Financial Crises in Emerging Markets: A Canonical Model

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Abstract: We present a simple model that can account for the main features of recent financial crises in emerging markets. The international illiquidity of the domestic financial system is at the center of the problem. Illiquid banks are a necessary and a sufficient condition for financial crises to occur. Domestic financial liberalization and capital flows from abroad (especially if short-term) can aggravate the illiquidity of banks and increase their vulnerability to exogenous shocks and shifts in expectations. A bank collapse multiplies the harmful effects of an initial shock, as a credit squeeze and costly liquidation of investment projects cause real output drops and collapses in asset prices. Under fixed exchange rates, a run on banks becomes a run on the currency if the central bank attempts to act as a lender of last resort.

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1. Introduction

Recent events in Asia must have convinced anyone who still needed convincing that financial crises in emerging markets must be a major priority for research in economics. Economies that until recently had been hailed as paragons of good macroeconomic management suddenly find themselves mired in a massive collapse of asset prices and economic activity. This situation is unprecedented in scope, but not kind. Other financial meltdowns, particularly in Chile in 1982 and in Mexico in 1994, were just as surprising to observers and just as difficult to rationalize using standard models.[1]

A model that provides a useful formalization of this phenomenon must have the following features:

1. *It must not rely on government misbehavior to generate the crisis.* A striking fact of recent crises is that government budgets were either in balance or showed surpluses. This has been stressed by Velasco (1987) for the case of Chile, by Sachs, Tornell and Velasco (1996a) for Mexico and by Radelet and Sachs (1998) for Asia. This means that "first generation" models of currency crises, (pioneered by Krugman, 1979) which rely on large money-financed fiscal deficits to generate reserve erosion and an eventual currency crash, are not well suited to explain these recent crashes.

[1] For a discussion emphasizing the similarities between the recent Asian crisis and those of Chile 82 and Mexico 94, see Chang and Velasco (1998b).

2. *It must be general enough to accommodate a wide variety of macroeconomic circumstances.* As Frankel and Rose (1996) and Sachs, Tornell and Velasco (1996b) have shown, there is no unique pattern of behavior for basic macroeconomic variables in the buildup to a crisis. Sometimes the current account is in deficit, but not always. The same is true for private consumption and investment. In the Frankel and Rose (1996) study of macroeconomic behavior over a large set of currency crises, there is often a contraction in output the year of the crisis but, as the authors themselves point out, causality could run in either direction. This suggests that "second generation" models (pioneered by Obstfeld 1994), in which the government devalues in reaction to mounting unemployment and/or a growing external imbalance, are not too useful either.

3. *It must be specific enough to explain why in some of these macroeconomic scenarios a crisis occurs, and in some it does not.* First, it must answer the question of why now and not before. Take the case of the current account, whose behavior is often blamed for currency crashes. East Asian countries often had large current account deficits in the 1980s and early 1990s, but the crash did not happen until now. Why? Second, it must also answer the question of why here and not elsewhere: in 1996 Malaysia, Korea, the Philippines and Thailand had large current account deficits (above 4 percent of GDP), but so did Brazil, Chile Colombia, and Peru. Yet the crisis happened in Asia and not in South America.[2]

4. *It must account for the high observed correlation between exchange rate collapses and banking crises.* In the Southern Cone of the Americas in the early 1980s, Scandinavia in the early 1990s, Mexico in 1995 and Asia today, the currency crashed along with the financial system. Casual observation also suggests that the prices of assets (real estate, the stock market) tend to rise before a crash occurs. Formal econometric work, such as that reported by Kaminsky and Reinhart (1996), confirms that financial variables, unlike real ones, do seem to be reasonably good predictors of crises. Sachs, Tornell and Velasco (1996b), for instance, find that the previous speed of bank credit growth helped explain which countries

[2]There has also been great heterogeneity within the set of Asian crisis countries concerning the behavior of the real exchange rate, the current account, etc. See Corsetti, Pesenti and Roubini (1998).

were affected by the Tequila effect. [3]

5. *It must replicate the puzzling fact that the punishment is much larger than the crime.* The real consequences of these crises are large: Chile's GDP contracted by 14 percent in 1982, Mexico's by almost 7 in 1995. The economies of once fast-growing Korea, Indonesia and Thailand are expected to shrink in 1998. Yet we saw above that not in all cases were the underlying macro fundamentals weak –and certainly not so weak as to justify the depressions observed in Chile and Mexico. A necessary correction in the current account of, say, 3 points of GDP naturally requires a contraction in aggregate demand, which in turn may be associated with higher interest rates and dampened activity. But no standard calibration of an RBC model requires real interest rates of 50 percent or higher to effect such a reduction in consumption and investment, and no standard sticky-price model can generate that kind of response of output to moderate changes in demand.

In this paper we offer a simple model that can satisfy the requirements just listed and can replicate observed stylized facts. Our story places *international illiquidity*, which may result in outright collapse of the financial system, at the center of the problem. Illiquidity, defined as a situation in which the financial system's potential short term obligations exceed the liquidation value of its assets, may emerge naturally as a response to some features of the environment. However, it may also make the system vulnerable to costly runs.

Any model in which financial entities issue demandable debt (for example, demand deposits) as a liability, therefore placing themselves in a potentially illiquid position, is a useful vehicle for our purpose. For concreteness we focus on an open economy version of the celebrated banking model by Bryant (1980) and Diamond and Dybvig (1983). In that model banks are essentially maturity transformers that take liquid deposits and invest part of the proceeds in illiquid assets. In doing so they pool risk and enhance welfare, but also create the possibility of self-fulfilling bank runs.

[3]Other financial variables having to do with the capital account of the balance of payments have also been found to be correlated with currency troubles. For instance, Frankel and Rose (1996) find that a low share of FDI in gross capital inflows is a good predictor of crises. Sachs, Tornell and Velasco (1996b) found that countries with a low share of short term capital inflows were less likely to be hit by the Tequila effect.

We embed that basic model of banks into a macroeconomic model of a small open economy. Such extension enables us to discuss, in a unified way, the issues raised by the recent sequence of crises in emerging markets. In particular, we argue that:

1. *Capital flows from abroad*, caused by an opening of the capital account and/or an increase in the country's access to international credit, can magnify the illiquidity problem. In particular, the vulnerability of domestic banks can be sharply increased when these foreign loans are of short maturity: a creditors' panic, that is, a creditors' refusal to roll over the short term loans, may render a self-fulfilling bank run possible.

2. The illiquidity problem may also be aggravated by a round of *financial liberalization*, which accentuates the maturity mismatch between assets and liabilities that is typical of commercial banks. In particular, we show how two kinds of financial liberalization, lowering of reserve requirements and increasing competition in the banking sector, can increase banks' vulnerability to runs.

3. *The financial system may greatly magnify the effects of small changes in exogenous circumstances* (i.e., terms of trade, competitiveness, world interest rates). Small shocks may result in financial distress, implying costly asset liquidation, an unnecessarily large credit crunch, and large drops in asset prices and economic activity.

4. *Prices of assets that are in inelastic supply* (such as land and real estate) will typically rise as financial flows from abroad are intermediated by the financial system, and then crash in the event of a bank collapse. But the initial increase is not, in and of itself, evidence of an "asset bubble;" similarly, the crash need not be an indication that prices are returning to their "fundamental level." In our model the meaning of "fundamental" *is conditional on the absence or occurrence of a bank collapse.* If a financial run occurs and asset prices crash, the resulting price drop is unnecessary, since it results from inefficient asset liquidation; a higher price (and associated higher welfare) would have prevailed if the run had not taken place.

5. The main danger of unsound policies of the kind described by Krugman (1998) and allegedly pursued in East Asia (*government deposit guarantees and investment subsidies, leading to overinvestment and overborrowing*) is that they can increase the fragility of banks.

If banks collapse as a result, the associated costs far outweigh the conventional efficiency losses caused by such policies.

6. *An exchange rate peg may collapse because, if and when a bank crisis comes, stabilizing the banks and keeping the exchange rate peg become mutually incompatible objectives.* A Central Bank may attempt to fight a bank crisis by keeping interest rates from rising (which would further wreck the banks) or by providing lender-of-last-resort funds. But then agents will use the additional domestic currency to buy reserves, eventually forcing the abandonment of the fixed exchange rate. It is in this sense that we observe "twin crises": a financial crisis and a balance of payments crisis.

While potentially illiquid banks exist in emerging and mature economies alike, we believe that our story is most relevant for emerging markets because of two reasons. First, banks play a much larger role in emerging than in mature economies; this observation justifies a focus on banks to the detriment of other credit mechanisms such as debt or equity markets.[4] Second, focusing on illiquidity is natural for emerging markets because their access to world capital markets is more limited. If fractional reserve banks in mature economies face a liquidity problem (as opposed to a solvency one) they are likely to get emergency funds from the world capital markets. This seldom occurs in emerging economies: a private bank in Bangkok or Mexico City will get lots of international loan offers when things go well, and none when it is being run on by depositors. The combination of fractional reserve (and hence potentially illiquid) banks and external credit ceilings is potentially devastating – and is the focus of our model.

This paper is a companion to Chang and Velasco 1998a, which focuses on the relations among financial crises, the exchange rate regime and monetary policy. While we depart substantially from the mainstream currency crisis literature, we also draw on a number of

[4] A key reason for the preeminent role of banks in emerging markets has recently been clarified by Diamond (1997). If markets for tradable instruments are deep, in the sense of having full participation by all potential market participants, then there is nothing banks can do that markets cannot replicate, and banks are therefore unimportant (a point first made by Jacklin 1987). But if there is limited participation in the non-bank markets, then banks add liquidity to the system as a whole and perform a useful function. Since emerging economies are, almost by definition, those in which markets for debt and equity are relatively shallow and illiquid, it is natural to expect banks to play a large role in them.

papers which have identified the main empirical features of this financial crisis syndrome and made some preliminary headway in formalizing its logic.[5]

2. The basic framework

In this section we present a framework that will serve as a benchmark for the discussion in later sections. The framework is a simple open economy version of the well known model of Diamond and Dybvig (1983). The Diamond-Dybvig paper focused on the microeconomics of banking; our version embeds banks into a small open country and allows for the analysis of macroeconomic questions.

2.1. The environment

Consider a small open economy populated by a large number of *ex ante* identical agents. There are three periods indexed by $t = 0, 1, 2$. There is only one good, which is freely traded in the world market and can be consumed and invested. The price of consumption in the world market is fixed and normalized at one unit of foreign currency (a "dollar"). Hence, we will speak interchangeably of dollars or units of consumption. Domestic residents are born with an endowment of $e > 0$ units of this good (worth e dollars) each.

