Currency Crises and Bank Panics: The Origins of Twin Crises in a Small Open Economy

by

Caroline M. Betts
Department of Economics
University of Southern California

Preliminary and incomplete. Do not cite. I would like to thank Mick Devereux, Tim Kehoe, Victor Rios-Rull, and Bruce Smith for many useful conversations and suggestions. I would also like to thank seminar participants at the Federal Reserve Bank of Minneapolis, the Annual Meetings of the NAEFA, and the Annual Meetings of LACEA for comments on related work.

1. Introduction

This paper is motivated by the recent spate of collapsing exchange rate regimes and banking crises in Latin America and East Asia. These events have raised many new questions regarding the origins of financial crises in an increasingly integrated world economy. Quite naturally, much current debate focuses on the role of monetary and financial market policy, for the incidence of domestic and external financial crises has risen sharply with the progression of international financial and capital market integration. This paper develops a dynamic equilibrium model of one element of the role of policy in financial crises; the role of domestic credit or "liquidity" policy for the probability of domestic and external financial crises.

The paper focuses on one particular feature of crisis data from the last twenty years. Namely, that there has been a close temporal relationship between balance of payments crises and domestic banking crises. Recent documentation of the facts for a large sample of countries by Kaminsky and Reinhart (1996) identifies a systematic pattern in which domestic financial sector illiquidity and bank failures precede and help predict future balance of payments crises. Exchange rate collapses, however, do not help predict future banking crises. Crucially, no temporal relationship is observable for the earlier post-war years which were characterized by an organized world monetary system and highly regulated international financial markets. Prior to the last two decades, banking panics and balance of payments crises appeared to have been largely independent events.

These recent empirical observations motivate the questions that this paper attempts to address. Can domestic financial illiquidity implicate the sustainability of a fixed exchange rate? How does the maintenance of a fixed exchange rate affect the possibility for domestic financial illiquidity? Is sterilization of foreign reserve outflows by a monetary authority concerned with preserving domestic liquidity the source of the observed correlation between banking crises and currency crises, as is often argued? And, if so, how does this explain the temporal precedence of domestic banking crises?

This paper develops a model in which the origins of "twin" domestic and external liquidity crises can be characterized. In particular, I examine conditions under which a higher frequency of domestic financial illiquidity is followed by a balance of payments crisis and abandonment of a one-sided exchange rate peg. In this analysis, I focus on the role of domestic government policy as a source of this temporal relationship between domestic and external financial crises. In fact, in the model the temporal pattern of "twin crises" observed in the data is *uniquely* associated with an unsustainable government policy of excessive consumption spending[1].

More specifically, the paper characterizes the standard "excessive domestic credit creation" explanation for balance of payments crises in a dynamic equilibrium environment (see Krugman (1979) for the seminal account). In doing so, a model is developed that can characterize indefinitely sustainable fixed exchange rate regimes, and also can provide a sharp characterization of how policy differs in this case relative to general equilibrium situations in which the exchange rate peg cannot be sustained indefinitely. The model also offers a sharp characterization of domestic financial sector illiquidity, in which optimizing banks are at the foreground of domestic intermediation and credit, as well as being central to the payments system. It then asks whether Krugman's "deteriorating fundamentals" argument can explain "twin" balance of payments and banking crises, as is often observed in the data.

To address these issues, the paper employs a small open economy inhabited by overlapping generations. Some agents born each period are lenders, while others are borrowers. The small open economy takes world monetary policy as given, as well as world prices of its goods and assets. There is a single final good in the world economy, which is effectively differentiated across domestic and world markets. In sum, some goods of the small open economy are non-tradable. Then, purchasing power parity need not hold, and real exchange rate movements can be large. However, world asset markets are complete and fully integrated. These features of the model are intended to capture the reality that large real exchange rate appreciations often precede domestic and external financial crises (Kaminsky and Reinhart (1996)) and typically are reversed following external crises.

In the model, all lenders (depositors) in the small open economy are subject to random liquidity shocks, which may constrain the individual to hold cash for future goods purchases rather than holding interest-bearing, internationally traded assets. While individual lenders cannot insure themselves against these shocks, banks can partially insure individuals by accepting their deposits, offering state contingent deposit returns, and holding diversified asset portfolios on behalf of their depositors. At every date, however, there exists an endogenously determined, positive probability that banks will be "illiquid" and "bank panics" arise.

[1]The focus of the paper is on how *liquidity* conditions in the domestic economy can produce banking and balance of payments crises. A more complete model would seriously address the origins of insolvency in the domestic financial sector.

By "bank panic" I refer to a situations in which banks cannot fully insure their depositors against a realization of the liquidity shock which exceeds a critically high value. In this situation, deposit returns to lenders that require liquidity decline below those to lenders that do not require liquidity. In effect, banks partially "suspend" payments when large numbers of lenders go to the bank to liquidate their account. Notably, there are no *aggregate* consequences of bank panics - only domestic, redistributional effects.

The probability of bank panic is increasing in real and nominal interest rates, since high interest rates cause optimizing banks to substitute into interest-earning assets and out of cash. Rising world real interest rates, for example, tend to raise the frequency of domestic banking sector illiquidity. This is consistent with evidence presented by Kaminsky and Reinhart, which shows that high world real interest rates tend to be associated with banking crises. In addition, in a steady state equilibrium, the probability of banking crisis is positive and constant for all time.

The government supplies currency to private agents, thereby meeting domestic bank and exogenous foreign demand. Under a one-sided peg of the nominal exchange rate of domestic for world currency, the government must allow its money growth rate to be endogenously determined at all dates. In addition, it maintains a constant nominal reserve level and allows its consumption spending to be endogenously determined also. Indefinite sustainability of the peg (attainment of a fixed exchange rate steady state) is possible only if both the domestic and fiscal policy of the government are entirely determined by world monetary conditions. In such a steady state, the real exchange rate is constant, there are zero reserve movements, and domestic real and nominal interest rates are equal to the prevailing world interest rate. The probability of domestic bank panic is therefore entirely determined by world interest rates. The higher is the world real interest rate, the higher is the probability of domestic bank panic, a feature of the model which also accords well with the Kaminsky Reinhart stylized facts. Notably, banking crises can occur quite independently of currency crises.

However, the converse is not true. In the paper, I find that currency crises are uniquely associated with excessive rates of domestic credit creation. In addition, they are always preceded by a higher freqency of banking crisis. If an economy is initially in a fixed exchange rate steady state, and the domestic government attempts to increase its consumption above the level consistent with indefinite sustainability of the peg, policy, it may suffer an immediate currency crisis (the government abandons the exchange rate peg to achieve the higher consumption level) with no apparent gain. In effect, the government attempts to raise domestic liquidity by supplying more currency in exchange for goods, but cannot do this while maintaining the peg unless additional financing is found. In fact, all of the features of this scenario in the model are inconsistent with the data.

One reason why such an immediate abandonment of the peg might not be undertaken is that the government can alternatively finance the additional consumption by running down its initial foreign reserve level. In other words, the government enacts a form of sterilization policy, in which foreign reserve losses are offset (at least temporarily) for the total outstanding money supply by higher domestic spending. In this case, the government can temporarily maintain the peg at the given world interest rates and prices, and with all other endogenous variables being equal to their initial steady state values. While on this stationary path, the government runs down the nominal reserve at an increasing rate (so that it runs down the real reserve at a constant rate).

As in Krugman (1979), of course, such a policy can only be maintained for a finite number of periods; until the foreign reserve falls to a critically low level that is inconsistent with continuation of reserve depletions. The timing of reserve exhaustion can be perfectly predicted by banks. In the period before the peg must be abandoned, banks precfectly anticipate a nominal depreciation in the following period, and nominal interest rates rise. Banks subtitute into interest-earning assets and out of currency, and the probability of bank panic rises, which is consistent with the stylized facts regarding the temporal relationship between bank panics and currency crisis. Thus, the rise in bank panic frequency is correlated with a tendancy of the nominal exchange rate to depreciates, and with faster reserve losses that precipitate the currency crisis in the following period. It is also correlated with an increase in domestic nominal interest rates.

Once the peg is abandoned, a new flexible exchange rate steady state is attainable within a period, in which the domestic currency depreciates at a rate equal to the relative domestic money growth rate, nominal interest rates are permanently higher, and there is a permamently higher frequency of bank panic.

While there exist many important contributions to the theory of banking crises[2] and to the theory of balance of payments crises[3], there are few that attempt to understand the relationships between internal and external financial flows and

[2]See, for example, Bryant (1980), Diamond and Dybvig (1983), Chari and Jagannathan (1984), Gorton (1985), Jacklin and Bhattacharya (1988), Wallace (1988, 1990), Chari (1989), Smith (1990), and Champ, Smith and Williamson (1995).

[3]Krugman (1979), Obstfeld (1994,1996), Calvo (1995), and Calvo and Mendoza (1996).

panics.[4] In this paper, a model is developed in which the relationship between the two can be partially uncovered. In particular, greater domestic liquidity provision by the government is self-defeating since it inevitably produces a higher probability of banking crises, which is followed by a collapse of the exchange rate peg. The collapse of the peg simply results from the loss of external liquidity which is required to finance the higher government consumption.

This interpretation is at least consistent with many views of the "twin crises" observed in Mexico during 1994-1995. That, by sterilizing reserve losses, and thereby maintaining the domestic money supply and domestic real and nominal interest rates, the government prevented self- correcting mechanisms (higher interest rates, in particular) that might have allowed the peg to be sustained. Here, the peg could only be sustained by an abandonment of the "bad policy" prior to reserve depletion.

Section 2 describes the economic environment. Section 3 is devoted to a description of banks and the characterization of banking crises, while Section 4 outlines alternative government policies. Section 5 develops conditions that obtain in general equilibrium, and Section 6 discusses steady state equilibria. Section 7 discusses the origins of currency crises, and twin crises. Section 8 concludes.

2. The Environment

The model that I use to analyze these issues is a small open overlapping generations economy in which the government issues domestic currency and pursues a one-sided peg of its currency.[5] In the model, there is a single final good in the world economy which is non-storable. In the model, all markets are competitive, prices are fully flexible, and all agents have equal access to international asset markets at each date. However, goods markets are characterized by a friction - market segmentation - which allows for deviations from the law of one price (LOOP) so that the real exchange rate need not be equal to one.

