Seigniorage revenue, deficits and self-fulfilling currency crises

David Fielding a, Paul Mizen b, *

a University of Leicester, Leicester, UK
b CEES, and CSAE, University of Nottingham, University Park, Nottingham, NG7 2RD, UK

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Abstract

This paper examines potential resolutions to the conflict between a fixed exchange rate and seigniorage revenue requirement of a stylized developing economy that gives rise to a currency crisis. The government has an informational advantage and can decide when it is optimal to invoke an ‘escape clause’, i.e. to drop the peg and float. Speculators must guess when the crisis will happen, based on their assessment of the probability of collapse, and this makes pegged exchange rate equilibria unstable. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

This paper offers a new perspective on the origin of currency crises in developing countries. Taking the ‘escape clause’ literature as its starting point, this paper recognises that the temptation to raise seigniorage revenue can lead to the collapse of an exchange rate peg. ¹ The event is dependent on the relative merits of maintaining the peg (at a cost to other internal objectives) and relinquishing it (at a fixed cost).

¹ The conflict between the objectives of raising seigniorage revenue and maintaining an exchange-rate peg is well known—a fixed exchange rate undermines the opportunity for seigniorage because the peg ties domestic inflation to foreign levels, acting as a nominal anchor to the system. We do not intend to return to this well trodden ground in our paper. We develop a model based on papers by Obstfeld (1986, 1994), Drazen and Masson (1994), Masson (1995), Bensaid and Jeanne (1997), Jeanne (1999), and Jeanne and Masson (1999).
An ‘escape clause’ model explains that self-fulfilling crises emerge because the government has the option to relinquish its external policy objective. The decision to do this is determined by the cost of maintaining the external objective, which can become prohibitively high, and may conflict with internal objectives; when push comes to shove, the government will choose to opt out. We illustrate our point for a developing economy where the government decides to intervene to maintain the peg so long as the costs of doing so do not exceed the costs of switching to a floating rate. This approach contrasts with nearly all of the previous papers that have industrialized countries in mind when they develop ‘escape clause’ models of currency crises. Existing models are inappropriate for developing countries, therefore we create a new model to fit with the experience of LDCs. Many LDC governments face conflicts between macroeconomic objectives that are different from those in industrialized countries. Moreover, these conflicts are often more acute, due to the underdeveloped nature of LDC fiscal and monetary frameworks. The adoption of a fixed exchange rate regime may serve to control domestic inflation but it stands in the way of the heavy reliance on seigniorage revenue that is typical of many LDCs. While seigniorage revenue is a trivial issue in the developed world and the Asian NICs, it is central to government finances in many LDCs, where seigniorage may be as large as 10% of GDP (Agénor and Montiel, 1996, p. 111ff). So there exists a temptation to relinquish the peg and draw on the revenue available through money creation.

The underlying rationale for developing the model is to show that fixed exchange rate systems can be vulnerable even when the government is currently exhibiting monetary prudence. In “first generation” currency crisis models (for example, Flood and Garber, 1984), the path to collapse is marked by monetary expansion. In our model, there is no excessive monetary expansion until after the collapse. Before the collapse the government has a hard time precisely because it earns no seigniorage revenue, and alternative sources of finance are limited. This is what generates the temptation to relinquish the peg.

How relevant is this scenario to LDCs? Table 1 shows some fiscal and monetary data from the 1970s and 1980s for three illustrative countries in the years preceding the abandonment of an exchange rate peg. All three—Bolivia, Honduras and Zambia—had persistent budget deficits that were not largely financed by an inflation tax (however, the size of the deficits varies greatly across the three countries. We will return to this point later). One explanation for the collapse of their exchange rate systems is that the ever-increasing public debt eventually made the temptation to abandon the peg and inflate the economy irresistible. In this paper, we explore the strength of the argument that if the fiscal fundamentals are not right, then a currency crisis will happen sooner or

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2 There exists a small literature on the conflict between a fixed exchange rate and seigniorage to raise tax or reduce the costs of debt servicing by De Koch and Grilli (1993), Cole and Kohoe (1996) and Velasco (1996) that are primarily directed towards industrialized countries. These tend to use a combination of Krugman–Flood–Garber technology with Barro–Gordon tradeoffs in explicit loss functions or Obstfeld self-fulfilling models not escape clause models.
Table 1