Each agent is also endowed with access to a constant returns *long term* technology whose yield per dollar invested at $t = 0$ is $r < 1$ dollars in period 1, and $R > 1$ dollars in period 2. That is to say, the long term technology is *illiquid:* it is very productive if the investment is held for two periods, but early liquidation causes a net loss of $(1 - r) > 0$ per dollar invested. Only domestic residents have access to this technology.

In addition, there is a world capital market where one dollar invested at $t = 0$ yields one dollar in either period 1 or period 2. Domestic agents can invest as much as they want in

[5] A partial and chronological list includes Díaz-Alejandro (1985), Velasco (1987), Dornbusch, Goldfajn and Valdés (1995), Calvo (1995), Calvo and Mendoza (1996), Frankel and Rose (1996), Kaminsky and Reinhart (1996), Sachs, Tornell and Velasco (1996a and b), Sachs (1997), Goldfajn and Valdés (1997), Corsetti, Pesenti and Roubini (1998), Krugman (1998), Radelet and Sachs (1998), and Chang and Velasco (1998b).

this market, but can borrow a maximum of $f > 0$ dollars. While we will treat the credit ceiling as exogenous, it could be justified by recourse to the many theories of international borrowing under sovereign risk. It can also be thought of as the result of domestic restrictions (a regulated capital account) that prevent domestic residents from borrowing more than f dollars.

Clearly, domestic consumption will be increasing in e. Also, domestic consumption will be rising in f, because the domestic technology has a higher return than the world rate of interest. For instance, if in period 0 an agent borrowed up to the full credit ceiling e, invested all of the loan proceeds in the domestic technology, and held the investment for two periods, her total resources available for consumption in period 2 would be $eR+f(R-1) > 0$ dollars.

Domestic agents face a non trivial decision, however, because they may be forced to consume early. We will assume, as in Diamond and Dybvig (1983), that at $t = 1$ each domestic agent discovers her "type". With probability λ she is "impatient" and derives utility only from period 1 consumption. With probability $(1 - \lambda)$ she turns out to be "patient" and derives utility only from period 2 consumption. Type realizations are i.i.d across agents, and there is no aggregate uncertainty. We shall also follow Diamond and Dybvig (1983) in assuming that the realization of each agent's type is private information to that agent.

In this paper, x and y will denote, respectively, the typical agent's consumption in period 1 if she turns out to be impatient, and in period 2 if she turns out to be patient. Then the expected utility of the representative agent can be represented by:

$$\lambda u(x) + (1-\lambda)u(y) \tag{2.1}$$

The function $u(.)$ is a CRRA utility function with coefficient of relative risk aversion $\sigma > 0$:

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma} \tag{2.2}$$

We choose a specific functional form to obtain closed-form solutions and facilitate the analysis that follows.

In this setup, as in the classic Diamond-Dybvig (1983) formulation, domestic residents face uncertainty about the timing of consumption and also a pattern of asset returns such that they would prefer to invest in the world market if they knew they were impatient, and in the illiquid technology if they knew they were patient. A new feature of the model is the openness of the economy. This introduces a number of new features into the model, as will become apparent below.

2.2. A commercial bank

Clearly, if each domestic agent acted in isolation from the others, each one would bear idiosyncratic risk; in particular, costly liquidation of the long term technology would often occur with positive probability. The absence of uncertainty in the aggregate implies that improvements may be attainable if, as we shall assume from now on, domestic agents act collectively; their coalition will be called a "commercial bank" (or simply "bank" when no confusion may arise) for reasons that will be clear shortly.

The objective of the bank is to pool the resources of the economy in order to maximize the welfare of its representative member. This requires assigning a consumption stream to each agent contingent on the realization of her type. In choosing such a contingent allocation, the bank is restricted not only by resource constraints but also by fact that type realizations are private information. This implies that the bank must find some way of eliciting such information.

While examining all of the bank's options would be exceedingly complex, the Revelation Principle[6] implies that attention can be restricted to feasible type contingent allocations that give no agent an incentive to misrepresent her type. As a consequence, the bank will choose an allocation to solve a relatively simple problem. Let d and b denote net foreign borrowing in periods 0 and 1, respectively, and let k be the amount invested in the domestic (illiquid)

[6] The Revelation Principle applied to the bank's problem is that the Bayesian Nash equilibria of any game that the depositors may play can be replicated by the truthful equilibria of a game in which each depositor is asked to report her types. See [27] for an excellent introduction to the Revelation Principle.

asset. The bank maximizes 2.1 subject to:

$$k \leq d + e \tag{2.3}$$

$$\lambda x \leq b + rl \tag{2.4}$$

$$(1-\lambda)y + d + b \leq R(k-l) \tag{2.5}$$

$$d + b \leq f \tag{2.6}$$

$$y \geq x \tag{2.7}$$

$$x, y, b, k, l \geq 0 \tag{2.8}$$

where l denotes liquidation of the domestic asset in period 1. The above problem will be referred to as the *basic social planning problem*, and its solution, the *social optimum,* will be denoted by tildes.

Constraint 2.3 restricts investment to be no larger than the endowment plus initial borrowing from abroad.[7] Constraint 2.4 is the feasibility constraint in period 1. The social optimum assigns $\tilde{x}$ units of consumption to each impatient; this is financed by period 1 borrowing abroad, $\tilde{b}$, and possibly by liquidating some portion of the long term asset. Constraint 2.5 is the feasibility constraint for period 2 and 2.6 is the external credit ceiling, both of which are self-explanatory.

Constraint 2.7 is the *incentive compatibility* or truth-telling constraint for patient agents, derived under the assumption that the commercial bank can monitor each agent's transactions with the domestic banking system but not her consumption or her world transactions. If a patient agent lies about her type she will be given $\tilde{x}$ units of consumption in period 1; given the assumption just stated, the best she can do then is to exchange them at the world market for $\tilde{x}$ units of period 2 consumption. On the other hand, she can obtain $\tilde{y}$ of period

[7]Notice that d can be positive or negative. It will be positive if f is sufficiently large relative to e so that investment in the illiquid asset takes up the whole of the initial endowment, the difference being made up by period 0 borrowing.

2 consumption from telling the truth; hence 2.7 ensures that patient depositors will not lie.

Finally, 2.8 contains the obvious non-negativity constraints.

The study of the social planning problem yields useful properties of the solution. It can be shown that $\tilde{l} = 0$ –that is, there is no liquidation in period 1 of the long term investment. This should be obvious, since the bank faces no aggregate uncertainty, and liquidating the long term asset in period 1 is costly. Given this fact, it can be shown that the value of the social problem is superior to the value of autarky. This also should be intuitive, since the bank pools resources to prevent the inefficient liquidation of the long term asset; in contrast, the long term asset must be liquidated with positive probability in autarky.

The other features of the solution follow from marginal optimality conditions. It is easy to see that the credit ceiling 2.6 will bind at the optimum. Given this result, the choices of x and y must satisfy the following equation, which can be thought of as a *social transformation curve*:

$$R\lambda\tilde{x} + (1-\lambda)\tilde{y} = eR + (R-1)f \equiv Rw \tag{2.9}$$

where $w = e + \left(\frac{R-1}{R}\right) f$ can be thought of as the economy's wealth.

The final optimality condition is that the *social indifference curve* be tangent to the above transformation curve:

$$\left(\frac{\tilde{x}}{\tilde{y}}\right)^{-\sigma} = R \tag{2.10}$$

Note that, since $R > 1$ and $\sigma > 0$, 2.10 guarantees that the incentive constraint 2.7 does not bind.

Combining 2.9 and 2.10 we have

$$\begin{aligned}(1-\lambda)\,\widetilde{y} &= (1-\theta)\,Rw \\ \lambda\widetilde{x} &= \theta w \end{aligned} \tag{2.11}$$

where $\theta \equiv \frac{\lambda R^{\frac{\sigma-1}{\sigma}}}{\lambda R^{\frac{\sigma-1}{\sigma}} + (1-\lambda)}$ is a coefficient in the unit interval. If the coefficient of relative risk aversion is exactly 1 (the case of log utility) we have $\theta = \lambda$. In that case per capita consumption is $\widetilde{y} = Rw$ and $\widetilde{x} = w$, and each set of consumers receives the technological return corresponding to their period of consumption; patient consumers consume more because investments kept until period 2 are more productive. If $\sigma > 1$ we have $\theta > \lambda$, so that patient consumers who get to consume in the "high productivity" period cross-subsidize impatient consumers who get to consume in the "low productivity" period.

Finally, since 2.4 and 2.5 hold with equality and liquidation is zero, the optimal investment strategy is given by

$$\begin{aligned} \widetilde{b} &= \theta w \\ \widetilde{k} &= \frac{f}{R} + (1-\theta) w \\ \widetilde{d} &= \widetilde{k} - e \end{aligned} \tag{2.12}$$

Next we discuss how this allocation can be implemented in a decentralized fashion.

2.3. Demand deposits and bank runs

The previous subsection identified the social optimum as the best allocation that, given the environment, the bank can achieve in principle. The bank must, in addition, find a mechanism to implement that allocation. One natural way, which will be the focus of this paper, is via *demand deposits.*

Demand deposits are contracts that stipulate that each agent must surrender her endowment and her capacity to borrow abroad to the bank in period 0. The bank invests $\tilde{k}$ in the long term technology and borrows $\widetilde{d}$ in period 0 and $\tilde{b}$ in period 1 . In return, the agent is promised the option to withdraw, at her discretion, either $\widetilde{x}$ units of consumption in period 1 or $\widetilde{y}$ in period 2.

We shall impose two additional assumptions on the problem. First, the bank must respect a *sequential service constraint* which requires, loosely speaking, that the commercial bank attend to the requests of depositors on a first come-first served basis. The existence of sequential service constraints can be justified by more primitive features of the environment, as suggested by Wallace (1988).

Second, for our benchmark case we will assume that the bank is committed to repay any foreign debt under all circumstances. This is not necessarily a realistic assumption, but it is the easiest to handle: it allows us to abstract, until the next section, from the possibility of foreign creditor panics. To ensure that the foreign debt is always repaid, the bank is committed to limit any possible period 1 liquidation of the long term investment to:[8]

$$\widetilde{l}^{+} = \frac{R\widetilde{k} - f}{R} \tag{2.13}$$

As a result of these assumptions, the timing of events is as follows. In period 1 depositors arrive to the bank in random order. Upon arrival, each agent reports may withdraw $\tilde{x}$ if the bank is still open. The commercial bank services withdrawal requests sequentially, first by borrowing abroad (up to $f - \widetilde{d}$), then by liquidating the long term investment up to the maximum $\widetilde{l}^{+}$; if withdrawal requests exceed the maximum liquidation value of the bank, given by $(f - \widetilde{d}) + r\widetilde{l}^{+}$, the bank closes and disappears. Finally, if the bank did not close in period 1, in period 2 the bank liquidates all of its remaining investments, repays its external debt, and pays $\tilde{y}$ dollars plus any profits to agents that did not retire their deposits in period 1.