[4] Exceptions are Diaz-Alejandro (1985), Velasco (1987), Stoker (1994), and Calvo (1995).

[5] The environment described here is similar in some respects to that described in Betts and Smith (1997), and Champ, Smith and Williamson (1995). In contrast to the former, private sector liabilities are traded here and in addition this economy is subject to aggregate uncertainty that induces bank panics. While bank panics here arise for very similar reasons as in Champ, Smith and Williamson, the economy described below integrates these into an open economy envrionment in which there is the possibility for currency crises and for "twin crises" - which is a primary contribution of this model.

2.1. Agents, Preferences and Endowments

The small open economy is inhabited by an infinite sequence of two-period lived overlapping generations and an initial old generation. In addition, there are two, symmetric locations in the domestic country and a continuum of young agents with unit mass is assigned to each location at each date t=1,2,... The small open economy takes as given the world price of the single final good, the world real and nominal interest rates, and world demand for its goods, real assets, and currency.

A fixed fraction ϕ of young agents born in either location at each date are lenders, while the remaining $1-\phi$ young agents are borrowers. Lenders and borrowers are differentiated by their intertemporal endowment patterns of the single non- storable consumption good. Generation t domestic lenders receive date $(t, t+1)$ endowments of $(y, 0)$ and generation t domestic borrowers' date $(t, t+1)$ endowments are $(0, q)$. In addition, each member of the initial old generation in any location is endowed with the per capita initial money stock of that location, which I denote $M_0 > 0$.

All young agents in the small open economy maximize the simple lifetime utility function

$$U(c) = lnc_t + \beta E_t ln(c_{t+1}) \tag{2.1}$$

c_t is first period and c_{t+1} second period consumption of the single good by a generation t agent expressed in units of the good in that agent's place of birth. "E_t" here is the standard conditional expectations operator, and $\beta < 1$ is the discount factor. The initial old generation in each country simply maximizes $U(c) = lnc_1$.

2.2. Assets

The pattern of endowments and preferences described above requires that agents trade intertemporally in the world economy to achieve an optimal consumption plan. In the model, I allow for two types of asset that permit intertemporal trade.

First, young agents can trade in real consumption loans at all dates, both domestically and internationally. I denote by l_t the per capita value of loans issued by young borrowers in the domestic country. I let a_t^* denote net foreign assets held by a domestic lender. In addition, a date t domestic loan of one good held by a domestic young lender pays a competitively determined gross real rate of return R_t between dates t and t+1 in domestic goods units, while a unit of net foreign assets held by a domestic lender pays a real gross rate of return of $R_t^*(x_{t+1}/x_t)$ in domestic goods. Here, R_t^* is the exogenous world real interest rate at t measured in foreign goods. x_t is the domestic country's real exchange rate defined as $(e_t p_t^*)/p_t$, where p_t $[p_t^*]$ is the domestic (exogenous world) currency price of the good at date t. I denote the nominal return to a domestic consumption loan by $I_t = R_t(p_{t+1}/p_t)$. The nominal return to a foreign loan expressed in domestic units is just $I_t^*(e_t/e_{t+1})$ where $I_t^* = R^*(p_{t+1}^*/p_t^*)$ is the exogenous world nominal interest rate.

In addition, young lenders may acquire and hold currency as a store of value between periods. I denote the date t per capita stock of domestic currency outstanding by M_t. Obviously, the gross real rate of return to a unit of domestic (world) currency in domestic (world) goods units is simply p_t/p_{t+1} $[p_t^*/p_{t+1}^*]$ between dates t and $t+1$. In addition, the real value of the per capita domestic (world) money stock of expressed in domestic (world) goods is simply $m_t \equiv M_t/p_t$ $[m_t^* \equiv M_t^*/p_t^*]$.

2.3. Markets

As mentioned above, the small open economy confronts spatial separation of agents domestically as well as internationally. I assume that there is limited communication of agents across all locations (two domestic and the rest of the world)[6]. In particular, during goods market trade (which occurs at the beginning of each period) there is no communication across locations or cross-location movements of goods or people. However, during subsequent asset market trades I allow for complete communication domestically and internationally.

The spatial separation and limited communication features of the economy reflect an actual friction - national goods market segmentation - that is widely believed to produce significant deviations from the law of one price and purchasing power parity. In this extreme case, there is no possibility whatsoever for arbitrage trades to eliminate price differentials across locations. However, in asset markets the standard interest parity conditions, that reflect an absence of arbitrage opportunites, will obtain.

However, this stylized representation of goods market segmentation does not rule out inter-location trade in goods. Some domestic country agents in every period can consume goods from other locations, while other domestic agents are restricted to consuming goods only in their location of residence. Interlocation trade in goods is accomplished by movements of agents between locations, rather

[6]See Champ, Smith and Williamson (1995), Schreft and Smith (1994) and Betts and Smith (1997) for other examples of this form of spatial separation with limited communication.

than by movements of goods. Some units of the good in each location are purchased by local residents, while other units are purchased by agents originating in other locations.

I now describe the pattern of goods and asset market trade.

2.4. Trade and the Timing of Transactions

At the beginning of each date, t, there is no movement of agents between locations either domestically or internationally and no communication between locations. All goods market trade is conducted locally at this time. Within either domestic location, old lenders can use domestic currency to purchase goods or directly consume the gross value of any loans they made to old borrowers. Old borrowers consume their endowment net of outstanding gross loan obligations, while young lenders consume their endowments net of any one period consumption loans that they make to young borrowers. These one period consumption loans finance the consumption of young borrowers.

When all local trade and consumption of today's goods is complete, domestic and international asset markets open, and young lenders may reallocate their portfolios among the currencies of each country and private loans of any location. At this time, there is complete communication between agents in all locations. Asset markets then close, and inter-location communication ends.

At the end of the period, an aggregate "liquidity" shock is realized, π_t, which for simplicity I assume is identical across domestic locations. In particular, with probability π_t a young lender in either location must move to another location before the end of date t. π_t is a random variable, with known, time invariant and continuously differentiable probability distribution $F(\pi_t)$. $F(\pi_t)$ has the associated continuously differentiable density function $f(\pi_t)$.

In addition, with probability $\epsilon\pi_t$, an agent must move to the second location within his own country, and with probability $(1-\epsilon)\pi_t$ an agent relocates to the rest of the world[7].

In the event that a lender moves, he must consume goods at the beginning of $t+1$ in another location - absent communication between locations. In this event, any privately issued loans that he holds are valueless in goods market exchange, for their authenticity cannot be verified by sellers in other locations. Currency, however, is non-counterfeitable and universally acceptable in exchange

[7]Note that ϵ is time invariant, since the focus here is on liquidity as a source of crises rather than on preferences over goods produced by different countries.

for goods. In the event that an agent is relocated, therefore, the currency of that location (country) must be offered to achieve consumption. All other assets become valueless to the agent, and he would prefer to liquidate any loans that he holds and sell any units of the currency which is now useless in exchange.

Realizations of π_t therefore reflect aggregate liquidity shocks against which individual agents cannot insure themselves. These shocks, which are realized when all markets are closed, require positive portfolio holdings of both types of currency by lenders. Currency has liquidity that dominates that of privately issued loans, and will generally be held even if dominated in rate of return by loans or, equivalently, if $I_t \geq 1$. It is worth noting also that if a lender remains in his initial location, he can use either the currency of that location or his private loan portfolio to purchase goods. Only his holdings of the second country's currency have no value in exchange. Thus, domestic currency has a liquidity advantage relative to foreign currency for a domestic lender.

One can therefore interpret relocation as a source of credit constraints on some agents. Agents that must relocate confront a cash-in-advance constraint on all future goods market purchases. Agents that do not relocate face no such constraints. Equivalently, the single final good can be thought of as generating two types of consumption good; cash goods, that are purchased by agents arriving from an alternative location, and credit goods, which are purchased by local residents.

Notably, since locations within a country are symmetric, the law of one price holds within the small open economy for the final good. However, any price differential between the domestic country and the rest of the world cannot be arbitraged away. Therefore, the relative price of the good in domestic units - simply the "real exchange rate" of the domestic country, $x_t = e_t p_t^*/p_t$, - need not be unity. Purchasing power parity generically fails to hold.

Finally, once relocation shocks are realized agents must move to their new location. A new period begins. This timing of transactions is depicted in Figure 1.

3. Banks

It is well known (from, for example, Greenwood and Smith (1993)) that in the presence of individual uncertainty concerning future liquidity needs, it is efficient for banks to arise. In particular, by accepting the deposits of young lenders, holding diversified asset porfolios on their behalf, and offering state contingent deposit returns, banks can help insure young lenders against the potential consumption losses consequences of liquidity shocks.

Domestic banks can partially overcome the implied consumption losses for lenders by offering deposit returns that are contingent on relocation status and ultimate destination, and which are paid to "movers" in the appropriate currency units at the end of a period before they physically relocate. Such agents are "early withdrawees". I assume that banks will arise in the present environment. Then, it is easy to show that all savings of young lenders will be intermediated and the following timing of events obtains.

3.1. Timing of Transactions with Banks

At the beginning of any date t, old borrowers repay any bank loans they have outstanding at local banks, and old lenders withdraw the gross value of any local bank deposits they hold. Young lenders subsequently contact banks in their location and deposit the value of their savings, and young borrowers then obtain consumption loans from banks.[8]

After all consumption has occurred, banks engage in international asset markets on behalf of young lenders and reallocate their asset portfolios in international money and loan markets. Local banks can indirectly hold the loans of borrowers in other locations through these trades, by agreeing to borrow and lend domestic and foreign goods or currency among themselves for a period. In equilibrium, of course, returns to the loans issued in all locations are equalized in a common unit.

Once asset trades are complete, markets close and remain closed. π_t is realized, and relocated agents withdraw the value of their local bank deposit which is paid in appropriate currency units. These agents then move. This timing of transactions is depicted in Figure 2.

