FEDERAL RESERVE BANK *of* ATLANTA

Liquidity Crises in Emerging Markets: Theory and Policy

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Working Paper 99-15
October 1999

Working Paper Series

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Abstract: We build a model of financial sector illiquidity in an open economy. Illiquidity is defined as a situation in which a country's consolidated financial system has potential short-term obligations that exceed the amount of foreign currency available on short notice. We show that illiquidity is key in the generation of self-fulfilling bank and/or currency crises. We discuss the policy implications of the model and study issues associated with capital inflows and the maturity of external debt, the role of real exchange depreciation, options for financial regulation, fiscal policy, and exchange rate regimes.

JEL classification: F3, E5, G2

Key words: crises, financial systems, exchange rate systems, liquidity

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This paper is forthcoming in the *NBER Macroeconomics Annual 1999*. The authors thank Philippe Aghion, Abhijit Banerjee, Ben Bernanke, Dean Corbae, Laura Hastings, Julio Rotemberg, Nouriel Roubini, Aaron Tornell, Chris Waller, and seminar participants at Harvard, Yale, the University of Kentucky, and the University of Pittsburgh for useful comments. Velasco acknowledges support from the C.V. Starr Center for Applied Economics at NYU. The views expressed here are the authors' and not necessarily those of the Federal Reserve Bank of Atlanta or the Federal Reserve System. Any remaining errors are the authors' responsibility.

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1. Introduction

The recent literature offers no shortage of villains to blame for the financial crashes in Mexico, East Asia, Russia and Brazil: corruption and cronyism, lack of transparency and imperfect democracy, misguided investment subsidies and loan guarantees, external deficits that are too large (or sometimes too small), fixed exchange rates that are maintained for too long (or abandoned too readily), poor financial regulation, excessive borrowing abroad –the list goes on and on.

It is tempting to argue that several or even all of these factors mattered for recent meltdowns. But such a kitchen sink approach would help little in understanding *why, when,* and *where* these crises happened. Which one of the many weaknesses exhibited by the afflicted countries is *necessary* for a crisis to occur? Can any of them conceivably be *sufficient* to trigger a collapse? There is also the pesky need to formulate policy. Central bankers and finance ministers can at best tackle a few issues at a time. Where should they focus their efforts to have the best chance of avoiding financial vulnerability?

At the risk of oversimplifying, in this paper we focus on a single factor behind financial and currency distress: *international illiquidity*, defined as a situation in which a country's consolidated financial system has potential short-term obligations in foreign currency that exceed the amount of foreign currency it can have access to on short notice.[1] Illiquidity is certainly not *necessary* for currency crashes to occur. The EMS troubles of the early 1990s, for instance, had more to do with governments' desire to fight unemployment than with any difficulties in servicing short-term obligations.[2] But illiquidity comes close to being *sufficient* to trigger a crisis. The options left after creditors lose confidence and stop rolling over and demand immediate payment on existing loans –whether to the private sector as in Asia or to the government as in Mexico and Brazil– are painfully few. The collapse of the currency, of the financial system, or perhaps both, is the likely outcome.[3]

We restrict our focus even further by stressing the role of domestic banks in causing and transmitting situations of illiquidity. In doing so we miss some of the action: the world now knows that in Indonesia it was corporates who did much of the borrowing, and who faced severe illiquidity when foreign lending stopped. Yet a focus on banks is justified for two reasons. The first is 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 more recently, the currency crashed along with the financial system. Formal econometric work, such as that reported by Kaminsky and Reinhart (1996), shows that a bank crisis helps predict a currency crisis.[4] The second is that

[1]This is close to what Dornbusch (1998) calls "balance sheet vulnerability." See also Feldstein (1999) for a set of policy recommendations that focus on increasing liquidity.

[2]This point has been forcefully argued by Obstfeld (1994).

[3]We say "close to sufficient" because, as Obstfeld and Rogoff (1995) have stressed, any Central Bank that has enough resources to buy back the monetary base is capable, in a technical sense, of maintaining an exchange rate peg. But, as Obstfeld and Rogoff themselves recognize, in situations of financial distress the *de facto* claims on Central Bank reserves may be as large as M2 or larger. In those cases, as we study in detail below, maintaining the peg becomes a more treacherous task.