Given the *demand deposit system* just described, depositors face a strategic decision about when to withdraw their funds; in other words, they are players engaged in an (anonymous) game. Hence the outcomes of a demand deposit system are given by the *equilibria* of such game; an equilibrium is a description of the strategies of each depositor and aggregate outcomes such that the aggregate outcomes are implied by the depositors' strategies and each depositor strategy is optimal for her given the aggregate outcomes.[9]

We can now discuss the outcomes of a demand deposit system. A first result is that

[8] The constraint 2.5 implies that the quantity l^{+} is the largest amount the bank can liquidate in period 1 while still having enough period 2 revenue to pay back loans totalling f.

[9] This definition is intentionally vague. This is because we have assumed a large number of depositors, who have measure zero. Given this, the equilibrium definition must ensure that depositors assume that their impact on aggregate outcomes is negligible. In such case the appropriate equilibrium concept is that of Schmeidler (1973).

demand deposits may implement the social optimum. This is because this game has an *honest equilibrium* in which each agent withdrawal decision corresponds to her true type: in period 1 only impatient depositors retire $\tilde{x}$ pesos, the bank does not fail, and pays $\tilde{y}$ to patient depositors in period 2. Verifying that honest behavior is an equilibrium entails only checking that honesty is consistent with the bank's solvency (which is true by construction) and that each depositor finds it optimal to tell the truth about her type (which is easy and left to the reader).

This result clarifies the role of a demand deposit system in an open economy. Banks may implement a socially optimal allocation that, in particular, improves upon what agents can achieve in isolation.

However, the banking system may attain such improvement only by holding less *internationally* liquid assets than its implicit liabilities. Consequently, the banking system may be subject to a *run*. In particular, it can happen that all domestic agents decide to attempt to withdraw their deposits in period 1 they expect all others to do the same. Such collective behavior turns out to be individually optimal, as it can be easily checked, if it forces the bank to run out of resources and fail before it can meet all the claims made on it. Now, if all agents attempt to withdraw their deposits in period 1, the bank will fail if

$$\tilde{z}^{+} \equiv \tilde{x} - \left(\tilde{b} + r\tilde{l}^{+}\right) > 0 \tag{2.14}$$

that is, if the *potential* short term obligations of the bank (given by $\tilde{x}$) exceed its liquidation value. Hence $\tilde{z}^{+}$ is a measure of the bank's *illiquidity* and plays a crucial role in our analysis.

The preceding argument shows that a run may emerge in equilibrium if the bank is illiquid: if 2.14 holds, there is an equilibrium in which all agents claim to be impatient and the bank fails in period 1. The converse can also be proven true: if 2.14 does not hold, there cannot be equilibrium bank runs. Hence, *a bank run equilibrium exists if and only if the bank is illiquid*, in the sense of 2.14.

Expression 2.14 is a condition on the solution of the social planning problem; one can describe equivalent conditions on the fundamental parameters of the economy under the assumption that $u(.)$ is CRRA. Using 2.11, 2.12 and the definition of θ, it turns out that 2.14 is equivalent to

$$R^{\frac{\sigma-1}{\sigma}} > r \tag{2.15}$$

Notice that if $\sigma \geq 1$ then 2.15 is always satisfied because $R > 1$ and $r < 1$ by assumption. Only if $\sigma < 1$ can runs be ruled out. Hence, while runs may or may not occur, the run condition is satisfied for many plausible parameter values of the utility and production technologies.

2.4. Summing up

We now have a basic framework with several desirable features. A banking system emerges naturally to attempt to implement a socially optimal allocation. A demand deposit system may implement the social optimum. However, it also creates a problem of illiquidity and the possibility of crises.

As in other models with multiple equilibria, what equilibrium prevails is essentially indeterminate and may depend on extraneous uncertainty or features of the environment that would otherwise be irrelevant.[10] This implies, in particular, that in our model bank and currency crashes may come as relatively unexpected events. This may seem surprising but is perfectly in keeping with the stylized facts. Sachs, Tornell and Velasco (1996a) provide evidence that the Mexican 1994 was not anticipated by investors, and Radelet and Sachs (1998) argue the same was largely the case in the 1997 Asian collapse.

Yet runs may occur only if the financial system is illiquid. This means, in particular, that adverse expectations are not, by themselves, sufficient for a run to occur: the fundamentals

[10] A concomitant issue, first noted by Postlewaite and Vives (1987), is that the social planning problem does not take into account that a run may occur. Rational expectations then require, strictly speaking, that the probability of a run be zero. An alternative interpretation, which is more in line with Diamond and Dybvig (1983), is that the occurence of a run may depend on a "sunspot" variable. In this case, the social planning problem can be taken as an approximation to the "true" problem, although then the probability of a sunspot must be small. A third alternative is to postulate that the form of the contract between the bank and depositors, i.e. demand deposits, is exogenously given; under this assumption, the probability of a run is arbitrary.

of the economy must also be "fragile."

Our next task is to employ this framework to study several issues related to crises in emerging markets. We pursue this agenda below, starting with a discussion of the role of international credit.

3. Foreign borrowing

The popular press often blames "excessive" foreign borrowing for bank and currency collapses. This view is also echoed in more formal discussions. It has been emphasized, for example in Corsetti, Pesenti, and Roubini (1998), that the recent crisis in East Asia was preceded by a notable increase in foreign borrowing, suggesting the existence of a causal link. However, the details of such a link remain controversial.

Accordingly, in this section we investigate the role, if any, of the size and kind of foreign borrowing in affecting the vulnerability of domestic financial intermediaries. We argue that two factors play a crucial role. The first is the attitude of foreign lenders in response to a bank run, and in particular whether they will refuse to extend new loans. The second is the maturity of the external debt. We will see that, in accordance with conventional wisdom (but not to traditional academic literature), both factors affect financial fragility.

3.1. Ongoing lending

It has been argued by Radelet and Sachs (1998) and others that recent Asian crises were triggered by a foreign creditors' refusal to extend new credit to the affected countries. The developing country debt crisis of the 1980s, according to some observers such as Sachs (1982), was also prompted by such a flight by foreign creditors.

This section shows that in our model it is not just domestic depositors, but also foreign creditors, who can panic. In fact, certain kinds of behavior by foreign lenders can increase the fragility of domestic banks even further.

To see the role of ongoing lending in our results so far, recall that constraint 2.5 on the social planning problem specifically allowed it to borrow in period 1 (up to the credit ceiling minus period 0 borrowing, $f-d$) to finance the withdrawals of impatient agents. In addition, we assumed that these additional period 1 loans would be extended even in the event that a run occurred that period. This is evident in the fact that run condition 2.14 allows the bank to liquidate capital all the way to the maximum level $\tilde{l}^{+}$, which includes the repayment of period 1 debt $\tilde{b}$ (see equation 2.13). For future reference, notice that 2.14 can be re-written as

$$\tilde{z}^{+}=\tilde{x}-\left\{r\tilde{k}+\left(\frac{R-r}{R}\right)\tilde{b}-\left(\frac{r}{R}\right)\tilde{d}\right\}>0 \tag{3.1}$$

Hence, our benchmark assumptions ensured that these new loans are always repaid, even if the bank fails. Hence, in the case of a run, ongoing lending takes place and is rational from the perspective of foreign creditors.

In contrast, consider what happens if such ongoing lending fails to take place in the event of a run. Since after a run the bank would then owe only $\tilde{d}$ in period 2, the maximum liquidation level consistent with not defaulting on the external debt would be

$$\tilde{l}^{++}=\tilde{k}-\frac{\tilde{d}}{R} \tag{3.2}$$

which is larger than $\tilde{l}^{+}$.

However, the bank would not be able to borrow $\tilde{b}$ if a run occurs in period 1. Hence the bank would be unable to service all of its depositors if

$$\tilde{z}^{++}\equiv\tilde{x}-r\tilde{l}^{++}=\tilde{x}-\left\{r\tilde{k}-\left(\frac{r}{R}\right)\tilde{d}\right\}>0 \tag{3.3}$$

Comparison of 3.1 and 3.3 reveals that

$$\tilde{z}^{++}-\tilde{z}^{+}=\left(\frac{R-r}{R}\right)\tilde{b}>0 \tag{3.4}$$

Hence, the run condition 3.3 is more stringent than 3.1, so the bank is *more* vulnerable to runs if foreign creditors fail to engage in ongoing lending in the event of a run. The intuition is, clearly, that the inability to borrow $\widetilde{b}$ as planned reduces the liquid resources that the bank has access to in the event of a run.[11]

Would it be rational for foreign lenders not to engage in ongoing lending? Suppose that 3.6 holds and that foreign lenders are "small." If every foreign creditor refuses to lend to the bank *and* depositors panic, the bank will have to liquidate all of the long term asset, except what is necessary to repay initial debt $\widetilde{d}$ in period 2 –and any debt above and beyond $\widetilde{d}$ could not be repaid then. Hence no individual creditor will find it profitable to lend to the bank in period 1.

This has the striking implication that the behavior of international lenders may, by itself, cause a depositors' run: if parameters are such that 3.6 holds but 3.5 does not, a run on deposits is possible *if and only if* external creditors refuse to extend additional loans in period 1. In such case, creditors may stop lending because they fear that a bank run will occur, which makes the bank run possible. By withholding additional funds the creditors may provoke a crisis, and by providing them they may avoid it.

Two aspects of this argument warrant further discussion. The first is that we have implicitly assumed that the bank waits until period 1 to borrow the resources necessary to finance the withdrawals of impatient depositors. An alternative strategy would have the bank borrow the full f dollars in period 0, to be repaid in period 2. At the same time, it would buy $\widetilde{b}$ dollars of the liquid asset, which in real-world parlance corresponds to having $\widetilde{b}$ dollars of "reserves" deposited in liquid form abroad. In period 1 it would use the $\widetilde{b}$ dollars to finance the consumption of impatient depositors, and hence it would not be vulnerable to confidence crisis by creditors. But in practice, this alternative strategy may not be feasible.

[11] This result can also be expressed in terms of the primitives of the model. Using 2.11 and 2.12, condition 3.1 boils down to

$$\frac{1}{\lambda} - 1 > r\left(\frac{1-\theta}{\theta}\right) \tag{3.5}$$

while run condition 3.3 in the case of no defensive lending boils down to

$$\frac{1}{\lambda} - \frac{r}{R} > r\left(\frac{1-\theta}{\theta}\right) \tag{3.6}$$

Since $R > r$, 3.5 is more stringent always.