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>DEF/GDP</th>
<th>ΔM/DEF</th>
<th>ΔM/DEF</th>
<th>DEF/GDP</th>
<th>ΔM/DEF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolivia (T = 1982)</td>
<td>T - 5</td>
<td>0.048</td>
<td>0.500</td>
<td>0.090</td>
<td>-0.006</td>
<td>0.090</td>
</tr>
<tr>
<td></td>
<td>T - 4</td>
<td>0.040</td>
<td>0.317</td>
<td>0.065</td>
<td>0.069</td>
<td>0.131</td>
</tr>
<tr>
<td></td>
<td>T - 3</td>
<td>0.074</td>
<td>0.151</td>
<td>0.036</td>
<td>0.415</td>
<td>0.144</td>
</tr>
<tr>
<td></td>
<td>T - 2</td>
<td>0.079</td>
<td>0.401</td>
<td>0.030</td>
<td>0.336</td>
<td>0.091</td>
</tr>
<tr>
<td></td>
<td>T - 1</td>
<td>0.204</td>
<td>0.240</td>
<td>0.033</td>
<td>0.525</td>
<td>0.185</td>
</tr>
<tr>
<td>Honduras (T = 1990)</td>
<td>T - 5</td>
<td>0.006</td>
<td>0.142</td>
<td>0.122</td>
<td>0.142</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T - 4</td>
<td>0.069</td>
<td>0.131</td>
<td>0.054</td>
<td>0.131</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T - 3</td>
<td>0.415</td>
<td>0.144</td>
<td>0.040</td>
<td>0.144</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T - 2</td>
<td>0.336</td>
<td>0.091</td>
<td>0.058</td>
<td>0.091</td>
<td></td>
</tr>
<tr>
<td>Zambia (T = 1981)</td>
<td>T - 5</td>
<td>0.131</td>
<td>0.054</td>
<td>0.144</td>
<td>0.144</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T - 4</td>
<td>0.131</td>
<td>0.054</td>
<td>0.144</td>
<td>0.144</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T - 3</td>
<td>0.054</td>
<td>0.144</td>
<td>0.040</td>
<td>0.144</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T - 2</td>
<td>0.058</td>
<td>0.058</td>
<td>0.058</td>
<td>0.058</td>
<td></td>
</tr>
</tbody>
</table>

The peg in each country was abandoned in year T. DEF = budget deficit; ΔM = annual change in reserve money. Source: IMF International Financial Statistics Yearbook (1983, 1999).

later. The interest of this argument is not merely historical. Table 2 shows data for Argentina in the late 1990s that look quite similar to the data in Table 1: there was a growing budget deficit that was not covered by seigniorage revenue. Argentina’s currency board may be more institutionally robust than the fixed exchange rate systems of the 1970s, and its domestic market for public debt may be relatively well developed, but reversion to a floating exchange rate is not impossible. The rest of the paper is organized as follows. Section 2 outlines a new model of currency crises for developing countries, and Section 3 offers simulations to determine likely magnitudes of the costs based on plausible estimates of parameter values. Section 4 concludes and discusses policy implications.

2. The modeling approach

We offer a brief synopsis of the speculative attack literature before developing an escape clause model appropriate for developing countries. The theoretical model will explore the dynamics of the cost of maintaining the peg and the probability of collapse; this model will form the basis of the simulations in the next section.

There have been two main approaches to currency crises to date (Jeanne, 1999). The first generation of ‘speculative attack’ models stressed the inevitability of a crisis when internal and external objectives of policy were in conflict, as in Krugman (1979), Flood and Garber (1984), and Flood et al. (1996). For a finite level of reserves, a collapse is inevitable if the government pursues a policy that requires a budget deficit to be funded by expanding domestic credit. Any level of reserves would be insufficient to prevent a speculative attack. The connection between the collapse and the so-called ‘hard’ fundamentals, e.g. reserves, is inescapable given the perfect foresight assumption of the model that prevents a jump in the exchange rate through the arbitraging rational backward induction of speculators. The second generation of models reasons differently.

