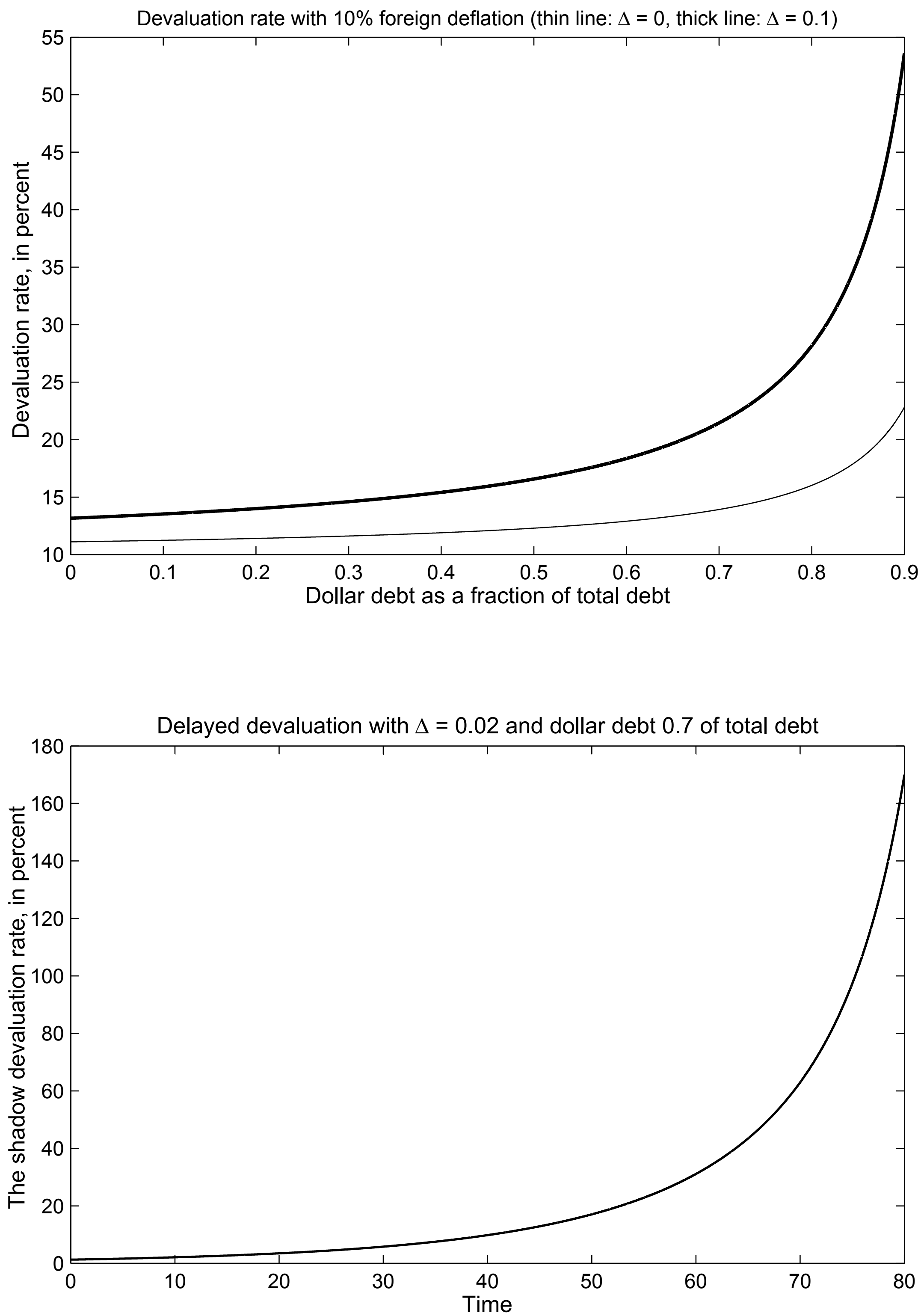

Figure 2: Numerical examples of the two-good model (thin lines: $\gamma = 0.6$, thick lines: $\gamma = 0.2$)