[4]Also, Sachs, Tornell and Velasco (1996b) find that the previous speed of bank credit growth helped

banks play a much larger role in emerging than in mature economies; this justifies focusing on banks to the detriment of other financing mechanisms such as equity.

Emphasizing illiquidity is natural for emerging markets because of their limited access to world capital markets. When fractional reserve banks in mature economies face a liquidity problem, they are likely to get emergency funds from the world capital markets as long as they are solvent. This is seldom the case in emerging economies: a private bank in Bangkok or Mexico City will get many 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 rationing is potentially devastating –and is the focus of our analysis below.

International illiquidity is what the very diverse recent crises in emerging markets have in common. Recently troubled countries in Asia[5] had high and sharply rising ratios of hard currency short-term liabilities, especially external debt, to liquid assets. They were therefore extremely vulnerable to what Calvo (1998) terms the *sudden stop syndrome*: a massive reversal of capital inflows, which occurred in the second half of 1997.[6] Bankruptcies, payments moratoria and asset price collapses (including the exchange rate, the price of domestic money) proliferated. The financial panic fed on itself, causing foreign creditors to call in loans and depositors to withdraw funds from banks –all of which magnified the

explain which countries were affected by the Tequila effect.

[5]Although our review is restricted to the Asian crisis, international illiquidity is also found in other crash episodes. For instance, in Chang and Velasco (1998c) we have argued, in this respect, that the recent Asian crisss resembles the experience of Chile in 1982 and Mexico in 1994.

[6]Radelet and Sachs (1998) estimate a capital outflow of US$ 34 bn. from the Asean 5 countries in the second half of 1997, equivalent to a negative shock of 3.6 of GDP.

illiquidity of domestic financial institutions and forced yet another round of costly asset liquidation and price deflation.

Our intention is not to provide yet another answer to the question of "who lost Asia." Nor do we want to compete with the many good and detailed accounts of what happened.[7] Rather, we tackle three sets of questions:

- *Analytics*: what is the right theoretical framework for illiquidity-driven crises? We have well-established "first generation" models of how loose money causes currency crashes, and "second generation" models of why governments may choose to devalue in response to mounting unemployment. By contrast, models of crashes caused by illiquidity and balance sheet vulnerability are still in their infancy.[8]

- *Crisis prevention*: can illiquidity-driven crises be avoided, and how? The easy yet useless answer is to require financial systems to be always liquid. Full liquidity is costly and may dispense with all benefits of financial intermediation: banks are in the business of transforming maturities and there is no way to do this without a mis-matched balance sheet. Hence, countries attempting to prevent crises face some unpleasant trade-offs, involving not only domestic financial regulation but also monetary, fiscal and exchange rate policy.

- *Crisis management*: how should one respond to a crisis caused by international illiq-

[7]See, especially, Corsetti, Roubini and Pesenti (1998 a and b) and World Bank (1998).

[8]We have made some preliminary progress in Chang and Velasco (1998a, 1998b, 1999). Other papers in the same research line include Calvo (1995, 1998), Detragiache (1996), Goldfajn and Valdes (1997), Jeanne (1998), Aghion, Bacchetta, and Banerjee (1999), and Krugman (1999).

uidity? In the aftermath of Asia there have been furious debates over the wisdom of increasing interest rates or letting the exchange rate go in the face of an attack. But the "correct" answers should hinge on the nature of the crisis. Current-account driven crises require a real depreciation and a contraction of demand; illiquidity-driven crises may call for different answers.

We study a model of a bank situated in a small open economy with limited access to international capital. This simple setup attempts to capture the main features of what Krugman (1998) has tentatively termed "third generation" crisis models, and enables us to discuss, in a unified way, a number of issues raised by the recent sequence of crises in emerging markets. In particular, we discuss the role of capital inflows and the maturity of external debt, the way in which real exchange rate depreciation can transmit and magnify the effects of bank illiquidity, options for financial regulation, the role of debt and deficits, and the implications of adopting different exchange rate regimes.