3.2. The Behaviour of Banks

The banks that arise in either domestic location therefore accept deposits of young lenders, and back these with both currencies as well as privately issued loans and net foreign assets. With respect to deposits, banks behave as Nash competitors, announcing state contingent deposit returns that are conditional on the realization of liquidity and portfolio preference shocks and accepting all deposits that are brought forth at these returns. However, they take asset returns as given.

[8]Limited communication at the beginning of a period rationalizes the fact that young agents contact only banks in their own location and cannot deposit in banks elsewhere.

In the presence of free entry into banking (any young lender can establish an intermediary) to attract deposits banks maximize the expected utility of a young lender by choice of deposit returns, while taking private loans at competitively determined real interest rates.

The decision problem of banks can be concisely represented in the following way. A balance sheet condition and three budget constraints must hold at each date. For any domestic bank,

$$d_t \geq m_{mt} + x_t m_{m*t} + l_{lt} + x_t a_t^* \tag{3.1}$$

is the relevant balance sheet condition, where d_t denote per depositor (lender) deposits, m_{mt} $[m_{m*t}]$ denotes per depositor holdings of domestic (foreign) real balances, l_{lt} denotes the real value of per depositor domestic loans held, and a_t^* denotes net foreign assets.

In addition the bank faces three budget constraints which reflect the need to meet withdrawal demand from three types of lender. First, I denote by $\rho_{mt}(\pi_t)$ the state-contigent gross real rate of return (paid in domestic real balances) that the bank promises depositors that are domestically relocated, $\rho_{m*t}(\pi_t)$ is the analagous real gross rate of return paid (in foreign real balances) to depositors relocated to the rest of the world, and $\rho_t(\pi_t)$ is the real gross rate of return paid to depositors that are not relocated.

In addition, I denote by $\gamma_{mt} \equiv m_{mt}/d_t$ the portfolio weight that a domestic bank assigns to domestic real balances as a fraction of per depositor deposits, $\gamma_{m*t} \equiv m_{m*t}/d_t$ the portfolio weight assigned to foreign real balances, and let $0 \leq \gamma_t = \gamma_{mt} + \gamma_{m*t} \leq 1$. These portfolio weights are not state contingent, since banks select them before π_t is realized.

Finally, $0 \leq \alpha_{mt}(\pi_t) \leq 1$ represents the fraction of domestic real balances paid out at the end of date t to the $\epsilon\pi_t$ depositors that are domestically relocated. The bank cannot predict π_t, but it can choose α after the realization of the liquidity shock, and - if less than one - can use the remaining domestic currency to pay non-movers that withdraw at the beginning of $t+1$. Since foreign currency has no value in domestic exchange, then if α_{m*t} denotes the analagous fraction of foreign real balances paid to the $(1-\epsilon)\pi_t$ depositors that are relocated abroad, then $\alpha_{m*t} \equiv 1 \forall t$. [9]

[9] I assume (following Champ, Smith and Williamson (1995)), that the real loan returns negotiated between lenders (domestic banks and the rest of the world) and local borrowers during t - R_t - is non-state contingent since lenders and borrowers are physically separated when π_t is realized and relocations occur. In addition, the world price of the single final good is non-state

Noting that for the loans of each country to be held in equilibrium a no arbitrage condition holds such that the real domestic value of returns to each asset are equal, then

$$R_t = R_t^*(x_{t+1}/x_t) \tag{3.2}$$

and from (1), the portfolio weight assigned to all interest-bearing assets is simply $1 - \gamma_t$. The portfolio weights assigned to the loans of different countries are indeterminate since banks are indifferent between these loans, and gross nominal returns to interest-earning assets satisfy the uncovered interest-parity condition

$$I_t = I_t^*(e_{t+1}/e_t). \tag{3.3}$$

Finally, for loans to be held at all by banks requires that $I_t \geq 1$, so that currency is weakly dominated in rate of return.

Then the budget constraints faced by a domestic bank at date t are

$$\epsilon\pi_t\rho_{mt}(\pi_t) = \alpha_{mt}(\pi_t)\gamma_{mt}\frac{p_t}{p_{t+1}} \tag{3.4}$$

$$(1-\epsilon)\pi_t\rho_{m*t}(\pi_t) = \gamma_{m*t}\frac{p_t}{p_{t+1}}\frac{E_t e_{t+1}}{e_t} \tag{3.5}$$

$$(1-\pi_t)\rho_t(\pi_t) = (1-\gamma_t)R_t + (1-\alpha_{mt}(\pi_t))\gamma_{mt}\frac{p_t}{p_{t+1}}. \tag{3.6}$$

These reflect the fact that banks face a problem of asset and liability maturity management. When liquidity shocks are large, banks cannot use loans to pay off early withdrawees since loans cannot be liquidated prior to maturation (borrowers have no resources) and loan paper has no value in exchange for relocated agents. By contrast, when liquidity shocks are small banks can use excess domestic currency to pay non-relocated depositors, although the same statement cannot be applied to foreign currency.

Given that the continuously differentiable density function of $F(\pi)$ is $f(\pi)$, banks maximize the expected utility of a young depositor

$$ln(c_t) + \int_0^1 \pi\left[\epsilon ln(d_t\rho_{mt}(\pi_t)) + (1-\epsilon)ln(d_t\rho_{m*t}(\pi_t)\right]f(\pi)d\pi + \int_0^1 (1-\pi)ln(d_t\rho_t(\pi_t))f(\pi)d\pi \tag{3.7}$$

contingent, the world demand for domestic goods is not state contingent, and the assumptions that maintain symmetry of domestic locations ensure that the demand for the domestic good - and hence prices - is also not state-contingent.

by choice of deposit returns, taking as given per depositor deposits and all asset returns, subject to non-negativity, (4)-(6) and $0 \leq \alpha_{mt}(\pi_t) \leq 1$, $0 \leq \gamma_t \leq 1$. The solution to this problem satisfies $0 < \alpha_{mt}(\pi_t) \leq 1 \forall \pi_t$, where $\rho_{mt} \leq \rho_t$ with strict inequality if $\alpha_{mt}(\pi_t) = 1$. Then,

$$\alpha_{mt}(\pi_t) \leq \frac{\epsilon \pi_t}{1 - \pi_t(1-\epsilon)} \left[\frac{(1 - \gamma_{mt} - \gamma_{m*t})}{\gamma_{mt}} I_t + 1 \right], \tag{3.8}$$

follows immediately, where (8) is a strict inequality for $\alpha_{mt}(\pi_t) = 1$.

Banks' total currency holdings satisfy

$$\gamma_t = 1 - \int_{\hat{\pi}_t}^{1} F(\pi) d\pi \tag{3.9}$$

10

The allocations assigned by a bank to domestic and foreign currency are simply

$$\gamma_{mt} = \epsilon \gamma_t + \int_0^{\hat{\pi}_t} (1-\pi) f(\pi) d\pi \tag{3.10}$$

$$\gamma_{m*t} = (1-\epsilon)\gamma_t - \int_0^{\hat{\pi}_t} (1-\pi) f(\pi) d\pi. \tag{3.11}$$

In (9) to (11), $\hat{\pi}_t$ is the "knife-edge" value of π_t at which (8) holds with equality when $\alpha_{mt} = 1$, or

$$\hat{\pi}_t = \frac{1}{1 + \epsilon \frac{(1-\gamma_t)}{\gamma_{mt}} I_t} \equiv g(\gamma_t, \gamma_{mt}, I_t) \tag{3.12}$$

so that the optimal choice of $\alpha_{mt}(\pi_t)$ can be summarized by

$$\alpha_{mt} = min\left(\frac{\pi_t}{\hat{\pi}_t}, 1\right). \tag{3.13}$$

$\hat{\pi}_t$ denotes a critically high value of liquidity demand at which banks can no longer maintain return equality between deposits backed by domestic currency alone and deposits that are also backed by illiquid assets. For $\pi_t \leq \hat{\pi}_t$, then

[10] This solution is exactly analagous to that obtained by Champ, Smith and Williamson (1995) in their closed economy model of note-issuing vs. non- note-issuing banks in the inelastic currency regime case. The intuition is identical. In neither case can banks insure against liquidity shocks that produce "excessive" early withdrawal demand, and they account for this possibility in the setting of portfolio weights to liquid and illiquid assets.

$\rho_{mt} = \rho_t = \frac{1}{1-\pi_t(1-\epsilon)} \left(\gamma_{mt} \frac{p_t}{p_{t+1}} + (1-\gamma_t)R_t\right)$ with $\alpha_{mt} \leq 1$, as banks allocate weakly return dominated domestic currency across both movers and non-movers.

When π_t attains a critically high value, $\hat{\pi}_t$, the bank exhausts its holdings of currency in payments to movers so that $\alpha_{mt} = 1$, while just maintaining return equality across domestic movers and non-movers. At $\pi_t > \hat{\pi}_t$, $\alpha_{mt} = 1$ and deposit returns to movers contract while those to non-movers rise. Return differentials emerge among domestic lenders and it is this possibility - of imperfect insurance against liquidity shocks - that I associate with "bank panic". Effectively, if a bank confronts an ex-post problem of insufficient case reserves in the event of a large domestic liquidity shock, then it partially suspends payments to credit constrained agents.

It is also possible to succinctly summarize the bank's choice of cash-reserve ratios. Following Champ, Smith and Williamson (1995), define the function $H : [0,1] \to [0,1]$ by

$$H(x_t) = \int_x^1 F(\pi_t). \tag{3.14}$$

Then () can be rewritten as

$$1 - \gamma_t = H_t[g(\gamma_t, \gamma_{mt}, I_t)]. \tag{3.15}$$

It is easy to show that $H[g(\gamma_t, \gamma_{mt}, I_t)]$ is decreasing in γ_t. Partially differentiating $\hat{\pi}_t$ with respect to γ_t it is evident that $\partial\hat{\pi}_t/\partial\gamma_t > 0$. In addition, partially differentiating $H[g(\gamma_t, \gamma_{mt}, I_t)]$ with respect to $\hat{\pi}$. In addition, it is straightforward to show that $\partial^2\pi_t/\partial\gamma_t^2 > 0$, so that H is concave in γ_t. In addition, $H[g(\gamma_t, \gamma_{mt}, I_t)]$ is decreasing and convex in γ_{mt}.