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3 A realistic way of interpreting the problems faced by countries like Argentina might be to see them as representing a mixture of our model and the Bensaid and Jeanne (1997) model for industrialized countries.
Table 2
Budget deficits and seigniorage in Argentina

<table>
<thead>
<tr>
<th>Year</th>
<th>DEF/GDP</th>
<th>ΔM/DEF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>0.000</td>
<td>—</td>
</tr>
<tr>
<td>1993</td>
<td>0.007</td>
<td>2.528</td>
</tr>
<tr>
<td>1994</td>
<td>0.073</td>
<td>0.068</td>
</tr>
<tr>
<td>1995</td>
<td>0.055</td>
<td>−0.175</td>
</tr>
<tr>
<td>1996</td>
<td>0.192</td>
<td>0.006</td>
</tr>
</tbody>
</table>


Obstfeld (1986) argues that the nature of the problem is not primarily a matter of fundamentals; rather the expectation of a collapse is a sufficient condition for a collapse to happen. The argument gained currency after the 1992/1993 ERM crisis, when many countries experienced crises even though they had ‘hard’ fundamentals that were consistent with the external policy, i.e. there were no expansionary monetary or fiscal policies to create a speculative attack. Of more importance were the ‘soft’ fundamentals, such as the belief in the governments’ resolve to maintain internal conditions (i.e. interest rates) consistent with the external objective. The apparent conflict of interest created self-fulfilling speculative pressure. Models that captured these types of phenomena apportioned responsibility for collapse between hard and soft fundamentals.

The second-generation focuses on the self-fulfilling characteristics of speculators’ expectations and conflict of interest that may arise for the policy choice of the government. In models where a government can alter the interest rate to offset speculators’ expectations of devaluation, the government controls the time of collapse, and can never be drawn involuntarily into a crisis. Only if the costs of pursuing this kind of interest rate policy are prohibitive will the collapse be inevitable and self-fulfilling (Ozkan and Sutherland, 1995; Drazen and Masson, 1994; Obstfeld, 1994; Masson, 1995; Bensaid and Jeanne, 1997; Jeanne, 1999).

Our framework is based on the escape clause models proposed by these authors. The basic feature introduced by all of these models is the choice exercised by the government over its instrument of monetary policy—typically the interest rate—to meet an external objective, i.e. an exchange rate peg. The dedication of the interest rate to the exchange rate objective can give rise to costs when the desired rate for internal conditions differs from the one required for the external target. The government balances these costs against those of departing from the external target. The precise cost of departing from the external objective is known only to the government but this cost is the subject of speculation in the markets, with speculators who update their beliefs in a Bayesian way. At the point where the cost of maintaining the exchange rate exceeds the costs of collapsing, the government will cease to keep the interest rate at the level required by the external objective. In such models there is a single ‘good equilibrium’, in which no exchange rate devaluation occurs; but away from this equilibrium there are many paths to devaluation, when a collapse occurs due to a self-fulfilling crisis.
Our model embodies this kind of conflict between external and internal objectives. The external objective is to maintain an exchange rate peg, but this removes any possibility of earning seigniorage revenue. At some point the lost seigniorage revenue is greater than the cost of allowing the peg to collapse. Like the papers above, the model embodies asymmetric information about the true cost of collapse (i.e. the true benefit of the peg), which is known to the government but unknown to speculators. The motivation for this asymmetry is that the benefits that a government perceives to arise from a pegged exchange rate regime are not easy to quantify precisely. The costs of a pegged exchange rate regime in terms of lost inflation seigniorage are easier to quantify, however, and we will assume that they are known by public and private sector alike. The underlying model can be written as follows.

\[
l(t) - p(t) = \mu - \alpha i(t)
\]

\[
l(t) = \left[1 - \beta\right]m(t) + \beta\left[s(t) + f(t)\right]
\]

\[
p(t) = s(t)
\]

\[
i(t) = i^*(t) + dS/dt
\]

\[
i(t) = i^*(t) + \pi(t)\Delta(t)
\]

\[
m(t) = s(t) + f(t) - \eta dS/dt
\]

\[
m(t) = s(t) + f(t) - \eta \pi(t)\Delta(t)
\]

where \(l(t)\) is the total liquidity held by the domestic private sector at time \(t\), \(m(t)\) the domestic currency held, \(f(t)\) the foreign currency held, \(i(t)\) the domestic interest rate, \(i^*(t)\) the foreign interest rate, \(s(t)\) the exchange rate, \(p(t)\) the domestic price level and \(\pi(t)\) the probability that, if the exchange rate is pegged at \(t\), it will collapse in the next instant. The magnitude of the collapse is \(\Delta(t)\). All other Greek letters are parameters; all variables are to be interpreted as logarithms except the interest rates.