Clearly this is not the only potentially useful way to study crises. Several analysts of recent crashes –most visibly Corsetti, Pesenti and Roubini (1998a and b)– have stressed the role of bad shocks and bad policy, presumably leading to insolvency. That emphasis leads to very different policy implications than does a model like ours, which stresses illiquidity and multiple equilibria. We can offer the usual disclaimer: both approaches are necessary and may turn out to be complementary. But it is important to realize that in our approach the line between illiquidity and insolvency is a fine one. Being illiquid can cause some investment projects to be left unfinished and others to be liquidated early. If this is sufficiently costly, illiquidity can breed insolvency. In practice, the bankruptcies and weak balance sheets recently observed in crisis countries may well be *consequences* rather than *causes* of the crisis.

2. International illiquidity in recent crises

Financial fragility is associated with the concept of *international illiquidity*, defined as a situation in which a financial system's potential short term liabilities in hard currency exceed the amount of hard currency it can have access to on short notice. International illiquidity was crucial in triggering recent crises. To make this case, we shall analyze data from the so-called Asean-5 countries (Korea, Indonesia, Malaysia, Thailand, and the Philippines) and also from comparable Latin American countries.[9] We need to answer at least two questions: how illiquid were the Asean-5 countries at the time the crisis erupted? And, were the Asian countries systematically different from otherwise similar ones in terms of international illiquidity? Answering these questions requires making the concept of "international illiquidity" operational, which in turn requires identifying the institutions that comprise each country's "financial system," as well as their relevant "short-term assets and liabilities in hard currency." The appropriate definitions depend on government policy.

Our definition of a financial system will naturally include domestic banks and other domestic financial entities that perform bank-like operations (such as Thailand's finance companies). In addition, because the countries under discussion had governments committed

[9] The discussion below is essentially taken from Chang and Velasco (1998c).

to act as lenders of last resort of private financial institutions, their central banks will be included as well. This is sensible because, in the presence of such a commitment, a crisis affecting private financial institutions will force a central bank to honor it, and this may pull the government itself into the crisis. Indeed, we shall argue later that a balance of payments crisis is best understood as a situation in which a central bank runs out of international liquidity in an attempt to fight a financial crisis.

Accordingly, an ideal definition of the liquid international assets of the financial system would include not only the short-term external assets of private financial institutions, but also the amount of foreign currency available to the central bank for last resort lending in the event of a crisis. (Notice that the latter should, in principle, exclude the amount of reserves that has already been committed, implicitly or explicitly, to other uses in a crisis, such as the repayment of Tesobonos in Mexico 94.) The definition would also include the amount of international loans that the financial system can have access to in the short run as well as the liquidation value of fixed assets. While a measure of short-term international liquid assets embodying these desiderata can perhaps be constructed, because of data constraints we use the stock of international reserves of the monetary authorities as a proxy of the ideal measure.

Similarly, an ideal definition of the short-term international liabilities of the financial system would include its short-term foreign debt as well as demandable deposits denominated in foreign currency; the only difference, from the viewpoint of international illiquidity, is that the former are obligations against foreigners while the latter are obligations with domestic residents. In addition, if there is a fixed exchange rate, demandable deposits in domestic currency should also be included, since fixed rates imply that such deposits are effectively obligations in foreign currency.

The relevant data on deposits in the consolidated financial system are available from IFS, but the situation for international debt is less satisfactory. As discussed by Corsetti, Pesenti, and Roubini (1998a), the most useful source of evidence on short-term external debt is published by the Bank of International Settlements. But the BIS data is restricted to the indebtedness of a country's residents against foreign banks. More importantly for our purposes, available BIS tables are not broken down sufficiently to identify the short-term external debt of the financial system. However, they do contain data on the short-term external debt (against BIS reporting banks) of a country as a whole, as well as on the amount of external debt (including debt of longer maturity) contracted by domestic banks. These aspects of the data force us to treat domestic deposits and external debt separately.

Keeping data limitations in mind, we now turn to the available evidence. The data on the Asean-5 countries does suggest that the international liquidity position of their financial systems deteriorated before the crisis. This is can be seen most clearly from the BIS data on foreign bank lending. Table 1 shows the behavior of the ratio of short-term loans from international banks to reserves; obviously, an increase in the ratio implies a higher likelihood of international illiquidity. The upper panel of the table shows that among the Asean-5 the ratio increased between mid 1994 and mid 1997 in every case except for Indonesia, where the ratio was stable. (In Korea, Malaysia and Thailand the ratio had also increased between 1990 and 1994. It had fallen in Indonesia but not by much. It had fallen sharply in the Philippines, but this was probably an anomaly following the Philippine Brady debt restructuring of 1991.)