In addition, $H[g(1,.,I)] = H[1] = 0$ and $H[g(1,1,I)] = H[1] = 0$, while $H[g(0,.,I)] = H[g(0,0,I)] = H[0] < 1$. Finally, H is also decreasing in I_t, and the slope of $H[g(\gamma_t, \gamma_{mt}, I_t)]$ if $\gamma_t = 1$ exceeds one in absolute value when $I_t > 1 + (1/\epsilon)\int_0^1 (1-\pi) f(\pi) d\pi = \gamma_{mt}/\epsilon$, equals one in absolute value if $I_t\epsilon = \gamma_{mt}$ and is less than one in absolute value if $I_t\epsilon < \gamma_{mt}$[11]. In addition, when $\gamma = 1$, $\gamma_m = \epsilon\gamma$.

These three possibilities are exhibited in Figure 3a, which graphically depicts the implied relationship between γ_t and H given by equation (). On this Figure, three possible nominal interest rates are examined that correspond to the above analysis. Notably, if $I_t = 1$, the only solution to the bank's is to set $\gamma_t = 1$. In

[11] It is worth mentioning that $\gamma = \gamma_m = 1$ is inconsistent with optimality, since zero payments will be made to agents who consume foreign goods.

addition, higher and higher nominal interest rates shift H upwards in the figure, so that the bank's optimal reserve/deposit ratio is decreasing in I. Since γ_{mt} is increasing in γ_t, then higher nominal interest rates also raise the bank's holdings of domestic currency reserves/deposits. It is easily verified that the interior solution in each case solves the optimization problem which characterizes an equilibrium. Figure 3b illustrates the relationship between γ_{mt} and H for completeness. Again, as I increases, the optimal γ_m rises.

I will henceforth denote the optimal reserve/deposit ratio by $\gamma(I_t)$, and optimal domestic currency/deposits as $\gamma_m(I_t)$, where $\gamma' < 0$, $\gamma_m' < 0$ and $\gamma(1) = 1$. The date t probability of bank panic occuring, which is simply $1 - F(\hat{\pi}_t)$, is thus increasing in I_t since higher interest rates reduce $\hat{\pi}$, the critical value of liquidity at which banks exhaust their holdings of currency.

3.3. Remarks

As the result of the bank's solution to this problem of liquidity management, aggregate *payments* to agents whose ultimate residence is in the small open economy are not state-contingent. In addition, while deposit payments to internationally relocated agents are always state-contingent, they move to the rest of the world where they are trivial. In fact, there are no *aggregate* consequences of the liquidity shock whatsoever - the consequences of liquidity shocks are entirely redistributional. It is also worth emphasizing that, since foreign currency has no alternative use, banks hold excess reserves of domestic currency to exploit its liquidity advantage relative to foreign currency as shown in (10) and (11).

3.4. Individual Behaviour

The depositors and borrowers that contact banks at the beginning of date t determine optimal deposits and optimal borrowing as follows

Standard intertemporal Euler equations determine optimal consumption allocations for all agents. Each young lender maximizes their expected utility, taking as given the deposit return schedules offered by banks, by choice of deposit and consumption. The solution to this problem for a generation t domestic lender sets

$$\begin{aligned} d_t &= \frac{y\beta}{1+\beta} \qquad (3.16) \\ c_t &= \left(\frac{y}{1+\beta}\right) \end{aligned}$$

while the date $t+1$ consumption of $\epsilon\pi_t$, $(1-\epsilon)\pi_t$ and $(1-\pi_t)$ lenders is simply

$$\begin{aligned} c_{t+1} &= \rho_{mt}(\pi_t)\frac{y\beta}{1+\beta} \\ c_{t+1} &= \rho_{m*t}(\pi_t)\frac{y\beta}{(1+\beta)} \\ c_{t+1} &= \rho_t(\pi_t)\frac{y\beta}{1+\beta}. \end{aligned} \tag{3.17}$$

Generation t borrowers set their intertemporal consumption allocation such that

$$\begin{aligned} c_t &= \frac{q}{(1+\beta)R_t} \\ c_{t+1} &= \frac{q\beta}{1+\beta}. \end{aligned} \tag{3.18}$$

Optimal borrowing, which can be denoted l_t is therefore given by

$$l_t = \frac{q}{(1+\beta)R_t}. \tag{3.19}$$

4. Governments

My goal in this paper is to consider the consequences of alternative monetary and fiscal policies in a small open economy for the sustainability of a fixed exchange rate regime and for domestic liquidity. In all policy regimes, the small open economy takes as given monetary policy in the rest of the world. I assume that the government mechanically selects policy without regard to welfare and simply ensures that its intertemporal budget constraint is respected. I can then evaluate the equilibrium consequences of alternative exogenous policy regimes.

4.1. Monetary Policy in the Rest of the World

I assume that in the rest of the world, foreign monetary policy comprises a choice of how much new foreign currency, M_t^* per capita, to print in every period, where any seignorage revenue finances an endogneous stream of foreign goods consumption by the centralized authority, g_t^* per capita. The rest of the world issues currency according to a fixed money growth rate rule

$$\frac{M_{t+1}^*}{M_t^*} = \sigma^* > 1 \forall t = 0,1,2,... \tag{4.1}$$

It satisfies the following budget constraint

$$m_t^* \left(\frac{\sigma^* - 1}{\sigma^*} \right) = g_t^* \forall t \geq 0. \tag{4.2}$$

Both M_t^* and g_t^* are exogenous to the small open economy. I assume that this policy is maintained in *all* equilibria that I analyze.

4.2. Domestic Country Policy

I consider two alternative exchange rate regimes that may be adopted by the domestic government - a fixed exchange rate against the foreign currency (which represents a one sided peg, since the foreign country's policy is taken as given), and a flexible (market determined) exchange rate regime. In addition, under either exchange rate regime, the domestic government may elect to exogenously fix either the growth rate of domestic currency, or the level of its real consumption spending.

The most general specification of domestic policy, which has all four policy regimes as special cases is as follows.

I denote the domestic money growth rate by

$$\frac{M_{t+1}}{M_t} = \sigma_t \forall t \geq 0 \tag{4.3}$$

which may generally be time varying. The domestic government's budget constraint is, $\forall t \geq 2$

$$\begin{aligned} m_t \left[\frac{\sigma_t - 1}{\sigma_t} \right] &= g_t + e_t \frac{F_t - F_{t-1}}{p_t} \\ &= g_t + x_t(f_t - f_{t-1}(p_{t-1}^*/p_t^*)) \end{aligned} \tag{4.4}$$

where F_t (f_t) is the nominal (real) per capita value of the domestic government's foreign exchange reserve, where F_t is measured in units of foreign currency and $f_t = F_t/p_t^*$ is measured in foreign goods. These denote the foreign value of the reserve at the end of date t, where I have used the fact that $e_t/p_t \equiv x_t/p_t^*$. In addition $m_t \equiv M_t/p_t$ is the per capita stock of domestic real balances outstanding in the hands of the public at the end of date t. In particular, since there is no foreign exchange rate intervention, these reserves must be acquired from sales of domestic currency to the private sector.

Thus, at date 1,

$$\frac{M_1}{M_0} = \sigma_1 \tag{4.5}$$

where M_0 is given. The domestic government's budget constraint is

$$\begin{aligned} \left[\frac{M_0}{p_1}\right]\left[\frac{1-\sigma_1}{\sigma_1}\right] &= g_1 + e_1\frac{F_1 - F_0}{p_1}, \\ &= g_1 + x_1\left[f_1 - (F_0/p_1^*)\right] \end{aligned} \tag{4.6}$$

where $F_0 > 0$ is given.

4.2.1. Fixed Exchange Rate Regimes

First, I consider a fixed exchange rate equilibrium in which $g_t = g$ is fixed and exogenous while σ_t and F_t are endogenous and may be time-varying. I also consider a fixed exchange rate regime in which the domestic government allows the money growth rate to be endogenous and time-varying and the behaviour of g_t and F_t is determined by general equilibrium

conditions. Here, the equilibrium value of $F_t - F_{t-1} = 0\ \forall t \geq 1$.

4.2.2. Flexible Exchange Rate Regimes

First, I consider a flexible exchange rate regime in which the domestic government fixes $g_t = g\ \forall t$, and the domestic money growth rate is endogenously determined. It will become evident that this policy requires that the equilibrium value of $F_t - F_{t-1}$ is zero at all dates ≥ 1. I also analyze a flexible exchange rate regime in which the domestic government fixes its own money growth rate exogenously at $\sigma_t = \sigma$ while endogenously determined seignorage revenue finances an endogenous stream of real consumption spending on domestic goods. It will become evident again that foreign exchange reserve movements are always zero.

5. General Equilibrium

For private loans to be valued in equilibrium, $I_t \geq 1$ ($I_t^* \geq 1$) is required. In addition, there is a no arbitrage condition that must hold in international markets:

$$R_t = R_t^*(x_{t+1}/x_t)\forall t \geq 1. \tag{5.1}$$

The government budget constraint (17) is satisfied so that:

$$m_t \left[\frac{\sigma_t - 1}{\sigma_t}\right] = g_t + x_t(f_t - f_{t-1}(p^*_{t-1}/p^*_t))\forall t \geq 2 \tag{5.2}$$

In addition, the domestic money market must clear at each date $t \geq 1$. The supply of domestic (foreign) real balances derives from government policy and the demand for real balances derives from the portfolio weights assigned by domestic banks to domestic real balances, and an exogenous foreign demand which I denote (in foreign goods) by ψ. Foreign demand for domestic currency derives directly from foreign demand for domestic goods, which requires domestic currency and movements of foreign agents into the domestic country. Then, in equilibrium

$$m_t = \phi \left[\gamma_{mt}(I_t)\left(\frac{y\beta}{1+\beta}\right)\right] + \psi x_t \tag{5.3}$$

The domestic goods market must clear at each date also. In each domestic location, the date t per capita supply of domestic country goods - which is simply $\phi y + (1-\phi)q$ - must equal the demand deriving from young domestic lenders and borrowers, old domestic borrowers, and old lenders (some of whom have been relocated from the second domestic location). In addition, the exogenous world demand for domestic goods is just ψ per period, expressed in foreign goods. Finally, the domestic government consumes some goods at each date.