Foreign lenders may not be willing to disburse the full f at first, especially if a portion is to be used for consumption, not investment. Moreover, the borrowing rate at which the bank could get the f dollars abroad is likely to be much higher than the deposit rate at which it could keep the $\tilde{b}$ dollars in liquid form; this interest rate wedge could render this scheme's cost prohibitive.

The second point that deserves attention is that we have allowed the bank to liquidate assets all the way to $\tilde{l}^{++}$, rather than stopping at the stricter limit $\tilde{l}^{+} < \tilde{l}^{++}$. This is permissible if a run occurs, in that liquidating up to $\tilde{l}^{++}$ still allows the bank to service its debt of $\tilde{d}$. But notice that, if the bank could precommit to liquidate only up to $\tilde{l}^{+}$, then resources would be available in period 2 to repay creditors who had kept on lending in period 1, and no ongoing lending flight would not be an equilibrium outcome. Hence in our story, as in the self-fulfilling attacks by Obstfeld (1994), lack of precommitment by domestic financial institutions is crucial in generating this kind of multiple equilibria.

3.2. Short term debt

So far we have not been explicit about the maturity of the debt incurred by the bank in period 0. It made no difference whether it was a one-period bond that was rolled-over in period 1 or a two-period bond that matured in period 2, for we have always implicitly assumed that a one-period bond was automatically renewed, and in the same conditions, in the middle period.

Consider now the implications of being explicit about the maturity structure, and assuming that the initial debt indeed consists of one-period loans (bonds?). What happens if international creditors refuse to roll over the debt in period 1? This is an important question, for both in the Mexican 1994 crisis (recall the infamous Tesobonos) and in the recent Asian episode foreign bondholders have balked at purchasing new short term bonds when the old ones matured at a time of crisis.[12]

[12] For a discussion of the Mexican experience in this regard, see Sachs, Tornell and Velasco (1996a) and Calvo and Mendoza (1996). For Asia, see Corsetti, Pesenti and Roubini (1998).

With no roll-over the bank has no external debt to repay in period 2, and hence it can liquidate the full long term investment in case of need:

$$\widetilde{l}^{+++} = \widetilde{k} \tag{3.7}$$

Now the bank can become bankrupt if its short term obligations, which now include the sum of its demand deposits and its short term external debt, exceed the liquidation value of the long term investment. This will be the case if

$$\widetilde{z}^{+++} \equiv \widetilde{x} + \widetilde{d} - r\widetilde{l}^{+++} = \widetilde{x} + \widetilde{d} - r\widetilde{k} > 0 \tag{3.8}$$

Subtracting 3.8 from 3.3 we have

$$\widetilde{z}^{+++} - \widetilde{z}^{++} = \left(\frac{R-r}{R}\right)\widetilde{d} \tag{3.9}$$

Clearly, if $\widetilde{d}$ is positive 3.8 is more stringent than both 2.14 and 3.3. That is to say, financial fragility is greater if lenders refuse to roll over existing debt in the event of a run.[13]

Why would creditors refuse to roll over short term debts? Because they may expect that the bank will not be able to repay its debt. This may turn out to be a self-fulfilling prophecy as in the case of ongoing lending: if run condition 3.8 is indeed satisfied, then in the event of a run there would not be enough resources in period 2 to repay a loan of size $\widetilde{d}$. Should a run occur, lenders are justified *ex post* in not having been willing to roll-over existing debts.[14]

Here, as with ongoing lending, lenders' fears on non-payment can be self fulfilling. If 3.8 holds but 3.3 does not, then a run is possible *if and only if* external holders of bonds panic in period 1 and demand immediate payment. In those circumstances, a panic by the creditors

[13]Broadly, $\widetilde{d} > 0$ if the endowment e is sufficiently small relative to the credit ceiling f that the bank finds it optimal to borrow abroad to finance investment in the first period. We discuss this condition more formally and in more detail below.

[14]Moreover, in this case even the old loan may not be repaid. If 3.8 holds, then in the event of a run there isn't enough cash to go around. Even if foreign creditors are senior, a small enough r may ensure that $r\widetilde{k} < \widetilde{d}$, so that they will get less than the contract initially entitled them to.

may cause a self-fulfilling run by both depositors and creditors; the resulting bank collapse need not have happened had the creditors behaved differently.[15][16]

The policy implication of our analysis is clear: if the presence of short-term debt increases vulnerability, then policies to avoid short-term debt must reduce it. In particular, imagine that the domestic authorities required that all foreign borrowing by the bank were no less than two periods in maturity. Then, the optimal response by the bank would be to borrow the full f dollars in period 0, while holding $\widetilde{b}$ dollars of "reserves." Under this arrangement the bank would not be vulnerable to creditor panic, because in period 1 it has no short term debt to roll over.[17] Hence, the policy of banning short-term borrowing abroad is all gain and no pain.[18]

3.3. The size of capital inflows

How does the gap between demandable debt in period 1 and total liquid resources in period 1 change with the amount of credit available from the rest of the world? Is is true in this model that "larger" capital inflows aggravate bank fragility? Is this effect also a function of the maturity of the capital inflows?

[15]While qualitatively (in terms of the economic mechanism for self-fulfilling panics) the cases of no ongoig lending and the short-term debt cases, quatitatively they are not. As 3.9 shows, a run on short term debt can cause a bank run for parameter values under which a cutoff of defensive lending would not have provoked a bank run.

[16]This result is reminiscent of Calvo (1995), in which short-maturity debt can give rise to multiple equilibria and self-fulfilling debt crises (see also Alesina, Prati and Tabellini 1990, and Cole and Kehoe 1997). Calvo presents a 2-period model in which the representative agent of a small open economy borrows to smooth consumption. If creditors refuse to roll over debts, the current account suddenly has to be cut; this causes output to fall given the existence of adjustment costs. Then resources may be insufficient to pay for outstanding debt, and the creditors' refusal to lend again is self-confirming. Calvo's argument relies on *ad-hoc* costs of adjusting the current account (for instance, labor unrest following the cut in consumption). An identical logical chain is present in our story, but the micro-foundations of the output loss are clear: the refusal to roll over debt causes costly liquidation of long-term domestic investments; if the cost is large enough, then output does not suffice to repay creditors, and their fears become self-fulfilling.

[17]No additional borrowing is needed in period 1, so issues of ongoing lending do not arise either. Of course, the bank may still be vulnerable to a run by domestic depositors.

[18]As we argued earlier, in practice there may be a wedge between the cost of borrowing abroad and the interest rate the bank earns on its reserves held abroad. In such a case the bank would face a well defined tradeoff between the cost of holding more reserves (up to a quantity $\widetilde{b}$) and the benefits of reducing vulnerability.

There is a basic sense in which financial vulnerability is a function of the size of the credit limit f, and hence of the size of the total inflows. Consider the case of a run on short-term external debt considered in the preceding subsection. Such an outcome can only take place if indeed the bank is a debtor and not a creditor in period 1. A bit of algebra readily shows that $\widetilde{d}$ is given by

$$\widetilde{d} = f\left(\frac{1+(1-\theta)(R-1)}{R}\right) - \theta e \tag{3.10}$$

Hence, an increase in the size of f relative to the endowment e must increase the size $\widetilde{d}$ of debt contracted in period 0, which must be repaid or rolled over in period 1. For small enough f (relative to e), $\widetilde{d}$ is negative; it becomes positive if $\frac{f}{e} > \frac{R\theta}{1+(1-\theta)(R-1)}$. Since the deleterious effect of a refusal to roll over on fragility is an increasing function of the size of debt, it follows that a higher credit ceiling and larger capital inflows, *ceteris paribus*, increase the vulnerability of the bank to runs.

Notice, however, that a larger f can make a crisis possible (in the sense that it can make z^{+++} change from negative to positive) only when the bank contracts short term debt in period 0. But in the cases of only long-term debt, the size of f cannot affect the vulnerability to a crisis (that is, it cannot make z^{+} or z^{++} change sign.) In this sense, it is not simply the ready availability of foreign loans that poses a danger, but a large loan volume contracted at short maturities.

This conclusion fits well with the finding by Sachs, Tornell and Velasco (1996b) that the maturity of capital inflows was a helpful predictor of vulnerability to the Tequila effect, while the size of those inflows was not. Notice also that if capital controls lengthen average maturity but do not affect loan volumes, as Valdés-Prieto and Soto (1996) and Cárdenas and Barrera (1997) find they do, then such policies are effective in reducing vulnerability.

4. Financial liberalization and fragility

Both casual observation of recent crises and formal econometric work suggest the existence of important links between financial liberalization and crises. In particular, Kaminsky and Reinhart (1996) examined a number of bank crises and balance of payments crises and found that:

a) Of the 26 banking crises they studied, 18 were preceded by financial sector liberalization within a five year interval.

b) Financial liberalizations accurately signalled 71 percent of all balance of payments crises and 67 percent of all banking crises.

c) The M2 multiplier rose steadily in the periods leading to the banking crises. Its growth rate was 20 percent higher than in tranquil times.

d) Growth in the ratio of domestic credit to nominal GDP was high and increasing as crises approached, peaking when crises erupted at about 15 above the growth rates observed during tranquil periods.

These "stylized facts" have been also verified in many notorious crisis episodes, including Chile in 1982, Sweden and Finland in 1992, Mexico in 1994, and Asia today.[19] Clearly, explaining why and how this is so has become crucial for the design of public policy.

Financial liberalization can mean many things. In this section we study how deregulation of the domestic banking environment can affect the banks' vulnerability to runs. We focus on two policies: changes in required reserves and changes in the degree of competition in the banking sector. In both cases we find that a more "liberal" policy improves welfare in the absence of runs, but also makes runs more likely.

4.1. Broad and narrow banking

One kind of common liberalization is a lowering of reserve requirements on commercial banks. Mexico, for instance, lowered required reserves on peso sight deposits all the way to zero in

[19] See Velasco (1987 and 1992), Dornbusch, Goldfajn and Valdés (1995), Sachs, Tornell and Velasco (1996) and Sachs and Radelet (1998).

the first half of the 1990s. The rationale is that such a reduction enhances the efficiency of financial intermediation. This section shows that conjecture is correct, but that lower reserve requirements also increase banks' vulnerability to runs.

To fix ideas, consider the polar case of *narrow banking*, in which intermediaries are required to keep liquid assets in an amount equal to potential liquid liabilities:

$$x \leq b \tag{4.1}$$

Given narrow banking, the commercial bank will choose an allocation to maximize 2.1 subject to 2.3, 2.6, 2.8, 2.4, 2.7, the reserve requirement 4.1, and

$$(1 - \lambda)\, y \leq Rk - f + [b - \lambda x] \tag{4.2}$$

which is the same as 2.5 except for the term in square brackets, which allows for the possibility that the bank may choose not to spend in period 1 all of the dollars obtained from liquidating the short term asset.