It is also remarkable that the short-term debt to reserves ratios at the end of 1996 were substantially above one in Korea, Indonesia, and Thailand. This suggests a financially fragile situation, in the sense that international reserves would not have been sufficient to repay the short-term debt had foreign banks decided not to roll it over. While the level of the short-term debt to reserves ratio was below one in Malaysia and the Philippines (the two countries among the Asean-5 least affected by the crisis), it doubled between mid 1994 and mid 1997.

As shown by the lower panel of Table 1, the corresponding data for Latin American countries looks rather different. The short-term debt to reserves ratio was stable and below one in Brazil, Chile, Colombia, and Peru; in Argentina and Mexico it was approximately 1.2 in mid 1997, thus exceeding one but not by much, and had been falling. The Latin countries appear to have been in a much less vulnerable position.

The BIS tables suggest, in addition, that the proportion of foreign bank lending intermediated by the domestic banking sector was stable in each Asian case except Thailand. In the case of Thailand, the decline in the share of the domestic banking sector in foreign borrowing is attributable, by and large, to the increased importance of finance companies. Finance companies seem to have emerged in response to regulatory distortions, but performed bank-like functions. In fact, they are included in the International Finance Statistics as part of the group "Other Banking Institutions;" the IFS notes that although finance companies were "not licensed to accept deposits from the public," they "issued promissory notes at terms comparable to the time deposits at commercial banks." The importance of Thailand's finance companies in the financial systems was also underscored by the fact that the Bank of Thailand was committed to support them as a lender of last resort.

The evidence thus strongly indicates that the short-term external liabilities of the relevant Asian financial systems were growing faster than their liquid international assets. In our interpretation, this trend weakened the international liquidity position of the Asean-5 countries to the point where a loss of confidence from foreign creditors could force the financial system into a crisis. The same was not true in Latin America.

The behavior of domestic deposits vis à vis international reserves shows a similar picture. The upper panel of Table 2 shows the evolution of the ratio of M2 to foreign reserves for the Asean-5 economies before their crises. The high level of the M2 to reserves ratio seems consistent with the hypothesis of international illiquidity. At the end of 1996, the M2 to reserves ratio was 6.5 or above in Korea and Indonesia and 4.5 in the Philippines. As the lower panel in Table 2 reveals, the same ratio was only 3.4 in Argentina, 2.7 in Brazil, and less than 2 in Chile and Peru. It was relatively higher in Mexico (4.65) but there it had been falling; it is notable (and maybe more than a coincidence) that the M2 to reserves ratio had been over seven in Mexico in June 1994, just before its own crisis!.

The M2 to reserves ratio was stable in each of the Asean-5 countries, except in Thailand where it was falling. The behavior of the Thai ratio most likely reflects, as we discussed above, that the relevant measure of the liabilities of Thailand's financial system vis à vis domestic residents should include the promissory notes of the finance companies, which are not included in M2.

In short, the ratio of M2 to reserves in the Asean-5 countries had been high in each case but Thailand. By contrast, in comparable Latin countries the M2 to reserves ratio was relatively high only in Mexico, where it had been falling drastically. This evidence, which proxies the short-term asset and liability positions of each financial system vis à vis domestic depositors, also favors the view that the Asean-5 but not the Latin countries had a problem of international illiquidity when the crisis started.