Eq. (1) is a money demand function, \(\mu\) is the scaling parameter, and \(\alpha\) is the semi-elasticity with respect to the interest rate. Eq. (2) is a logarithmic approximation to the accounting identity for total liquidity, expressed in domestic currency units. Domestic (but not foreign) residents hold domestic currency and foreign currency in the proportions \([1 - \beta]\) and \(\beta\). The parameter \(\beta\) measures the extent of dollarization. Eq. (3) is the purchasing power parity condition, where the foreign prices are normalized at zero. Eqs. (4a,b) is an uncovered interest parity condition: Eq. (4a) represents the condition under a float, and Eq. (4b) the condition under a peg. Under a float, the change in the exchange rate is a continuous variable determined by the foreign exchange market, which equals the interest differential due to arbitrage (we abstract from risk premia). With a peg, the change in the exchange rate is a discrete variable that equals the gap between the official exchange rate and its shadow rate that occurs with probability, \(\pi(t)\). Eqs. (5a,b) is a currency substitution equation relating the demand for domestic currency (relative to that for foreign currency) to expected depreciation of the
Under a peg, the endogenous variables are $l(t)$, $m(t)$, $f(t)$, $p(t)$ and $s(t)$, and $s(t) = 0$. By assumption, the government maintains the peg by adjusting $i(t)$ to keep the equilibrium exchange rate from changing. Under a float, $s(t)$ is endogenous and $i(t)$ is set to maximize seigniorage revenue. We will discuss the determination of $\pi(t)$ later, but it is to be interpreted as the speculators' subjective probability of collapse given the past (revealed) behaviour of the government and is updated by Bayesian learning.

The government's policy choice, which can be interpreted as the duration of the peg or the precedence of the external over the internal objective(s) of policy, is made subject to the constraints represented by Eqs. (1), (2), (3), (4a,b) and (5a,b). This choice is determined by the form of the function describing the net utility that the government derives from the peg. Net utility is the difference between the benefit of a fixed exchange rate (low inflation, higher credibility and credit rating) and the cost of a fixed exchange rate, i.e. the total seigniorage revenue lost by adhering to the peg. The longer the peg lasts, the greater will be the total benefit that accrues, but the greater also the value of revenue that has been lost. The collapse will occur when the instantaneous marginal benefit to the government of sticking with the peg is equal to the marginal cost of sticking with the peg.

We will assume that the marginal benefit is constant at a level $\kappa$, which is known to the government alone, but not to the private sector. The marginal cost, $dC/dt$, is the seigniorage revenue lost by delaying the collapse for a moment longer, i.e. by moving from period $t$ to period $[t + dt]$ without collapsing. The loss $dC$ is composed of two parts. One corresponds to the seigniorage revenue earned at the point of collapse, as a result of the inflationary devaluation of magnitude $\Delta$, and the other corresponds to the seigniorage revenue earned in the post-collapse era, which depends on the interest rate in each period after the collapse.\(^4\) Altogether:

$$dC = \max\{\text{SR}(t)\} - \max\left\{\frac{\text{SR}(t + dt)}{\Delta(t + dt)}\right\} + \int_{t}^{t+\infty} \exp(-r\tau) \max\left\{\text{SR}^+(\tau)\right\} d\tau$$

$$- \int_{t}^{t+\infty} \exp(-r\tau) \max\left\{\text{SR}^+(\tau)\right\} d\tau$$

where $r$ is a social discount rate, $\max(\text{SR}(t))$ is the maximum possible seigniorage revenue that could be earned instantly from collapsing now, which depends on the magnitude of the devaluation, $\Delta$, and $\max(\text{SR}^+(\tau))$ is the maximum possible seigniorage revenue that could be earned in any future period $\tau$ if the peg collapsed now, which depends on the interest rate set in the future, $i$.\(^5\) As we shall see in a moment, each

\(^4\)Note that the sum of all the marginal costs before collapse and after the collapse can be summarised in the form of a loss function that gives the objective function for the government.