Solving the bank's problem is a standard exercise. Here we will only discuss the relevant aspects of the solution, which will be identified with asterisks. The reserve requirement 4.1 is strictly binding at the solution. One can use the bank's feasibility constraints to show that the optimum values x^* and y^* must satisfy

$$[R - (1 - \lambda)]\, x^* + (1 - \lambda)y^* = Rw \tag{4.3}$$

which should be thought of as the "transformation curve" in a narrow banking regime. Comparing 2.9 against 2.9 makes it clear why narrow banking is costly: the "price" of x under narrow banking is $R - (1 - \lambda)$, which is larger than λR, the price of x when narrow banking is not imposed. Intuitively, this occurs because, under narrow banking, an increase of x of, say, dx, requires increasing b by more than λdx, the difference being an increase in required reserves.

The solution is summarized by

$$\begin{aligned}(1-\lambda)\,y^* &= (1-\phi)\,Rw \\ \lambda\beta x^* &= \phi w \qquad (4.4)\end{aligned}$$

where $\phi \equiv \frac{\lambda R^{\frac{\sigma-1}{\sigma}}\beta^{\frac{\sigma-1}{\sigma}}}{\lambda R^{\frac{\sigma-1}{\sigma}}\beta^{\frac{\sigma-1}{\sigma}}+(1-\lambda)}$ is a coefficient in the unit interval and β a constant larger than one.

Comparisons with the social optimum are now straightforward. It can easily be shown that $x^* < \widetilde{x}$. Moreover, y^* is greater or smaller than $\widetilde{y}$ depending on the relative strength of familiar income and substitution effects associated with the increase in the "price" of x.[20] Clearly, the narrow banking solution is not socially optimal, because the bank is now solving the same problem as in the fixed rates case studied above, but with the tighter constraint $x \leq b$ instead of $x\lambda \leq b$.

The narrow banking solution can be decentralized as a demand deposit system, as described before. The reserve requirement 4.1 would then imply that bank runs cannot occur. But because the resulting allocation is inefficient, completely avoiding bank runs is costly: there is no free lunch.

This analysis directly implies that lowering reserve requirements may have ambiguous effects. Financial reformers who lower reserve requirements may well be increasing social welfare if a good equilibrium prevails, but also may be rendering a bad equilibrium possible.

4.2. Increasing competition in the banking sector

So far we have treated the bank as a coalition of individual agents bent on maximizing their joint welfare. As a result, the bank earns no profits, and manages assets and liabilities to maximize the expected utility of the representative depositor. An alternative interpretation is that the bank is a perfect competitor in a banking market into which there are no barriers

[20] More precisely, y^* is greater than, equal to, or less than $\widetilde{y}$ if σ is less than, equal to, or greater than 1 respectively.

to entry. Free entry would ensure that equilibrium profits were zero, and in order to attract customers and not be undercut by competitors banks would have to offer depositors contracts that promised as high a level of expected utility as possible.

Such free-wheeling competition in a the banking sector is one of the typical aims of financial liberalization. But what did the banking sector look like before such deregulation took place? And how do the regulated and unregulated (or liberalized and non-liberalized) banking sectors compare in terms of vulnerability to runs? To answer those questions we study here the polar case of monopoly banking.

Imagine that one person (perhaps the eldest son of the local ruler) is granted the exclusive right to run a commercial bank. Assume in addition that this agent is risk neutral (or, plausibly, that he has access to world capital markets where the interest rate is zero). In that case, in designing the bank contract the monopoly banker will want to maximize the present value of his profits

$$[b + rl - \lambda x] + [R(k - l) - (1 - \lambda)\, y - b - d] \tag{4.5}$$

subject to constraints 2.3, 2.6, 2.8, 2.4, 2.5, 2.7 and the requirement that the expected utility of agents be no lower than v, which denotes the expected utility associated with autarchy:

$$\lambda u\,(x) + (1 - \lambda)\, u\,(y) \geq v \tag{4.6}$$

The first order conditions of this problem, whose solution is denoted by hats, are:

$$R - 1 - \mu_1 + R\mu_2 = 0 \tag{4.7}$$

$$-\lambda\,(1 + \mu_1) + \mu_3 \lambda u'\,(\widehat{x}) = 0 \tag{4.8}$$

$$-\,(1 - \lambda)\,(1 + \mu_2) + (1 - \lambda)\, u'\,(\widehat{y}) = 0 \tag{4.9}$$

where μ_1, μ_2 and μ_3 are the multipliers associated with inequality constraints 2.4, 2.5 and 4.6.

By standard arguments it can be shown that constraints 2.4 and 4.6 will always be binding, and therefore μ_1 and μ_3 are always positive. By contrast, 2.5 need not hold with equality, which means that $\mu_2 = 0$. That is to say, bank income in period 2 (given by $R\widehat{k}$) will be larger than bank outlays in the same period (given by $(1-\lambda)\,\widehat{y} + f$).[21] The intuition is that, given risk neutrality and the high yield of the long term investment, the monopoly banker will choose to concentrate all of his profits in period 2.

The fact that $\mu_2 = 0$ implies that $1 + \mu_1 = R$. By 6.7 and 4.9, in turn, we have $u'(\widehat{x}) = Ru'(\widehat{y})$. Using this and 4.6 written as an equality we can solve for the consumption levels $\widehat{x}$ and $\widehat{y}$. Using $\widehat{x}$ and combining it with 2.4 written as an equality we can solve for $\widehat{b}$. The values for $\widehat{d}$ and $\widehat{k}$ then come from the facts that $\widehat{d} + \widehat{b} = f$ and $\widehat{k} = e + \widehat{d}$. That completes the solution of the monopolist's problem.

Not surprisingly, monopoly is bad for depositors: the monopoly bank holds them to their autarky values, leaving them worse off relative to the competitive case. It is more interesting to compare the monopolistic and the competitive banks' vulnerability to runs.

Given that $\lambda\widehat{x} = \widehat{b}$, the condition for runs to be feasible is

$$(1-\lambda)\,\widehat{x} > r\widehat{l}^{+} \tag{4.10}$$

which, using the intertemporal optimality condition $u'(\widehat{x}) = Ru'(\widehat{y})$ and the usual definition of the maximum liquidation level $\widehat{l}^{+} = \widehat{k} - \frac{f}{R}$, becomes

$$\frac{(1-\lambda)\,\widehat{y}}{R\widehat{k} - f} > R^{\frac{1-\sigma}{\sigma}} r \tag{4.11}$$

Because the monopoly bank has positive profits in period 2, the L.H.S. is less than one. Hence, condition 4.11 may not hold even if $\sigma \geq 1$.

In contrast, the condition for a run to be possible in the competitive case is exactly

[21] Of course, liquidation will be zero in equilibrium, just as for the competitive bank.

the same as 4.11, except that tildes replace hats and that the L.H.S. is equal to one: the competitive banks earns no profit in either period, and the L.H.S. of 4.11 is simply the period 2 ratio of payments to depositors to bank income net of interest paid abroad.

Hence, the condition for a bank run to be feasible is less stringent, given R, r and σ, for a competitive than for a monopolistic bank.[22] The intuition is that a monopolist will reduce payments to depositors, which will tend to depress x (and y). He also wants to increase bank income (and hence profits) in the second period, which tends to increase k. Lower first period payments x and higher investment k both reduce the vulnerability of the bank relative to the competitive situation.

Abolishing monopolies in the banking system is clearly good for depositors' welfare as long as runs do not take place. This is true because the monopoly bank earns profits and the competitive one does not. Since the competitive bank manages its assets and liabilities in an efficient way, there is no way the monopolist can squeeze out profits merely by reshuffling the composition of the balance sheet. It can only do so by reducing the expected value of payments made to depositors, and this is bad for welfare.

However, we saw that abolishing monopolies may be dangerous in that the range of circumstances in which bank runs can take place is enlarged. Hence, bank regulators may face a trade-off between competition and stability in the banking sector.

The analysis suggests that recent attempts at enhancing competition may have been behind the fragility observed in the banking sectors of many emerging markets. It is noteworthy that this is consistent with recent evidence provided by Demirguc-Kent and Detragiache (1998).

[22] A caveat is that the value of autarchy is also a function of these parameters, so one is not free to change them freely in a comparative statics fashion. The proper statement is that the monopolistic bank is less fragile than the competitive bank, holding constant R, r and σ.

5. Asset prices, booms and busts

In many recent episodes, a financial crisis was preceded by sharp increases in the prices of inelastically supplied assets –such as real estate– which crashed when the crisis erupted. It has been argued, most prominently by Krugman (1998), that this observation implies that the crisis was caused by some distortion (typically, a government subsidy or guarantee) leading to investment over and above that warranted by the economy's fundamentals. In this view, asset prices can be propped up temporarily by the expectation of government handouts, and a crash simply brings them down to their "fundamental" value.

The problem with this line of argument is that it neglects the fact that such a "fundamental" value depends crucially on whether a collapse erupts or not. If illiquid banks and firms are forced to leave plants half-built and liquidate investment projects before they mature, the value of these assets is likely to be much lower that it would have been in the absence of a collapse. A financial crash is more painful than the healthy puncturing of an asset price bubble.

To examine this issue, this section amends our basic model to examine the pricing of assets whose supply is inelastic. We show that financial intermediation can cause a boom in asset prices, followed by a crash in the event of a financial panic. Most importantly, we show that in a situation where self fulfilling runs are possible, the "fundamental" value of such assets is not a uniquely defined concept and depends on the equilibrium that actually obtains.

Take the basic setup, but assume now that there is a domestic asset, which we will call "land," whose quantity is fixed at some number $\alpha > 0$. At the beginning of time land is owned by a group of competitive agents, called "rentiers", who maximize their period 1 consumption. We assume that a unit of land is in the hands of rentiers in period 1, it produces an exogenously given quantity $\pi > 0$ of consumption in that period. We will think of π as being low, so that it will be efficient for rentiers to sell the land.

To ensure that an alternative use of the land will be efficient, we assume that the usage of land enhances the return on the long term asset. The simplest way to impose this is to assume that if the commercial bank buys a units of land in period zero, the rate of return on the illiquid asset is $R = R(a)$, where $R(.)$ is an increasing function satisfying $R(0) > 1$, $R'(a) > 0$, $R''(a) < 0$, and $R'(0) = \infty$; the last condition ensures that some land will always be traded in equilibrium.