Thus, the domestic goods market at each date $t \geq 2$ satisfies

$$\begin{aligned} \phi y + (1-\phi)q &= \left[\frac{\phi y}{1+\beta}\right] + \left[\frac{(1-\phi)q}{(1+\beta)R_t}\right] + \left[\frac{(1-\phi)q\beta}{1+\beta}\right] \\ &+ \left[\frac{\phi y\beta}{1+\beta}\right]\left[\gamma_{m(t-1)}(I_{t-1})\right](p_{t-1}/p_t) + \psi x_t(p_{t-1}/p_t) \\ &+ \left[\frac{\phi y\beta}{1+\beta}\right][(1-\gamma(I_{t-1}))R_{t-1}] + g_t. \end{aligned} \tag{5.4}$$

Note that the entire outstanding stock of domestic real balances at the beginning of date t is used to purchase domestic goods, $\left(\gamma_{m(t-1)}(I_{t-1})\right) + \psi x_t$ which has depreciated in real terms by the factor (p_{t-1}/p_t) between dates $t-1$ and t. The first three terms on the right hand side of the equation represent the consumption demand of domestic young lenders, domestic young borrowers, and domestic old borrowers respectively. The demand by domestic old lenders who hold domestic currency is the fourth term, and the demand by foreign agents is the fifth. Finally, the demand by domestic old lenders who hold interest earning assets is the sixth term and government consumption the last.

5.1. The Initial Period

In the initial period, date 1, both the government budget constraint and goods market clearing condition take a different form than they do at any other date. The domestic country government budget constraint becomes

$$\left[\frac{M_0}{p_1}\right]\left[\frac{1-\sigma_1}{\sigma_1}\right] = m_1\left[\frac{\sigma_1 - 1}{\sigma_1}\right] = g_1 + x_1\left[f_1 - (F_0/p_1^*)\right], t = 1. \tag{5.5}$$

In addition, the initial period goods market clearing conditions simplifies dramatically since all initial old agents in the domestic country are identical, have zero outstanding initial net claims on anyone else, and have no contact with banks. They simply supply the outstanding initial money stock. In addition, there are no relocatees at this time from anywhere in the world economy, and the goods market clears according to

$$\phi y + (1-\phi)q = \left[\frac{\phi y}{1+\beta}\right] + \left[\frac{(1-\phi)q}{(1+\beta)R_1}\right] + \left[\frac{M_0}{p_1}\right] + g_1, t = 1 \tag{5.6}$$

5.1.1. Fixed Exchange Rates

Suppose there exists a sustainable fixed exchange rate policy. Then $e_t = \bar{e}\ \forall t \geq 1$, and by uncovered interest rate parity, $I_t = I_t^*\ \forall t$.

Case 1: Exogenous government consumption

If $g_t = g$ is exogenous and constant $\forall t$ under such a sustainable regime, then the initial period is described as follows.

The initial period money market clearing condition is simply

$$m_1 = \phi\left[\gamma_{mt}(I_t^*)\left(\frac{y\beta}{1+\beta}\right)\right] + \psi x_1 \tag{5.7}$$

so that equilibrium domestic real balances are determined for an initial real exchange rate. It is also worth noting that, given an initial real exchange rate, the domestic price level is given by $p_1 = \bar{e}p_1^*/x_1$. Given this initial price level, then $\sigma_1 = m_1 p_1/M_0$ is determined also. The government budget constraint immediately determines f_1 and so F_1.

For a given initial real exchange rate, the initial goods market clearing condition determines R_1. Finally, once R_1 is determined then, from the date 1 no arbitrage condition, $x_2 = x_1 R_1 / R_1^*$ is given, which is the real exchange rate at date 2 that supports this equilibrium. Of course, given $x_2 = \bar{e} p_2^* / p_2$, p_2 is given.

Thus, for an initial real exchange rates, the entire date 1 equilibrium can be retrieved. Three independent equilibrium conditions determine in effect the three unkowns; R_1, m_1, and f_1, while p_1 is given. σ_1 is not determined independently of m_1 in this economy.

In addition, from this initial period, the entire equilibrium sequence of all endogenous variables can be uncovered. Once x_2 and p_2 are determined, equation () determines date 2 domestic real balances and hence σ_2 and f_2 can be derived from the date 2 budget constraint. Then R_2 (and hence x_3) follow from the goods market clearing condition () and the no arbitrage condition ().

Case 2: Endogenous government consumption

Now, with both g_1 and σ_1 endogenous, it is immediately apparent that the equilibrium value of f_1 must be zero. In other words, initial period government policy that sustains a fixed exchange rate is to leave unchanged the initial reserve position F_0.

Then, given an initial real exchange rate x_1, p_1 is given. The money market clearing condition determines m_1 (and hence σ_1) and the government budget constraint yields the value of g_1 that is required to maintain the exchange rate peg at date 1 since $\bar{e} F_0 / p_1$ is given. The goods market clearing condition determines R_1 and the no arbitrage condition determines the next period's real exchange rate x_2 which supports this equilibrium. Thus, p_2 follows immdediately from x_2 as described in Case 1.

As in the case of exogenous government consumption, once these initial values are determined the entire equilibrium sequence of endogenous variables (if it exists) can be recovered where $F_t = 0 \; \forall t \geq 1$.

Under either policy with a fixed exchange rate, it is clear that the initial price level in the domestic country p_1 is non-state contingent. In addition, from money market clearing, it is clear that m_1 is not state contingent, and hence neither is σ_1. Thus, g_1 is not state contingent in either case of a fixed exchange rate regime, and nor is R_1 (by assumption, but also an equilibrium outcome at date 1. Finally the initial reserve position taken at date 1 under Case 1 government consumption policy cannot be state contingent either. Thus x_2 is deterministic and p_2, as well as all future values of variables in an equilibrium sequences.

5.1.2. Flexible Exchange Rates

Suppose there exists a sustainable flexible exchange rate policy. Then $e_t \neq e_{t+1}$ in general, and the uncovered interest parity condition holds $I_t = I_t^*(e_{t+1}/e_t)\ \forall t$. In addition, the government no longer attempts to manipulate the exchange rate by allowing for foreign exchange movements, so that $F_t = F_0 0\ \forall t$.

Case 1: Exogenous government consumption

If $g_t = g$ is exogenous $\forall t$ under such a sustainable regime, then σ_t must be endogenous in any equilibrium. The initial period is described as follows.

Again, the initial period money market clearing condition is simply

$$m_1 = \phi \left[\gamma_{mt}(I_t) \left(\frac{y\beta}{1+\beta} \right) \right] + \psi x_1 \tag{5.8}$$

so that equilibrium domestic real balances are determined as a function of the nominal interest rate for an initial real exchange rate. From the domestic budget constraint, we find $m_1(\sigma_1)$, and hence $I_1(\sigma_1)$. In the domestic goods market, substituting from the government budget constraint for $M_0/p_1 + g = m_1(\sigma_1) + x_1(F_0/p_1^*)$, we determine $R_1(\sigma_1)$. All equilibrium date 1 variables can then be expressed as functions of σ_1, including $x_2(\sigma_1)$. However σ_1 cannot be endogenously determined at date 1. This suggests that there is a potential source of indeterminacy in the flexible exchange rate case deriving from the absence of an initial condition on σ_1.

Case 2: Endogenous government consumption

If the government elects to fix, for once and for all, its money growth rate $\sigma_t = \sigma$, then g_t is endogenous $\forall t$. The initial period is described as follows.

Again, the initial period money market clearing condition is simply

$$m_1 = \phi \left[\gamma_{mt}(I_t) \left(\frac{y\beta}{1+\beta} \right) \right] + \psi x_1 \tag{5.9}$$

so that equilibrium domestic real balances are determined as a function of the nominal interest rate for an initial real exchange rate. The government budget constraint gives $m_1(g_1)$, so that $I_1(g_1)$ results. In the domestic goods market, we can determine $R_1(g_1)$, by substituting from the budget constraint for $g_1 + M_0/p_1 = m_1(g_1) - x_1 F_0/p_1^*$.

All equilibrium date 1 variables can then be expressed as functions of g_1, including $x_2(g_1)$. Again, there is no obvious way to determine the initial government consumption level, and a potential source of indeterminacy given the absence of this initial condition.

6. Steady State Equilibria

I consider steady state equilibria in which the real exchange rate, real interest rate and the equilibrium values of all other real variables are constant. Then, under any policy regime, $R_t = R = R^*$. In addition, the world inflation rate always satisfies $p_t^*/p_{t+1}^* = (m_{t+1}^*/m_t^*)(M_t^*/M_{t+1}^*) = (1/\sigma^*)$, so that the world nominal interest always satisfies $I_t^* = I^* = R^*\sigma^*$ in any steady state equilibrium. I now consider the steady state conditions that must hold under each of the four policy regimes.

6.1. Fixed Exchange Rates

In a steady state under fixed exchange rates, $x_{t+1} = x_t \Rightarrow p_{t+1}/p_t = (e_{t+1}p_{t+1}^*/e_t p_t^*) = \sigma^*$. Then, $M_{t+1}/M_t = (m_{t+1}/m_t)(p_{t+1}/p_t) = p_{t+1}/p_t = \sigma^*$. Domestic money growth must exactly match foreign money growth, and the domestic inflation rate is identical to the world inflation rate. In addition, under fixed exchange rates, $I = I^*$ obviously holds which implies that bank portfolio weights, $\gamma_m(I), \gamma_{m*}(I)$ are constant in any steady state.

The following equations describe the remaining steady state conditions that are consistent with indefinite sustainability of a fixed exchange rate regime.

First, the government budget constraint takes the form, where government expenditure is exogenous,

$$m\left[\frac{\sigma^* - 1}{\sigma^*}\right] = g + x\left[f_t - f_{t-1}\frac{1}{\sigma^*}\right]. \tag{6.1}$$

As noted above, $\sigma = \sigma^*$ must obtain in a steady state under fixed exchange rates. Obviously, if Case 2 policy obtains, in which g is endogenous, then $F_t = F_0 > 0$

$\forall t$, and the budget constraint becomes simply

$$m\left[\frac{\sigma^*-1}{\sigma^*}\right]=g. \tag{6.2}$$

I will return to Case 1, in which g is exogenous, below.