\(^5\)The assumption that the government will be able to maximise seigniorage revenue is a simplification: empirical evidence (Easterly et al., 1995) suggests that many LDCs are in fact on the “wrong” side of their inflation tax Laffer curve.
period’s maximisation problem is independent of all others, so time consistency is not an issue. \( SR^+(\tau) \) will be determined by:

\[
SR^+(\tau) = \left[ \frac{dp}{d\tau} \right] \exp(m(\tau) - p(\tau))
\] (7)

In other words, it will be the product of the inflation rate and the real domestic currency stock. Substituting the post-collapse versions of Eqs. (1), (2), (3), (4a,b) and (5a,b) into Eq. (7) yields:

\[
SR^+(\tau) = \left[ i(\tau) - i^+(t) \right] \exp(\mu - \alpha_i(\tau) - \beta \eta [i(\tau) - i^+(t)])
\] (8)

In any one post-collapse period, seigniorage revenue depends just on the current interest rate and a set of fixed parameters, so the solution to the post-collapse maximisation problem yields a time-invariant interest rate and the second half of the RHS of Eq. (6) will be of the form \([A/r] \exp[B - rt - \exp(B - r[t + dt]])\), where \(A\) and \(B\) are constants. For the sake of simplicity, we will assume that the government is myopic enough (that \(r\) is high enough) for this expression to be small relative to the seigniorage from the inflationary devaluation, so that we can approximate Eq. (6) by:

\[
dC = \max_{\Delta} \{SR(t)\} - \max_{\Delta} \{SR(t + dt)\}
\] (9)

In other words, the marginal cost of adhering to the peg for another instant depends just on the seigniorage revenue, which is being given up from the discrete jump in the exchange rate at the point of collapse. Analogous to Eq. (7) is a definition of seigniorage revenue at the point of collapse:

\[
SR(t) = \left[ \frac{dp}{d\tau} \right] \exp(m(t) - p(t))
\] (7a)

Substituting the pre-collapse versions of Eqs. (1), (2), (3), (4a,b) and (5a,b) into Eq. (7a) yields:

\[
SR(t) = \left[ \frac{dp}{d\tau} \right] \exp(m(t) - p(t))
\]

\[
= \Delta(t) \exp(\mu - \alpha i^+(t) - [\alpha + \beta \eta] \pi(t) \Delta(t))
\] (10)

This can be interpreted as the revenue generated from inflation as a result of the discrete jump in the exchange rate, \(\Delta(t)\), when the peg is relinquished. Since the problem of maximizing \(SR^+(\tau)\) is independent of \(\Delta(t)\), the government’s choice of \(\Delta(t)\) to maximize \(SR(t)\), if it does decide to relinquish the peg at period \(t\), can be made without having to look to the future. The solution to this maximization problem is:

\[
\Delta(t) = [\alpha + \beta \eta] \pi(t) \] (11)

Substituting Eq. (11) into Eq. (10):

\[
\max \{SR(t)\} = \exp(\mu - \alpha i^+(t) - 1) / [(\alpha + \beta \eta] \pi(t)\]
\] (12)
Substituting Eq. (12) into Eq. (9), we have:

\[
dC = \exp(\mu - \alpha i^{*}(t) - 1)/[[\alpha + \beta \eta] \pi(t)] - \exp(\mu - \alpha i^{*}(t) - 1)/[[\alpha + \beta \eta] \pi(t + dt)]
\]

or alternatively:

\[
dC/dt = \{\exp(\mu - \alpha i^{*}(t) - 1)/[\alpha + \beta \eta]\} [d\pi/dt]/\pi^2
\]

Inverting this expression, and letting \(c = dC/dt\), we can form a differential equation for the probability of collapse (\(\pi\)):

\[
d\pi/dt = hc\pi^2, \quad h = [\alpha + \beta \eta]/\exp(\mu - \alpha i^{*}(t) - 1)
\]

The dynamics of \(\pi\) and \(c\) can be solved by specifying how the perceived probability of collapse depends on the current cost of being in the pegged regime. Here we follow Bensaid and Jeanne (1997), who suggest that the speculators are Bayesian learners. They reassess each period the probability that the cost is about to reach the threshold value \(\kappa\) given that it has not already reached the critical value at which the government will allow the peg to collapse, i.e. the probability that \(\kappa^-\) lies between \(c(t)\) and \(c(t + dt)\), given that \(\kappa^->c(t)\). The speculators’ prior beliefs about the true cost of devaluation, \(\kappa\), are captured by a probability distribution of \(\phi(\kappa)\) and a corresponding cumulative distribution \(\Phi(\kappa)\). \(\phi(\cdot)\) is continuous over a given range \((\kappa^-, \kappa^+)\). This range corresponds to speculators’ ballpark estimate of the value of \(\kappa\), which will depend on, for example, the size of the budget deficit (the larger the deficit, the less attractive the government finds the peg). By the application of Bayes’ Theorem, we can infer that

\[
\pi(t)dt = \int_{c(t)}^{c(t + dt)} \{\phi(\kappa)/[1 - \Phi(c(t))]\}d\kappa = \{\phi(c(t))/[1 - \Phi(c(t))]\}dc
\]

and hence:

\[
\pi(t) = \{\phi(c)/[1 - \Phi(c)]\}dc/dt
\]