The bank can buy land in period 0 at a competitively determined price of p_0 per unit. The bank's problem is now to maximize $\lambda u(x) + (1-\lambda)u(y)$ subject to

$$k + p_0 a \leq e + d \tag{5.1}$$

$$\lambda x \leq b \tag{5.2}$$

$$(1-\lambda)y \leq R(a)k - (b+d) \tag{5.3}$$

and the usual credit ceiling, incentive compatibility and nonnegativity constraints.

The difference between the basic case and this one is that now the bank can buy a units of land in period 0, at cost $p_0 a$. This may be optimal since land increases the return of the long term asset to $R(a)$. The solution, marked by a curly bracket, is given by the following three conditions:

$$p_0 R(\overbrace{a}) = R'(\overbrace{a})\overbrace{k} = \frac{R'(\overbrace{a})\left[(1-\lambda)\overbrace{y} + f\right]}{R(\overbrace{a})} \tag{5.4}$$

$$\left(\frac{\overbrace{x}}{\overbrace{y}}\right)^{-\sigma} = R(\overbrace{a}) \tag{5.5}$$

$$\lambda \overbrace{x} + \frac{(1-\lambda)\overbrace{y}}{R(\overbrace{a})} = e + \left[\frac{R(\overbrace{a}) - 1}{R(\overbrace{a})}\right] f - p_0 \overbrace{a} \tag{5.6}$$

The interpretation is straightforward. Consider the optimal choice of land. By purchasing an additional unit of land in period 0, the bank obtains $R'(a)k$ units of consumption in period 2. Alternatively, it can invest p_0 in the long term asset and obtain $p_0 R(a)$ in period 2. At the optimum, the bank must be indifferent between these two options: this is the first equality in 5.4. The second equality follows from the fact that 5.3 and the credit ceiling must bind at the optimum. The other conditions have the usual interpretations. 5.5 equates the slope of the bank's indifference curve with the slope of its transformation curve; the latter is given by 5.6 and is conditional on the optimal choice of land.

Clearly, there are only two possibilities for the equilibrium price of land in period 0: either not all of the land will be sold and the price will be $p_0 = \pi$, or all of the land will be sold and the price will be

$$\overbrace{p_0} = \left(\frac{R'(\alpha)}{R(\alpha)}\right)\overbrace{k} > \pi \tag{5.7}$$

where $\overbrace{k}$ is given by the optimal solution of the bank's problem. The second possibility will obviously emerge if π is small enough; we shall assume that this is the case for the remainder of our discussion.

Notice that in period 0 the price of land will rise above the discounted value of the yield π that would be obtained if the land were not sold. Moreover, the price of land increases between periods 0 and 1. To see why, note that the bank will be willing to sell land if and only if the price compensates it for the reduction in the return on the long term asset; hence the period 1 price of land must be $\overbrace{p_1} = R'(\alpha)\overbrace{k}$, which exceeds $\overbrace{p_0}$ and hence π. But this "price boom" is socially optimal and reflects the fundamental value of land in its association with the long term investment.

Now, suppose that the bank establishes a demand deposit system to implement the optimal allocation. The optimum will obtain if depositors act honestly, which is always an equilibrium. But a bank run may happen if

$$\overbrace{z} = \overbrace{x} - \overbrace{b} - r\,\overbrace{l^+} - \pi\alpha > 0 \tag{5.8}$$

where $\overbrace{l^+}$ denotes, as usual, the maximum liquidation of capital consistent with repaying all external debt; clearly 5.8 may hold if r and π are small enough. To see why 5.8 is the relevant condition, recall that if a run occurs the bank must pay $\overbrace{x}$ to depositors in period 1. It can meet these obligations by borrowing up to its credit limit, by liquidating the long term asset (and obtaining $r\widehat{\ l^+\ }$) and by selling the land. But once the long term asset is liquidated, the price of the land in period 1 must be equal to its yield in isolation, π.

If there is a run, therefore, the price of land crashes to its "fundamental" value π; but clearly this meaning of "fundamental" *is conditional on the occurrence of a run.* Such a price is unnecessarily low, since a higher price (and associated higher welfare) would have prevailed if a run had not taken place.[23]

6. The role of fundamental shocks

There is considerable debate as to whether financial crises are in fact caused by self fulfilling expectations. Skeptics have maintained that this view is wrong (or at best a theoretical *curiosum*) and that actual crises are triggered by shocks to fundamentals or by bad policies. The *bad exogenous fundamentals* view has been vigorously advocated by Corsetti, Pesenti and Roubini (1998) with respect to the Asian crisis. The *crazy policies* view has its most forceful advocate in Krugman (1996 and 1998).

In this section we extend our basic framework to allow for stochastic shocks; crazy policies are discussed in the next section. Our objective is to show that the line between *fundamental* shocks and *confidence* shocks is a very thin one. We argue, in particular, that a "bad" shock may become "worse" if it places the economy in a position where a financial panic may happen. In such case the financial system may act as a *multiplier* mechanism, implying a much greater social cost than that consistent with the change in fundamentals.

Suppose that in our basic model we allow the short term interest rate between periods 0 and 1 to be stochastic (many shocks would have similar effects, but this is the simplest to model). If that rate is denoted (in gross terms) by ρ, we will assume now that $\rho = \rho_s$ with probability q_s, $s = 1, ..., S$. We assume that $0 < \rho_s < R$ for all s, and that the realization of

[23]A caveat in this argument is that we have assumed that the bank's demand for land in period 0 is determined by its planning problem, which ignores the possibility of a run (this, of course is what we have done all along in computing the bank's solution). If a run may happen with positive probability, this would affect the bank's behavior. This possibility remains to be worked out, although we doubt that our results would be substantially affected.

ρ is observed at the beginning of period 1.

The commercial bank's problem can now be written as

$$Max \sum_s q_s \left[\lambda u(x_s) + (1-\lambda)u(y_s)\right] \tag{6.1}$$

subject to

$$k \leq e + d \tag{6.2}$$

and, for each s,

$$\lambda x_s \leq b_s \tag{6.3}$$

$$(1-\lambda)y_s \leq Rk - b_s - \rho_s d \tag{6.4}$$

$$b_s + d \leq f \tag{6.5}$$

$$x_s \leq y_s \tag{6.6}$$

and the obvious nonnegativity constraints.

Expression 6.2 denotes, as usual, the period 0 budget constraint. Notice that d and k, decided upon at this time, are not state contingent. In period 1, after observing ρ_s, the bank chooses how much more to borrow, b_s, so as not to violate the credit ceiling 6.5. This decision determines the payoffs to impatient and patient agents, x_s and y_s, by the usual budget constraints 6.3 and 6.4. Finally, 6.6 is the appropriate incentive compatibility constraint.

Let the optimal choices be marked with overbars. Without further restrictions on the parameters, the above problem is fairly complicated. However, some features of the solution are easy to derive. As before, the bank may attempt to implement the optimum via demand deposits; in contrast with previous cases, now the withdrawal options offered to depositors are stochastic and depend on ρ_s. In other words, demand deposits now require each depositor to surrender her endowment and her opportunities for investment and borrowing to the bank, in exchange for the right to withdraw $\bar{x}_s$ units of consumption in period 1 or $\bar{y}_s$ units in period

2.

If $\bar{d}$ is positive –which, as we saw earlier, will be the case if the credit ceiling is sufficiently high– a large realization of ρ is a "bad" shock: it increases the interest burden on outstanding debt and implies reduced consumption. To see this, suppose that at the optimum the credit ceiling 6.5 binds in all states (it is not too difficult to find cases for which this is true[24]). Then, $\bar{x}_s = \bar{b}_s/\lambda = (f - \bar{d})/\lambda$, which does not depend on s, for $\bar{d}$ (as well as $\bar{k}$) is set at time 0 before the shock is realized, and hence depends on the distribution of the shock instead of on its realization. On the other hand,

$$\bar{y}_s = \frac{R\bar{k} - \bar{b}_s - \rho_s \bar{d}}{1-\lambda} = \frac{R\bar{k} - f - (\rho_s - 1)\,\bar{d}}{1-\lambda} \tag{6.7}$$

Hence (assuming henceforth the "normal case" of positive $\bar{d}$), the consumption of patient agents must fall when the interest rate increases.[25]

So far we have assumed that depositors act honestly in all states and have shown that interest rate shocks are costly in that case. But there is another, more ominous possibility: a bad shock may increase the vulnerability of the bank to a run. To see this, notice that the condition for a run to be possible in state s is

$$z_s = \overline{x}_s - \overline{b}_s - rl_s^+ > 0 \tag{6.8}$$

where l_s^+ is the maximum amount of liquidation consistent with full repayment of the external debt and is given by[26]

$$l_s^+ = \overline{k} - \frac{\rho_s \overline{d} + \overline{b}_s}{R} \tag{6.9}$$

Suppose again that 6.5 binds in all states. Then, as we saw, neither $\overline{x}_s$ nor $\overline{b}_s$ depend on

[24] In fact, from the first order conditions one can show that there are only two possibilities for an optimum: (i) the credit ceiling always binds, or (ii) the credit ceiling binds for interest rate realizations below a threshold rate, and it does not bind if ρ is higher. Whether (i) or (ii) obtains depends on the parameters of the problem.

[25] Notice that impatient agents may be completely insured when patient ones are not. This is not inconsistent with the model: while the consumption of patient types is random, they consume more than impatient ones.

[26] Hence l_s^+ is defined by $R(k - l_s^+) = \rho_s d + b_s$

ρ_s. Since $\bar{k}$ is predetermined as of period 0, l_s^+ must fall and therefore z_s must increase with the interest rate ρ_s; the intuition, clearly, is that a larger ρ implies a higher foreign debt burden, which reduces the amount of capital that can be liquidated in case of a run.

Since z_s is a measure of the bank's illiquidity, it follows that the vulnerability to a run must increase with the observed interest rate. In particular, it is possible to find cases in which z_s is negative for low realizations of ρ and positive for large realizations. In such cases, *a bank run is possible if and only if there is a bad shock.* [27]

If a bad shock brings the economy to the region where runs are possible, the harmful effects of the bad shock will be multiplied when, in addition, a run actually takes place. It may be a plausible conjecture that such scenario would arise because (loosely speaking) the bad shock makes depositors and bank creditors *pessimistic*, in the sense of expecting a run when one is feasible.[28] Such a story, as we argued at the outset, is reminiscent of events in Mexico in 1994 and East Asia in 1997, in which moderate shocks (higher world interest rates in the Mexican case, dollar appreciation and slow Japanese growth in Asia's) triggered major financial crises coupled with large contractions in economic activity.