The money market clears in a steady state equilibrium under fixed exchange rates as follows;

$$m=\phi\left[\gamma_m(R^*\sigma^*)\right]\left[\frac{y\beta}{1+\beta}\right]+x\psi. \tag{6.3}$$

Finally, the goods markets equilibrium takes the form

$$\begin{aligned}\phi y+(1-\phi)q &= \left[\frac{\phi y}{1+\beta}\right]+\left[\frac{(1-\phi)q}{(1+\beta)R}\right]+\left[\frac{(1-\phi)q\beta}{1+\beta}\right] \\ &+ \left[\frac{\phi y\beta}{1+\beta}\right]\left[\frac{\gamma_m(R^*\sigma^*)}{\sigma^*}\right]+\left[\frac{x\psi}{\sigma}\right] \\ &+ \left[\frac{\phi y\beta}{1+\beta}\right]\left[(1-\gamma(R^*\sigma^*))R^*\right]+g\end{aligned} \tag{6.4}$$

Case 1: Exogenous Government Consumption

In this case, a steady state equilibrium (sustainable fixed exchange rate) must be consistent with an initial period in which $x_1\left[f_1-F_0/p_1^*\right]$ is non-zero and in which $x_t\left[f_t-f_{t-1}(p_{t-1}^*/p_t^*)\right]$ is generally non-zero in any equilibrium sequence. In a steady state, it is evident that $f_{t+1}-f_t/\sigma_t^*=f_t-f_{t-1}/\sigma^*$ implies that $F_{t+1}-F_t=\sigma^*(F_t-F_{t-1})\ \forall t$. Thus the domestic value of the real reserve movement can be constant if the nominal reserve grows over time at the rate σ^*. This necessitates that $f_1>F_0/p_1^*$, or reserves will fall to zero, and the regime will be abandoned.

The initial reserve movement will be positive if $\sigma_1>1+(g\bar{e}p_1^*/p_1)$ from the date 1 budget constraint. However, there is no guarantee that this can be achieved, since σ_1 must be endogenously determined. Therefore, the economy under this policy regime will generically fail to achieve a steady state equilibrium. From henceforth, we therefore ignore it, and note simply that an exogenous constant government consumption policy is generically inconsistent with a steady state equilibrium under fixed exchange rates.

Case 2: Endogenous Government Consumption

In this case, a steady state equilibrium (sustainable fixed exchange rate) must be consistent with an initial period in which $x_1\left[f_1 - F_0/p_1^*\right] = 0$ and in which $x_t\left[f_t - f_{t-1}(p_{t-1}^*/p_t^*)\right]$ is zero in any equilibrium sequence. Thus, $F_t = F_{t-1}\ \forall t$, implying that $F_t = F_0$.

In a steady state, we can write the budget constraint as

$$m\left[\frac{\sigma^* - 1}{\sigma^*}\right] = g \tag{6.5}$$

$\forall t$. In addition, the goods market and money market equilibrium conditions are just given by () and (). Substituting for g from the budget constraint into the goods market clearing condition yields $g + m/\sigma^* = m$, so that this condition can be rewritten as

$$\begin{aligned}\phi y + (1-\phi)q &= \left[\frac{\phi y}{1+\beta}\right] + \left[\frac{(1-\phi)q}{(1+\beta)R^*}\right] + \left[\frac{(1-\phi)q\beta}{1+\beta}\right] \\ &+ \left[\frac{\phi y \beta}{1+\beta}\right]\left[\gamma_m(R^*\sigma^*)\right] + x\psi \\ &+ \left[\frac{\phi y \beta}{1+\beta}\right]\left[(1-\gamma(R^*\sigma^*))R^*\right].\end{aligned} \tag{6.6}$$

Then x is immediatly determined, and from () real balances are determined. Finally g follows from the government budget constraint.

Thus, the steady state value real exchange x is determined by goods market equilibrium and steady state real balances by money market clearing under either regime, while the government budget constraint yields the equilibrium value of g.

6.2. Flexible Exchange Rates

Under flexible exchange rates the domestic government can either select a constant money growth rate σ or a constant value for g. In the case in which the monetary authority sets a constant money growth rate, equilibrium allocations are unaffected by the choice of exchange rate regime for $\sigma = \sigma^*$.

Under either policy regime, in a steady state under flexible exchange rates, $p_{t+1}/p_t = M_{t+1}/M_t = \sigma$ which must be constant from the government's budget constraint

$$m\left[\frac{\sigma-1}{\sigma}\right] = g. \tag{6.7}$$

Then, $I = R\sigma = R^*\sigma$ is constant, and satisfies $I = I^*(e_{t+1}/e_t) = R^*\sigma^*(e_{t+1}/e_t) = R\sigma^*(e_{t+1}/e_t)$. Hence, the gross rate of nominal depreciation is $e_{t+1}/e_t = \sigma/\sigma^*$ in a flexible exchange rate steady state. Once again, the bank portfolio weights - $\gamma_m(I)$ and $\gamma_{m*}(I)$ - are constant in this steady state, as is $\hat{\pi}$ which also depends only on I. In addition, the probability of bank panic is simply the positive constant $1 - F(\hat{\pi})$.

The money market clearing condition is simply

$$m = \psi\left[\gamma_m(R^*\sigma)\right]\left[\frac{y\beta}{1+\beta}\right] + x\psi \tag{6.8}$$

and goods market clearing requires that

$$\begin{aligned} \phi y + (1-\phi)q &= \left[\frac{\phi y}{1+\beta}\right] + \left[\frac{(1-\phi)q}{(1+\beta)R^*}\right] + \left[\frac{(1-\phi)q\beta}{1+\beta}\right] \\ &+ \left[\frac{\phi y\beta}{1+\beta}\right]\left[\frac{\gamma_m(R^*\sigma)}{\sigma}\right] + \left[\frac{x\psi}{\sigma}\right] \\ &+ \left[\frac{\phi y\beta}{1+\beta}\right]\left[(1-\gamma(R^*\sigma))R\right] + g \end{aligned} \tag{6.9}$$

Again, substituting from the government budget constraint for g yields

$$\begin{aligned} \phi y + (1-\phi)q &= \left[\frac{\phi y}{1+\beta}\right] + \left[\frac{(1-\phi)q}{(1+\beta)R^*}\right] + \left[\frac{(1-\phi)q\beta}{1+\beta}\right] \\ &+ \left[\frac{\phi y\beta}{1+\beta}\right]\left[\gamma_m(R^*\sigma)\right] + x\psi \\ &+ \left[\frac{\phi y\beta}{1+\beta}\right]\left[(1-\gamma(R^*\sigma))R^*\right]. \end{aligned} \tag{6.10}$$

Case 1. Exogenous government consumption

When the exchange rate is flexible, if g is the government's choice variable while σ is endogenous, then the three unknowns x, σ and m must be jointly determined by the budget constraint (which can be thought of as yielding $m(\sigma)$), the money market clearing condition (which yields $m(\sigma, x)$), and the goods market clearing condition (which gives $x(\sigma)$).

Case 2. Endogenous government consumption

When the exchange rate is flexible, if σ is the government's choice variable while g is endogenous, then x is derived from the goods market clearing condition, m from the money market clearing condition, and g from the budget constraint. The system in this case is recursive.

6.3. Properties of Steady States

Under either fixed or flexible exchange rates, there exists a unique steady state equilibrium for any given domestic policy choice variable. I now characterize the relationship between x and R^* and prove the uniqueness of the steady state.

Consider the impact for the steady state goods market of a change in $R = R^*$.

Fixed Exchange Rates

Consider the case in which government consumption is endogenous. The goods market clearing condition can be thought of as a locus in R^*, x space, given g.

Then, the partial effect of a change in the world real interest rate is just

$$-\psi\left\{\frac{\partial x/\partial R^*}{\sigma}\right\} = -\left[\frac{(1-\phi)q}{(1+\beta)R^{*2}}\right] + \left[\frac{\phi y\beta}{1+\beta}\right][\gamma_m'(R^*\sigma^*)] + \left[\frac{\phi y\beta}{1+\beta}\right][(1-\gamma(R^*\sigma^*))] - \left[\frac{\phi y\beta}{1+\beta}\right][\gamma'(R^*\sigma^*)]\,\sigma^* R^*. \tag{6.11}$$

This can be rewritten, using the expression for γ_{mt} in equation (3.10), as

$$-\psi\left\{\frac{\partial x/\partial R^*}{\sigma}\right\} = -\left[\frac{(1-\phi)q}{(1+\beta)R^{*^2}}\right]+\left[\frac{\phi y\beta}{1+\beta}\right][(1-\gamma(R^*\sigma^*))] + \left[\frac{\phi y\beta}{1+\beta}\right]\left[(\epsilon-I^*)\gamma'(R^*\sigma^*)+f(\hat{\pi})(1-\hat{\pi})(\partial\hat{pi}/\partial R^*)\right]. \tag{6.12}$$

Since $(\partial\hat{pi}/\partial R^*) < 0$, and $(\partial^2\hat{\pi}/\partial R^{*^2}) < 0$ it is evident that the last term on the second line is negative but increasing in R^*. In addition, $\gamma'(I^*) < 0$, and $\gamma''(I^*) < 0$, while $\epsilon - I^* < 0$. The first term on the second line is therefore positive. Since the last term is negative and increasing, at high values of R^* the second line tends to be positive, while at low values of R^* it can be small and positive or negative.

The sign of the first line also depends on the value of R^*. This first line represents the impact for net foreign assets of an increase in R^*. When R^* is high, $\gamma(I^*)$ is low and banks want to hold more of all interest-earning assets so that $(1-\gamma(I^*))$ rises. When R^* is high, optimal domestic borrowing decreases. Thus the sum of the first two terms is positive (bank total assets exceed domestic loans - net foreign assets are positive). The converse is true when R^* is very low.