The solution to the model is tractable if, like Bensaid and Jeanne, we choose a distribution for \(\kappa\) that yields a linear differential equation. We assume below that \(\phi = \lambda \exp(-\lambda [\kappa - \kappa^-])\), where \(\lambda\) is a fixed parameter, so

\[
\pi = \lambda dc/dt
\]

Eqs. (15) and (18) imply a pair of equations determining the evolution of \(\pi\) and \(c\) over time:

\[
\pi(t) = [H_\pi - hc(t)t]^{-1}
\]

\[
c(t) = H_c + \pi(t)[t/\lambda]
\]
where $H_s$ and $H_c$ imply starting values for $\pi$ and $c$. Since there are only costs of adhering to the regime this instant when $d\pi/dt > 0$, it makes sense to impose the restriction $H_s = 0$.

If we start with $H_s = 0$ (so $\pi = 0$), then $d\pi/dt = dc/dt = 0$; but this is an unstable equilibrium. Any perturbation of $H_s$ (any rumour that the regime is about to collapse) will set $c$ and $\pi$ on an explosive growth path that leads inevitably to a point where $c = \kappa$ and the regime collapses (see Fig. 1). All the different paths (finite values of $H_s$) leading to this outcome constitute self-fulfilling crises. In order to get a feel for the speed at which a crisis drives the regime to a point of collapse, the next section discusses simulations of the model with specific values for the parameters $h$, $\lambda$ and $H_s$.

3. Simulation

If we put numerical values on $h$ and $\lambda$ in Eqs. (19) and (20), then we can plot the evolution of $c$ and $\pi$ over real time elapsed from the date of a given perturbation to $H_s$. $h$ will depend on the units in which we measure seigniorage revenue, in the way described below. Fig. 2 plots time paths for $c$ with different values of $h$ and $\lambda$. In order to interpret this figure, we need to determine what economic characteristics lead to high or low values of $h$ and $\lambda$.

$\lambda$ is the parameter of the frequency distribution describing the private sector’s beliefs about the probability of collapse; it is the ratio of their assessment of the collapse
probability to the rate of growth of losses from adherence to the regime. A large λ implies that the private sector’s assessment is very sensitive to changes in losses per period. Fig. 2 illustrates examples with λ varying between 0.1 and 1.0.

In order to interpret different values of h, we first note that if t measures time elapsed in years, then 1 year’s seigniorage revenue can be written as:

\[ R = \int_{t=0}^{t_1} [d p / dt] \exp(m(t) - p(t)) dt \]  \hspace{1cm} (21)

If ex ante we have \( H_s = \infty \) (so there is no tendency towards collapse), then \( \pi = d s / dt = 0 \) and real money demand, \( m(t) - p(t) \), will be equal to \( \mu - \alpha i^*(t) \). So we can write:

\[ R = \int_{t=0}^{t_1} [d p / dt] \exp(\mu - \alpha i^*(t)) dt = [d p / dt] \exp(\mu - \alpha i^*(t)) \]  \hspace{1cm} (22)

and so

\[ \mu - \alpha i^*(t) = \log(R / [d p / dt]) \]  \hspace{1cm} (23)

Eq. (23) allows us to translate the intuitively opaque quantity \( \mu - \alpha i^*(t) \) into something that is directly measurable, i.e. the log of the ratio of seigniorage revenue to inflation. If \( R \) is measured as a fraction of GDP, then the RHS of Eq. (23) could plausibly be positive or negative; it is perhaps more likely that it will be negative in most developing countries, i.e. that \( R < d p / dt \).
The level of $h$ will be now determined from Eqs. (15) and (23).

$$h = \left[ \alpha + \beta \eta \right] / \exp \left( \log \left( R / \left[ dp/dt \right] \right) - 1 \right) = e \left[ \alpha + \beta \eta \right] \left[ dp/dt \right] / R$$

(24)

So $h$ depends on three factors: inflation, seigniorage revenue and $[\alpha + \beta \eta]$, which is the sum of (i) the interest elasticity of money demand and (ii) the elasticity of the ratio of domestic to foreign currency with respect to expected currency depreciation times the share of foreign currency in money holdings. Since both $[\alpha + \beta \eta]$ and $\left[ dp/dt \right] / R$ could be greater or less than unity, the range of possible values of $h$ is very wide. Fig. 2 illustrates examples with $h$ between 0.1 and 10.0.