7. Crazy government policy

It is commonly accepted that countries in East Asia adopted some government policies, such as guarantees on the liabilities of banks or investment subsidies, that raise the private rate of return and cause overinvestment, overborrowing, and asset price increases. Krugman (1998) and others have argued that the recent Asian crises are in fact the result of these misguided government policies.

[27] This result must be qualified if the credit ceiling does not bind in some states. To see this, note that if the credit ceiling is not binding in state s, one can show that $\overline{x}_s = \overline{y}_s = R\overline{k} - \rho_s\overline{d}$. Then using 6.8 and 6.9 one can show that z_s increases in ρ_s. Together with the argument in footnote 6, this implies that z_s may be decreasing, but only for sufficiently large values of ρ.

[28] The "loose" part of the argument is that, if the stochastic interest rate actually served as a sunspot variable that coordinated agents' expectations accross feasible equilibria, then the probability of a run would no longer be zero, and this would have to be taken into account from the beginning in solving the bank's optimal problem.

The resulting distortion can produce a crisis if one additionally assumes (as does Krugman) that there is an exogenous limit on the cumulative financial cost of government support policies. If bad exogenous shock exhausts the subsidy pool today, then such subsidies will not be available tomorrow; the expected return on capital will crash, and so will its market value. Self fulfilling collapses in asset prices are also possible. Suppose agents suddenly expect future government guarantees or subsidies to be removed. Falling asset prices in turn cause losses to firms and banks. Since the government is committed to bailing them out, it will spend resources; if the cost of bailouts is large enough, the exogenous limit will be reached, and the future subsidies or guarantees will indeed have to be removed, making the initial expectation self-fulfilling. In short, crises are can be caused by a sufficiently *crazy policy.*

This story has strong normative implications. Since in a crisis asset prices fall to their "true" value (the value they would have had in the absence of the distorting government policy), financial crises of this sort are salutary. It follows that any kind of international bailout that prevents asset prices from dropping is an unsound policy.

Such a view is in sharp contrast with the flavor or our story. We have emphasized self-fulfilling panics by domestic depositors and/or foreign lenders, which have large real costs. Moreover, those costs could be completely avoided by timely liquidity injections, for instance by a lender of last resort.

This section grafts onto our model a *crazy policy* of the sort just described to make two points. First, crazy policies can indeed make bank crises possible. But they are detrimental not so much in that they create inefficient overinvestment, but in that they can make banks less liquid and hence more vulnerable to a run. Second, that if banks do indeed perform a useful function (as they do in our model but not in Krugman's), crises partially caused by crazy policies are far from salutary. On the contrary, they cause inefficient liquidation of investment and excessively large drops in asset prices.

As in the last section, suppose that the world interest rate on loans between periods 0 and 1 is stochastic and can take values ρ_s, $s = 1, ..., S$. In addition, assume now that the government subsidizes the rate of return on the long term investment. Let the rate of the subsidy be denoted by η. We assume that the subsidy is paid in period 2; hence the bank is entitled to receive ηR units of consumption per unit of the long term asset it has in period 2. In order to finance the subsidy, we assume that the government imposes a lump sum tax τ on the bank in period 0, and invests the tax proceeds in the long term asset.

In this model, there is no rationale for subsidizing the long term investment and the proposed tax-transfer policy is purely distorting. In this sense, the policy is *crazy.* In fact, it is easy to see that a positive η will induce overinvestment in the illiquid asset.

The resulting equilibrium is as follows. The bank's planning problem is exactly the same as in the previous section, except that e is now replaced by $e - \tau$, and R by $R(1 + \eta)$. That is, from the bank's viewpoint the effect of the crazy policy is to reduce its endowment by the amount of the lump sum tax in period 0, and to increase the rate of return on the long term asset by ηR. In addition, the tax τ must be enough to cover the cost of the crazy policy. This requires, since the tax proceeds are invested in the long term asset, that $R\tau$ be equal to $R\eta\overline{k}$, or $\tau = \eta\overline{k}$, where $\overline{k}$ denotes, as before, the bank's long term optimal investment (which is now conditional on τ and η).

Solving for the equilibrium is a straightforward exercise. Clearly, the effect of the investment subsidy (at least if η is small enough) is to increase $\overline{k}$ and $\overline{d}$, and to redistribute consumption from impatient to patient depositors. These changes reduce the expected utility of the typical depositor, and bring about suboptimally large levels of investment and of foreign borrowing period 0. But one should expect the magnitude of these distortions to be small, since they are caused by pure substitution effects.

As in the case of small shocks, though, the effect of the crazy policy may be greatly magnified in a demand deposit system if the policy is associated with a greater likelihood of a bank run. This is the case even if the government is committed to helping the bank in case of trouble.

To see this, assume (analogously to what Krugman 1998 assumes) that in case of a bank run the government transfers the liquidation value of its investment to the bank. Then a bank run is possible in state s if and only if

$$z_s^* = \overline{x}_s - \overline{b}_s - r(l_s^+ + \tau) > 0 \tag{7.1}$$

where l_s^+ is given by 6.9.

Consider again the case in which the credit ceiling 6.5 is binding in all states. Then, as in the previous section, $\bar{x}_s = \bar{b}_s/\lambda = (f - \bar{d})/\lambda$. In addition, $\overline{k} = (e - \tau) + \overline{d}$ and $\tau = \eta\overline{k}$ imply that $\overline{k} = (e + \overline{d})/(1 + \eta)$. Using these facts and 6.9 in 7.1 imply that

$$z_s^* = (\frac{1}{\lambda} - 1 + \frac{r}{R})f + \left[\frac{r}{R}(\rho_s - 1)\right]\overline{d} \tag{7.2}$$

We saw that the investment subsidy increases $\overline{d}$ (relative to the case of no subsidy). Hence, as long as $\overline{d}$ is positive this crazy policy exacerbates the bank's illiquidity, as given by z_s, in every state of the world in which $\rho_s > 1$, i.e., in "bad" states.[29] A consequence is that the crazy policy may make a bank run possible in states that would have been free of runs without the policy.

The intuition is that the investment subsidy encourages investment in the long run asset, and consequently borrowing in period 0 increases. If the interest rate on that borrowing turns out to be large, there is a larger external debt burden, the liquidation value of the bank falls, and the bank becomes less liquid.

Since bank runs are associated with inefficient liquidation and wealth loss, one should expect their cost to be far superior to that associated with inefficient investment. In the example here, the policy is "crazy" primarily because of its effect on the liquidity of the financial system and not because of the loss of efficiency in investment.

We conclude that the role of overinvestment and related distortions in actual crises may have been greatly exaggerated. Clearly, it is not difficult to find examples of government policies that induce overinvestment in any given country. But while there are losses associated

[29] Notice also that the policy could make $\overline{d}$ negative in circumstances (that is, for levels of e and f) where, without the policy, it could have been zero or negative.

with overinvestment, they may pale in comparison with the cost of actual crises.[30]

8. Going from bank to currency crises

So far only banks have been the victims of runs, but going from financial crises to currency crises (and hence runs on the Central Bank) is a short step. It involves introducing a domestic currency, "pesos," that can be costlessly created and destroyed only by the country's Central Bank. The existence of a positive demand for pesos could be ensured in any of the standard ways (money in the utility function, cash-in-advance constraint, etc.). To keep things simple we just assume that the bank's promised payments to depositors are denominated and paid in pesos. (By contrast, and in the interest of realism, foreign loans continue to be denominated in dollars.) Domestic residents can only get consumption goods by selling the pesos at the Central Bank. If dollars are available at the Central Bank, the domestic agent then consumes.

Since only the domestic Central Bank can print pesos, the analysis of this model must include a specification of the way pesos are issued and exchanged for dollars. The analysis of two alternative regimes is the subject of our ensuing discussion.

8.1. A currency board

Suppose first the Central Bank follows a very simple rule: it stands ready to exchange dollars for pesos at a fixed exchange rate and, in addition, it is committed not to create or destroy pesos in any other way. In other words, the Central Bank acts as a currency board. One consequence is that it does not extend domestic credit to the banking system or to any other agent. We shall assume without loss of generality that the Central Bank guarantees that the

[30] There are additional questions associated with the crazy policy view. The existence of crises hinges upon two exogenous assumptions about government policy –that it inefficiently raises rates of return and that the cumulative cost of financing it is bounded above– which seem hardly natural. Since one can always postulate a sufficiently crazy policy to rationalize a bad outcome, such specific assumptions demand a strong justification. Moreover, the empirical plausibility and importance of crazy policies in actual crises remain to be established.

exchange rate will be one peso for each dollar in both periods.

The commercial bank now solves the same problem as in section 2 above, except that now the path for the exchange rate is an additional constraint. Since that changes nothing of substance, the solution to that problem is the same as before, and is still denoted by a tilde over a variable.

This solution can, once again, be implemented via a demand deposit system. In period 1 depositors arrive to the bank in random order. Upon arrival, each agent reports her type realization and withdraws either $\tilde{x}$ or 0 pesos, depending on her type. The commercial bank services requested withdrawals sequentially, as long as it is solvent. The bank becomes insolvent if withdrawals exceed the maximum amount of short term funds (still given by $\widetilde{b} + r\widetilde{l}^{+}$) that the bank can use while ensuring that its external debt will be honored. After all depositors have visited the bank, the Central Bank starts selling dollars at an exchange rate of unity. We will assume that the Central Bank closes if it runs out of dollars (this cannot happen under this monetary arrangement, but may happen in other regimes).

Finally, if the bank did not close in period 1, in period 2 the bank liquidates all of its remaining investments, repays its external debt, and sells the remaining dollar proceeds to the Central Bank. It then pays $\tilde{y}$ pesos plus any profits to agents that reported to be patient in period 1. These agents exchange the pesos for dollars at the Central Bank in order to get the necessary units of the consumption good.

It should be evident that under these conditions an honest equilibrium exists, just as in the non-monetary economy. There is also a run equilibrium if and only if condition 2.14 is satisfied. Hence, the range of possible outcomes and their characteristics are unchanged.

Notice also that the existence of a Central Bank and of peso-denominated deposits in no way affects the potential vulnerability of a bank operating a demand-deposit system. This is because we have specified a rule for monetary policy that prevents the Central Bank from extending credit to the bank. Of course, the advantage of this system is that the demand for dollars by importers (and indirectly, by depositors) at no point exceeds the availability of dollars at the Central Bank. The one-to-one parity between the peso and the dollar survives regardless of whether the bank crashes or not.