Thus at high values of R^*, it is evident that $(dx/dR^*) < 0$, while at low values of R^* $(dx/dR^*) > 0$. Then, the goods market equilibrium locus is "hill-shaped". This is illustrated in Figure 4. For a given world real interest rate, x is immediately determined, and x will be increasing in R^* at low real interest rates, and decreasing in R^* at high real interest rates.

The intuition for this is simply that higher real interest rates unambiguously reduce the first period consumption of young borrowers. They also reduce bank holdings of domestic currency. Then, old lenders that are relocated have lower purchasing power in their new location. However, old lenders who consume loan income gain purchasing power as their gross interest income rises.

At high real interest rates the positive income effect for old lenders dominates. Thus, at low real interest rates domestic real exchange rate depreciation - a higher x - is required to maintain goods market equilibrium as the real interest rate rises. This real exchange rate movement raises the purchasing power of foreign agents over domestic goods. At high real interest rates, the converse real exchange rate movement is required to preserve equilibrium.

Since we know that there exists a unique steady state x for any given R^* under fixed exchange rates, and obviously there exists a unique steady state $I = I^*$, then steady state real balances and, therefore, government consumption or real foreign reserves are also unique.

Under flexible exchange rates, $\sigma \neq \sigma^*$, the same analysis applies exactly as in the example of fixed exchange rates, as is easily verified. Thus, Figure 4 represents the steady state relationship between R^* and X irrespective of the policy regime.

6.4. Bank Panics

Proposition 2 *In any steady state equilibrium*
a) There is a constant and positive probability of bank panic in every period.
b) This probability is increasing in the world real interest rate
c) The probability is increasing in the domestic money growth rate
d) Under flexible exchange rates, the probability of bank panic is increasing in the rate of nominal depreciation of domestic currency. vspace*0.2in

The proof of Proposition 2 is straightforward. Since $I = R^*\sigma$ is constant at every date, then under any policy regime banks' optimal portfolio weights are constant. In addition, $\hat{\pi}$ is constant when I is constant. The probability of bank panic is simply $1 - F(\hat{\pi})$, and this is clearly decreasing in $\hat{\pi}$. A higher nominal interest rate reduces $\hat{\pi}$, thereby raising the probability of bank panic. Such an increase in I can either be achieved by a higher (exogenous) σ (σ^* under fixed exchange rates), or by a rise in the exogenous world real interest rate. Under flexible exchange rates, σ determines the rate of nominal depreciation of the domestic currency $e_{t+1}/e_t = \sigma/\sigma^*$, for a given money growth rate. When σ is exogenous, a rise in σ represents a higher depreciation rate, as well as a higher nominal interest rate.

6.5. Comparative Statics

From Figure 4, it is clear that if the world real interest rises, the impact for x depends on how high the existing real interest rate is. At low real interest rates, $dx/dR^* > 0$ and the real exchange rate depreciates, while at high world real interest rates $dx/dR^* < 0$ and the real exchange rate appreciates (since the domestic gross interest income increase dominates all other effects, requiring a decline in the purchasing power of foreign agents for goods market equilibrium.) In addition, higher world real interest rates, reduce $\hat{\pi}$ and γ thereby raising the probability of domestic bank panic as described above. Thus, as world real and nominal interest rates rise, at a high initial world real interest rate, a real exchange rate appreciation is associated with a higher frequency of bank illiquidity and panic. This accords well with ideas about the sources of financial crisis in Mexico during 1994-1995.

7. Currency Crises and Bank Panics

I define a currency crisis as a situation in which the fixed exchange rate must be abandoned. Indefinite maintenance of a fixed exchange rate is possible only when the domestic government perfectly coordinates its money growth rate policy with that abroad *and* allows its consumption level to freely adjust in response to this monetary policy. In other words, domestic monetary and fiscal policy must be completely endogenous if a fixed exchange rate regime is to be sustained - as was demonstrated in the steady analysis above.

This suggests a simple characterization of a currency crisis which is analagous to that of Krugman (1979). I consider a situation in which the small open economy is initially in a fixed exchange rate steady state. The fixed exchange rate steady state is then unexpectedly disturbed by a change in domestic government policy. Private agents do not anticipate the policy change.

For simplicity, I will consider situations in which the disturbance in government policy involves an attempt to exogenously fix government consumption at a constant level[12].

7.1. Endogenous Government Consumption

Suppose the economy is in an intial fixed exchange rate steady state. The government allows g to be endogenously determined, as well as σ which must be equal to σ^* in this steady state.

From some date $t = \hat{t}$, the domestic government attempts to peg the level of its real consumption at a constant value $\hat{g} > \bar{g}$, where $\bar{g}$ denotes per capita real reserves that obtain in the fixed exchange rate steady state.

From the budget constraint, a date $\hat{t}$ rise in g to $\hat{g}$ requires an immediate change in m,

$$dm_{\hat{t}}\left[\frac{\sigma^* - 1}{\sigma^*}\right] = dg_{\hat{t}} > 0. \tag{7.1}$$

[12]Obviously, more complicated dynamic policies could also be characterized, in which real government spending is set differently in every period. Here, for simplicity, I confine attention to a stationary policy.

Using the money market clearing condition,

$$dm_{\hat{t}} = \psi dx_{\hat{t}} \tag{7.2}$$

which implies that the impact for $x_{\hat{t}} > 0$. From the goods market, however, we have

$$dg_{\hat{t}} = -\psi dx_{\hat{t}}/\sigma^* < 0 \tag{7.3}$$

or, substituting in the initial steady state equation for $m/\sigma^* + g = m$, then $\psi dx_{\hat{t}} = 0$. In other words, the condition required for goods market clearing is clearly inconsistent with the satisfaction of the budget constraint. Thus one possibility is an immediate abandonment of the exchange rate regime.

In this event, if $\hat{g}$ is to be maintained, then it is straightforward to show that σ must rise above σ^* and m must decline at the intial date, or the converse is true. Which outcome is realized depends crucially on the initial level of m. If m is small, this corresponds to a high world real interest rate and a low value of ψ (foreign demand). When these two conditions hold, then σ tends to fall at the initial date, while m tends to rise. The domestic nominal interest rate declines, and the nominal exchange rate appreciates. The probability of bank panic declines as a result. However, none of these features of the model are consistent with the actual data on currency crises. On the other hand, assumptions under which σ rises and m falls are also inconsistent with the actual data (ie. high foreign demand for domestic goods and low world real interest rates).

It therefore appears as though this is not an interesting case, empirically. In particular, it does not accord with conventional wisdom that currency crises partly originate in a "history" of bad policy. Nor does it involve any losses of reserves.

However, there is an alternative method by which the government may attain a new stationary path. This authority could sell off initial reserves which it has maintained since date 1 to finance the new consumption. These reserves have current real value of $x_{\hat{t}}(F_0/p^*_{\hat{t}})$.

From the budget constraint, a date $\hat{t}$ rise in g to $\hat{g}$ can be accomodated by simply altering the reserve level

$$0 = dg_{\hat{t}} - x(dF_0/p^*_{\hat{t}}). \tag{7.4}$$

This equation simply determines $F_{\hat{t}}$, where m and x remain at their initial steady state values.

In the goods market, substituting in the initial steady state for $m/\sigma^* + g = m$, it is evident that the initial steady state can be sustained in this manner since the equilibrium movment in x is zero.

Now, we can rewrite the stationary budget constraint as

$$m\left[\frac{\sigma^*-1}{\sigma^*}\right]=\hat{g}+x\left[f_{\hat{t}+k}-f_{\hat{t}+k-1}/\sigma^*\right]\forall k\geq 1. \tag{7.5}$$

For the small open economy to maintain this stationary solution requires that real balances, and hence the real exchange rate, are sustained at their initial levels, while the real foreign exchange reserve is run down at a constant rate to finance the higher spending. For this rate to be constant over time requires that

$$\begin{aligned} f_{\hat{t}+k}-f_{\hat{t}+k-1}/\sigma^* &= f_{\hat{t}+k+1}-f_{\hat{t}+k}/\sigma^* \Rightarrow \\ \left[\frac{F_{\hat{t}+k}}{p^*_{\hat{t}+k}}\right]-\left[\frac{F_{\hat{t}+k-1}}{p^*_{\hat{t}+k}}\right] &= \left[\frac{F_{\hat{t}+k+1}}{p^*_{\hat{t}+k+1}}\right]-\left[\frac{F_{\hat{t}+k}}{p^*_{\hat{t}+k+1}}\right] \Rightarrow \\ \left[F_{\hat{t}+k}-F_{\hat{t}+k-1}\right]\sigma^* &= \left[F_{\hat{t}+k+1}-F_{\hat{t}+k}\right]. \end{aligned} \tag{7.6}$$

In other words, the nominal reserve must decline in each period at an increasing rate.

In this economy, initial conditions for each variable are determined by their steady state values. Then, one can characterize a temporary, stationary path for the economy which (1) can be attained at $\hat{t}$ (2) is consistent with private sector expectation that the government will now maintain the fixed exchange rate until it can no longer do so (3) in which there are constant, market clearing values for the endogenous real variables x, R, m and e and in which $\sigma=\sigma^*$ (4) the nominal value of the government's foreign exchange reserve falls each period $\forall t\geq\hat{t}$ and $\Delta F_{\hat{t}+k}/\Delta F_{\hat{t}+k-1}=\sigma^*\ \forall k$.

Obviously, this is not a sustainable policy. As in Krugman (1979), eventually the reserve must run out, and the small open economy must abandon the fixed exchange rate peg. For a finite number of periods, the number of which depends on the initial reserve and on σ^*, government reserves are sold in foreign exhange markets in return for domestic currency which is used to finance $\hat{g}$. During this period, the frequency of domestic bank panic is preserved. Thus, the higher g could be thought of as a policy designed to sustain liquidity of the domestic banking system. As in Krugman (1979), reserve losses under a fixed exchange rate finance a rate of domestic credit creation which is ultimately inconsistent with maintenance of the exchange rate peg.