The time paths for $c$ in Fig. 2 are calculated by solving Eqs. (19) and (20) with $H_s = 0$ to produce an implicit equation for $c$ as a function of time:

$$t = H_n / \left[ hc(t) + 1 \left[ \lambda c(t) \right] \right]$$

(25)

The simulations are based on a small initial perturbation in the probability of collapse, with $H_n = 100$, so that $\pi(0) = 0.01$. Fig. 2 plots the inverse of Eq. (25) for different values of $h$ and $\lambda$ in the ranges indicated above. For larger values of $\lambda$, the variation in $c$ at any one point in time from changing $[\alpha + \beta \eta]$ and $\left[ dp/dt \right] / R$ within a sensible range is very small (and invisible in the figure), so the figures show alternative values of $h$ only for $\lambda = 0.1$. $t$ is measured in years and $c$ is measured as a fraction of GDP.

Larger values of $h$, due to low seigniorage revenue relative to inflation or high elasticities in the asset demand functions, reduce $c$ a little; larger values of $\lambda$ reduce $c$ substantially. When $\lambda$ is very low, $c$ rises very rapidly in the wake of a perturbation. For example, with a value of $\lambda$ equal to 0.1, irrespective of the value of $h$, $c$ will have reached about 10% of GDP after 1 year, 20% of GDP after 2 years and so on, if the regime has not already collapsed. For higher values of $\lambda$, the value of $c$ at any one point in time is much smaller.

The main message to come from the simulation results is that small differences in parameter values can generate large differences in the time it takes for a peg to collapse, when fiscal fundamentals are inconsistent with the peg. To put it another way, the countries whose pegs have collapsed recently may have had quite different recent macroeconomic histories. The countries in Table 1 exhibited a substantial amount of fiscal and monetary heterogeneity in the period immediately preceding the collapse of their peg. Zambia had a persistently large budget deficit for a long time; Bolivia had a relatively small deficit that expanded rapidly just before collapse; Honduras had a relatively small deficit right up to the point of collapse. Such heterogeneity is entirely consistent with our theoretical model. Of course, the timing of collapse is likely to depend also on political economy characteristics outside the scope of our theory. Both our model and the experience of countries like Honduras indicate that a relatively moderate deficit is no guarantee of financial stability.

4. Conclusion and policy implications

We have presented a model of self-fulfilling collapses for a developing country that examines the conflict of interest between a currency peg and seigniorage revenue. The
results are analogous to those of Bensaid and Jeanne (1997) for industrialized countries.
Simulations based on the theoretical model highlight the relative importance of the
macroeconomic parameters determining the speed of collapse. The speed of collapse can
vary enormously with the parameters describing the macro-economy, but if there is any
reason for the government to value seigniorage revenue, then a collapse is eventually
inevitable. These stylized facts are relevant to recent discussions about the costs and
benefits of different types of exchange rate regime.

Frankel (1999) discusses some of the costs and benefits of adhering to a fixed
exchange rate, and concludes that the optimal regime is likely to vary from one country
to another. Our paper contributes to this discussion by suggesting that getting the fiscal
fundamentals right is a necessary condition for the success of a fixed exchange rate
system. Even countries with moderate budget deficits can reach a point of collapse very
quickly under certain circumstances, and if there is any value attached to seigniorage
revenue then there will be a collapse some day. Fixing fiscal policy is a precondition for
a sustainable peg, and so a fixed exchange rate is likely to be a realistic policy option
only for those countries that already have well designed and effective tax collection
systems. Countries that lack such a system, and have from time to time to rely heavily
on seigniorage revenue, are likely to be better off with a relatively flexible exchange rate
regime. If some short-term stabilization of the exchange rate is desirable, then Chilean-
style capital inflow restrictions may represent a more realistic option than a fixed peg.

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