The situation is reminiscent to that in Argentina in 1995, where a sudden wave of deposit withdrawals threatened the integrity of the local banking system. Under the currency board system in operation (which, in essence, is like the system we have just characterized) the Central Bank could reduce bank reserve requirements, but beyond that had little room to intervene. That is because a currency board prevents the Central Bank from extending credit to the commercial bank even in the event of a run. In other words, such an arrangement commits the Central Bank never to act as a *lender of last resort*. What saved the day was an infusion of capital from abroad, mostly from the World Bank and the Inter-American Development Bank. The episode, nonetheless, underscored the potential fragility of banks under a currency board system.[31]

8.2. A fixed exchange rate with a lender of last resort

We shall now examine the consequences of allowing for domestic credit and permitting the Central Bank to act as a lender of last resort. But we shall still assume that the Central Bank maintains a fixed exchange rate regime in the sense that it will defend the peso parity (at one-to-one to the dollar) until it is not feasible for the economy to obtain more dollars. We will see that the key implication of this regime is that, while the commercial bank may be insulated from crises, *balance of payments crises* become possible.

A regime of fixed exchange rates with a lender of last resort is best formalized as follows. The Central Bank offers to lend an unlimited quantity of pesos to the commercial bank if more than λ customers claim to be impatient. If such emergency credit is used, we assume that the Central Bank obtains in period 1 control over the domestic asset $\widetilde{k}$ and also assumes the debts that the commercial bank should have repaid in period 2. The Central Bank then liquidates the asset as needed to sell dollars to agents who have claimed impatience, up to the maximum liquidation consistent with the repayment of the external debt.

In period 1, the commercial bank meets withdrawals by borrowing $\widetilde{b}$ on it remaining credit

[31]For details on the whole experience see Caprio, Dooley, Leipziger and Walsh (1996).

line abroad, and then drawing on the emergency credit from the Central Bank. Because the emergency credit is unlimited, the bank does not close.

Withdrawing depositors then go to the Central Bank, which is committed to selling them dollars at a unity exchange rate. To honor its commitment, the Central Bank uses first the dollars obtained from the commercial bank, and then liquidates the domestic asset up to the limit $\widetilde{l}^{+}$; this implies that, just as under a currency board, the maximum quantity of dollars that the Central Bank can sell in period 1 is $\widetilde{b}+r\widetilde{l}^{+}$. After the Central Bank sells this quantity of dollars, it stops selling more [32]; if this happens while there are still agents attempting to purchase dollars, we say that there is a "balance of payments crisis."

Under these assumptions one can show that if all depositors act honestly the social optimum is implemented. Now, the same conditions under which there was a *bank run* in the previous regime imply that there is a *balance of payments crisis* with a lender of last resort. In particular, there is an equilibrium in which all depositors claim to be impatient and the Central Bank is unable to service all dollar demands in period 1 if and only if 2.14 holds.

A sketch of why 2.14 is a sufficient condition is as follows (necessity can be proven along the lines of the argument given in the appendix). If all depositors claim to be impatient in period 1, they withdraw their funds and run to the Central Bank with $\widetilde{x}$ pesos. The Central Bank obtains $\widetilde{b}$ dollars from the bank (which uses the remainder of its available international credit), and $r\widetilde{l}^{+}$ from liquidation of the long term investment it now owns. Given 2.14, the Central Bank will close while there are still some agents trying to buy dollars. [33]

The preceding result reveals that, if the Central Bank acts as a lender of last resort, the vulnerability to a crisis is the same as with a currency board. The difference is whether the crisis is expressed as a *bank run* or a *balance of payments crisis,* but this has no economic

[32] And earmarks the nonliquidated domestic investment to service the external debt

[33] Clearly, the commercial bank does not close in period 1. Since all deposits are paid in the first period, the bank has no further liabilities *vis à vis* depositors in period 2. The bank has no resources to repay its debt to the Central Bank in period 2 –but this is not important, since by then the Central Bank has become bankrupt. Alternatively, one can assume that the debt is cancelled when the Central Bank fails to return the long term asset to the commercial bank.

importance. The intuition is that, when 2.14 holds, implementing the socially optimal allocation under fixed rates requires that the financial system *as a whole* be *internationally illiquid* in the following sense: given the commitment to fixed rates, the total amount of demandable debt of the system, $\tilde{x}$, is a short term *dollar* obligation which exceeds the quantity of dollars that the system can tap in period 1.[34]

That this situation may cause a bank run under a fixed rate with no domestic credit (a currency board) is not very surprising. What may be surprising is that the Central Bank cannot fully succeed as a lender of last resort. This happens because, although the Central Bank can print pesos, it cannot print the dollars that are effectively needed to back the whole amount of demand deposits. By printing domestic currency to save the banks it only ensures the demise of the peg, as central banks in Mexico, Indonesia, Korea and Thailand, among others, have recently learned.

8.3. Other exchange rate arrangements

The analysis of this section so far assumes that the Central Bank fights a devaluation *like a dog*.[35] This is implied, in particular, in the assumption that the Central Bank stops selling dollars in the first period only after the domestic asset has been liquidated to the maximum consistent with external debt being serviced. One may ask what would happen with a less committed Central Bank. For example, a Central Bank procedure may could for stopping the sale of dollars before using up the maximum amount of dollars available in the short run, and allowing the market to clear via an exchange rate adjustment. That would be, effectively, a system of flexible rates.

We have studied that question (and several others having to do with the design of exchange rate systems under bank fragility) in Chang and Velasco (1998a). Our main conclu-

[34] Of course, this situation of international illiquidity could be avoided if the Central Bank held additional liquid reserves. But this raises a host of new issues. Where does the government obtain these resources to begin with? If via taxation, this clearly reduces consumption possibilities for the private sector. The inefficiency is particularly acute because to be effective the Central Bank must keep the resources in the less productive liquid asset. For a detailed discussion of these issues, see Chang and Velasco (1998a).

[35] This famous phrase is attributed to Mexican President López Portillo in describing his commitment to defend the peso in 1982; he devalued a few weeks later.

sion is that flexible exchange rates, coupled with a Central Bank that acts as a lender of last resort, can reduce financial fragility in a way fixed exchange rates cannot.

9. Conclusions

Rather than restating our analytical results, we conclude by underscoring the main policy implications of our analysis.

1. The short maturity of capital inflows, more than their absolute size, can contribute to bank fragility. Therefore, disincentives for short-term foreign borrowing by banks may well be justified. High required reserves on bank liquid bank liabilities (whether in domestic or foreign currency, and whether owed to locals or foreigners) is an obvious choice . It may be sound policy even if it has some efficiency costs or if causes some disintermediation. An obvious caveat is that, if banks are constrained, firms will do their own short-term borrowing, as it happened massively in Indonesia. A policy that is not subject to this caveat is taxes on all capital inflows, where the tax rate in inverse proportion to the maturity of the inflow (and where long term flows such as FDI go untaxed at the border) –as employed by Colombia and Chile in the 1990s. But this advantage is also a potential cost, in that the inefficiencies associated with a restricted set of borrowing options apply to a larger share of the economy.

2. Financial liberalization that increases welfare if bank crises do not occur may also enlarge the set of circumstances in which such crises are indeed possible. The analysis in section 3 above suggests that moves to de-regulate the banking system –whether by lowering reserve requirements or fostering greater competition among banks– must be undertaken with care.

3. In the event of a crisis, large real costs may be incurred as a result of early liquidation of investments, and asset prices may consequently fall farther than they would have had this liquidity crunch been avoided. This observation is helpful in designing policies to respond to the crisis –for instance, in dealing with troubled banks. The proper policy prescription clearly depends on one's assessment of the crisis. If the problem is primarily one of moral hazard and overlending (as Krugman 1998 has claimed for Asia) or of outright fraud (as

Akerlof and Romer 1996 argued for the U.S. S&L crisis), then banks are insolvent and they should be either closed or forced to recapitalize. But if the problem is one of illiquidity made acute by panicked behavior by depositors and creditors (as we have argued), liquidity should be injected into banks, not withdrawn from them, in order to minimize costly asset liquidation.

4. Section VI suggests that distorting government policies such as deposit guarantees or investment subsidies are to be avoided not so much because they cause efficiency losses, but because they can increase banks' illiquidity and hence worsen financial fragility. While "overinvestment" may be part of the Asian story, for instance, it is hardly plausible that it could account for the magnitude of the real contraction in activity. That can only be understood as the result of the accompanying financial collapse.

5. The combination of an illiquid financial system and fixed exchange rates can be lethal. If the central bank commits not to serve as a lender of last resort, then bank runs can occur; if it acts as a lender of last resort in domestic currency, bank runs are eliminated at the cost of causing currency runs. Hence, with fixed exchange rates and insufficient reserves (that is, illiquidity), a crisis is unavoidable if investor sentiment turns negative; the only choice authorities face is what kind of crisis to have.

In our view this represents a strong case in favor of flexible exchange rates. But there are caveats. One is that the combination of flexible rates plus a lender of last resort in local currency can protect banks against self-fulfilling pessimism on the part of domestic depositors (whose claims are in local currency), not against panic by external creditors who hold short-term i.o.u's denominated in dollars.

6. If financial crises such as those in East Asia were at least partially caused by self fulfilling liquidity squeezes on banks, there is a role for an international lender of last resort that can help overcome a financial system's international illiquidity. Funds from abroad to prevent unnecessary credit crunches and avoid costly liquidation of investment can increase welfare.

The usual (and valid) objection is moral hazard. But this need not be a rationale for policy paralysis. Fire insurance and bank deposit guarantees also risk inducing moral hazard, but the risk can be minimized by proper contract design and appropriate monitoring. No one advocates banning fire insurance simply because it leads some home-owners to be careless with their fireplaces. The same should be true of an international lender of last resort.

10. Appendix

Here we show that condition 2.14 is also necessary for bank runs to occur in the basic model. Suppose that a number $\vec{\lambda}$ of depositors claim to be impatient in period 1. Clearly it is enough to restrict attention to the case in which $\vec{\lambda} > \lambda$. We shall argue by contradiction and show that if 2.14 does not hold the bank is able to pay at least $\tilde{y}$ pesos to honest patient types in period 2, which implies that it cannot be optimal for the patient to lie.

Let $\vec{l}$ denote the amount of liquidation of the domestic asset; it is defined by $\vec{\lambda}\tilde{x} = \widetilde{b} + r\vec{l}$. Now, it is easy to check that the bank will be able to pay $\tilde{y}$ to the $\left(1 - \vec{\lambda}\right)$ reportedly patient depositors if $R(\tilde{k} - \vec{l}) - \widetilde{d} - \widetilde{b} \geq \tilde{y}\left(1 - \vec{\lambda}\right)$. This inequality will hold, from the definition of $\tilde{y}$ and the last equation for $\vec{l}$, if $r\left(\frac{R\tilde{k} - \widetilde{d} - \widetilde{b}}{R}\right) \geq (1 - \lambda)\tilde{x}$. But the latter is equivalent to the failure of 2.14 to hold. The proof is complete.

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