At some date T, which is endogenously determined, the reserve loss required to sustain this stationary path cannot be achieved, since F_{T-1}, is not large enough. If $\hat{g}$ is to be maintained, then at T, either m or σ must rise. Suppose the government attempts to sustain the fixed exchange rate with $\sigma = \sigma^*$. Then

$$m\left[\frac{\sigma_* - 1}{\sigma^*}\right] < \hat{g} \tag{7.7}$$

, while

$$dm_T\left[\frac{\sigma^* - 1}{\sigma^*}\right] = 0 \tag{7.8}$$

is the only solution for dm_T at T if $\sigma_T = \sigma^*$. Thus, the government must abandon the fixed exchange rate regime.

Since private agents can perfectly anticipate this outcome, at $T-1$ the expected nominal exchange rate $E_{T-1}e_T$ is different than $\sigma^* e_{T-1}$. Thus, domestic nominal interest rates rise to $R^*(Ep_T/p_{T-1})$. I seek a stationary solution to the decision problem of banks at $T-1$, such that a new flexible exchange rate steady state can be attained at T.

I guess a solution of the form $(Ep_T/p_{T-1}) = \hat{\sigma}$, where $p_{T-1} = \sigma^* p_{T-2}$. Thus, $Ep_T = \sigma_T \sigma^* p_{T-2}$. Then domestic nominal interest rates become $I_{T-1} = R^* \sigma_T$.

Suppose that $\sigma_T < \sigma^*$. Then at $T-1$, banks reallocate their portfolios into currency and out of loans as the domestic nominal interest rate falls. While this will not directly affect the goods market at $T-1$, it will influence the date $T-1$ money market directly. In particular, the portfolio weight assigned to domestic real balances is higher than in the previous period, and this tends to raise m_{T-1} given $x_{T-1} = x$. A higher value of m_{T-1} means that the rate of nominal reserve sales can decline at $T-1$. Which renders the original hypothesized date of the currency crisis inconsistent with the behaviour of agents at $T-1$.

Suppose $\sigma_T > \sigma^*$. Then the opposite chain of events occurs at $T-1$. Nominal interest rates rise, banks reallocate their portfolios out of currency and into loans, and real balances at $T-1$ are lower than at $T-2$. This aggravates the loss of reserves at $T-1$. Then, assuming that the original hypothesized date of crisis is correct, which is accounted for by agents in determining I_{T-1} and hence a rational expectation σ_T, reserves indeed reach their lower bound at $T-1$. Thus σ_T is the rational forecast of private agents for the date T money growth rate that ensures that nominal interest rates rise just sufficiently to ensure that the lower bound of F is reached exactly at $T-1$ (ie. m_{T-1} falls exactly the "right amount").

In addition, there is a positive rate of nominal depreciation of the exchange rate. Between $T-1$ and T, since $I_{T-1} = R^*\sigma_T > R^*\sigma^* = I^*$, then $I_{T-1} = I^*(e_T/\bar{e}) \Rightarrow$ that $e_T > \bar{e}$. In addition, if the transitional money growth rate is sufficiently high, then there is a real depreciation between $T-1$ and T. In addition, the probability of banking crises unambiguously rises in the domestic country in this period *prior* to the abandonment of the fixed exchange rate as the domestic nominal interest rate rises (and γ falls).

While the analysis of transitional dynamics is not yet complete, we can describe a new flexible exchange rate equilibrium. In this, σ is endogenous while $g = \hat{g}\ \forall t$. Thus, denoting the new steady state values with $\hat{.}$,

$$\hat{m}\left[\frac{\hat{\sigma}-1}{\sigma}\right] = \hat{g} \tag{7.9}$$

while

$$\hat{m} = \psi\left[\gamma_m(R^*\hat{\sigma})\right]\left[\frac{y\beta}{1+\beta}\right] + \hat{x}\psi \tag{7.10}$$

and goods market clearing requires that

$$\begin{aligned}\phi y + (1-\phi)q &= \left[\frac{\phi y}{1+\beta}\right] + \left[\frac{(1-\phi)q}{(1+\beta)R^*}\right] + \left[\frac{(1-\phi)q\beta}{1+\beta}\right] \\ &+ \left[\frac{\phi y\beta}{1+\beta}\right]\left[\frac{\gamma_m(R^*\hat{\sigma})}{\hat{\sigma}}\right] + \left[\frac{\hat{x}\psi}{\hat{\sigma}}\right] \\ &+ \left[\frac{\phi y\beta}{1+\beta}\right]\left[(1-\gamma(R^*\hat{\sigma}))R\right] + \hat{g}.\end{aligned} \tag{7.11}$$

Clearly, this steady state exists and is unique. The goods market clearing condition determines $\hat{x}(\hat{\sigma})$, and the money market therefore yields $\hat{(m)}(\hat{\sigma})$. The government budget constraint supplies the remaining requires equation in $\hat{m}(\hat{\sigma})$. In the new steady state, if $\hat{m}$ is lower than m, then $\hat{(\sigma)}$ is higher than σ^*, and there is a permanently higher probability of domestic bank panic. This scenario is reminiscent of the banking crises observed in Mexico and Argentina following Mexico's balance of payments crisis in 1994.

In fact, it is straightforward to construct equilibria in which agents rationally anticipate that at T the domestic government will abandon the exchange rate peg, set $\Delta F_t = 0 \forall t \geq T$, and a constant $\hat{\sigma} > \sigma^* \forall t \geq T$ to satisfy its budget constraint at a continued rate of government consumption $\hat{g}$. In the new steady state equilibrium which can be attained at date $T+1$, 1) $e_{t+1}/e_t = \hat{\sigma}/\sigma^* > 1$ 2) the domestic country's real exchange rate is permanently raised (depreciates) relative to the previous finite stationary period 3) the probability of bank panic in the domestic country is permanently raised relative to that in the foreign country since $\hat{I} > I^*$, and (5) the probability of bank panic is increased.

Thus, if a country ever attempts to run an excess domestic credit creation policy which stabilizes the probability of bank panic, when the exchange rate peg is inevitably abandoned such a country experiences a permanent increase in the frequency of banking crises.

8. Conclusion

This paper has characterized the origins of banking crises and currency crises in a model where both result entirely from changes in fundamentals. The origins of both appear to be consistent with many ideas and empirical evidence regarding financial crises. In addition, the features of "twin" banking crises and currency crises in the model match well with some of the stylized facts concerning the recent twin crises in Latin America and East Asia.

REFERENCES

Betts, C.M. (1996) "Currency Crises and Bank Panics", manuscript, USC

Betts, C.M. and B.D. Smith (1996) "Money, Banking and the Determination of Real and Nominal Exchange Rates", forthcoming, *International Economic Review*

Bryant, J. (1980) "A Model of Reserves, Bank Runs and Deposit Insurance", *Journal of Banking and Finance*, **4** pp. 335-344

Calomiris, C.W. and G. Gorton (1991) "The origins of Banking Panics: Models, Facts, and Bank Regulation", in G. Hubbard (ed.) *Financial Markets and Financial Crises* University of Chicago Press: Chicago pp. 109-173

Calvo, G.A. (1995) "Varieties of Capital Market Crises", University of Maryland Center for International Studies Working Paper

Calvo, G.A. and E. Mendoza (1996) "Reflections of Mexico's Balance of Payments Crisis: a Chronicle of a Death Foretold", University of Maryland: Maryland

Champ, B., B.D.Smith and S. Williamson (1995) "Currency Elasticity and Banking Panics: Theory and Evidence", forthcoming, *Canadian Journal of Economics*

Chari, V.V. (1989) "Banking Without Deposit Insurance or Bank Panics: Lessons From a Model of the US Banking System", Federal Reserve Bank of Minneapolis *Quarterly Review* pp. 3-19

Chari, V.V. and R. Jagannathan (1988) "Banking Panics, Information, and Rational Expectations Equilibrium", *Journal of Finance*, **43**: pp. 749-760

Diamond, D. and P. Dybvig (1983) "Bank Runs, Deposit Insurance and Liquidity", *Journal of Political Economy*, **85**, pp. 191-206

Diaz-Alejandro, C. (1985) "Good-bye Financial Repression, Hello Financial Crash", *Journal of International Economics*, **19**

Diaz-Gimenez, J., E.C. Prescott, Terry Fitzgerald, and Fernando Alvarez (1992) "Banking in Computable General Equilibrium Economies", *Journal of Economic Dynamics and Control*, **16**, pp. 533-559

Gale, D. and M. Hellwig (1985) "Incentive Compatible Debt Contracts: The One Period Problem", *Review of Economic Studies*, **52**: pp. 647-663

Gorton, G. (1985) "Banking Suspensions of Convertibility", *Journal of Monetary Economics*, **15** pp. 177-193

Jacklin, C. and S. Bhattacharya (1988) "Distinguishing Panics and Information-Based Bank Runs: Welfare and Policy Implications", *Journal of Political Economy*, **96** pp. 568-592

Kaminsky, G. and C. Reinhart (1996) "The Twin Crises: Causes of Banking and Balance of Payments Crises", forthcoming, *Journal of International Economics*

Krugman, P. (1979) "A Model of Balance of Payments Crises", *Journal of Money, Credit and Banking*, **11**: pp. 311-325

Obstfeld, M. (1994) "The Logic of Currency Crises", NBER Working Paper No. 4640

Obstfeld, M. (1996) "Models of Currency Crises with Self-Fulfilling Features", *European Economic Review*, conference volume

Smith, B.D. (1990) "Bank Panics, Suspensions, and Geography: Some Notes on the Contagion of Fear in Banking", *Economic Inquiry*

Stoker, J. (1994) "Intermediation and the Business Cycle Under a Specie Standard: the role of the Gold Standard in English Financial Crises 1790-1850 ", University of Chicago: Chicago

Velasco, A. (1987) "Financial and Balance of Payments Crises", *Journal of Development Economics*, **27**: pp. 263-283

Wallace, N. (1988) "Another Attempt to Explain an Illiquid Banking System: the Diamond and Dybvig Model with Sequential Service Taken Seriously", Federal Reserve Bank of Minneapolis *Quarterly Review* **14** pp. 3-16

Wallace, N. (1990) "A Banking Model in Which Partial Suspension in Best", Federal Reserve Bank of Minneapolis *Quarterly Review* **14** pp. 11-23