We conclude from this quick review of the data that international illiquidity was in fact a distinguishing characteristic of the Asean-5 economies prior to their 1997-98 crises. Latin countries did not suffer from that condition —and did not go into crisis.[10]

Two caveats are in order. First, it bears repeating that, because the Asean-5 countries had effectively fixed exchange rates, our accounting includes domestic currency deposits as obligations in international currency. The relative magnitudes of deposits to international reserves implies that the latter would not have been sufficient to honor the outstanding stock of deposits at the fixed exchange rate. Given this condition, a run by domestic depositors was bound to result in either the bankruptcy of the financial system or the abandonment of the

[10] In contrast, the performance of several key real variables was not that different across regions. East Asian countries often had large current account deficits in the 1980s and early 1990s, but the crash did not happen until 1997. In the mid 1990s a number of Latin countries, including Brazil, Chile, and Colombia, had external deficits over 5% of GDP. Mexico, Malaysia, Thailand and Brazil surely suffered from real exchange rate misalignment, but so did Argentina, Colombia, Chile and Peru, and no crisis has yet hit these South American countries. For a detailed discussion, see Chang and Velasco (1998c).

fixed exchange rate. The M2 to reserves ratio, however, overstates international illiquidity in countries with flexible exchange rates, such as Mexico and Peru, to the extent that M2 includes deposits in domestic currency. This is because, in case of a crisis, a central bank can always print enough domestic currency to honor those deposits; see section 8 below.

The second caveat that, because comparable data is not currently available, we have not included short-term domestic public debt in our liquidity measures. In the Asian crisis, this is not likely to be an important omission. Around the time of the collapse there does not seem to have been much short-term public debt in the strongly affected countries of Indonesia, Korea and Thailand (see Table 3 of Ito 1998). However, public debt may have played a role in other episodes. We know that the Mexican government's inability to roll over its large stock of short-term debt (in particular, the infamous Tesobonos) was to prove key in triggering the financial crisis in December 1994. More dramatically, Brazil's debt situation seems to be crucial for understanding its current predicament.[11] This raises the question of whether our international illiquidity view of crises can be reconciled with the presence of fiscal and/or domestic debt problems. We delay our answer until section 7.

[11]Except for Brazil, public debt has not a major problem recently for comparable Latin American countries either. Mexico managed substantially to extend the maturity of its public debt after the 1994 collapse. At the end of September 1994, its short term domestic federal debt was equivalent to US $26.1 billion; by the end of June 1997 this figure was down to less than US $8.5 billion. Argentina, Chile and Peru have not issued domestic short term debt in any substantial magnitude.

3. A basic framework

Focus on a small open economy with three periods indexed by $t = 0$ (the *planning period*), 1 (the *short run*), and 2 (the *long run*). There is a single, perishable consumption good in each period. The consumption good is freely traded in the world market; we take its world price to be the *numeraire* or, equivalently, we assume that the price of consumption is fixed at one unit of an international currency (the *dollar*).

The economy is populated by a continuum, whose measure is normalized to one, of *ex ante* identical individuals, whom we refer to as *depositors* for reasons that will become clear shortly. Each depositor is endowed with an amount $a \geq 0$ of the single good only at $t = 0$. Depositors maximize expected period 2 consumption.

They have access to a world capital market where interest rates are zero. Each depositor can lend as much as she wants in the world market; more precisely, in each period she can purchase any nonnegative quantity of a world *liquid* asset, that yields a zero interest rate and can be costlessly liquidated at any time. In contrast, each depositor can borrow at most an amount $f > 0$ and then only from a continuum of identical foreign *creditors*, whose measure is also unity. Each foreign creditor is risk neutral, can freely borrow or lend in the world market, and maximizes expected second period consumption. Hence creditors will lend to domestic agents if and only if they are offered an expected net return of zero.

Domestic depositors can also invest in a *long-term* asset with the following characteristics. Each unit of the consumption good invested in this asset at $t = 0$ yields R units of consumption at $t = 2$. However, with probability λ, the investment is hit by a bad shock, in the sense that it needs a further infusion of resources in period 1 if any yield can be collected in period 2. The required infusion is of size $i < a + f$, and is independent of the size of the initial investment in the long-term asset. In other words, when a long-term investment of size k is hit by a shock, period 2 output is Rk if and only if an additional i is invested in period 1.

Assume that $R(1 - \lambda) > 1$ –that is, the long-term asset's expected yield is higher than the world interest rate even though it can go to waste when hit by a shock. Assume also that the long-term asset k can be liquidated at $t = 1$ for rk units of output in that period, where $r \in [0, 1)$.[12] These assumptions ensure that the long-term asset is very profitable in the long run but *illiquid* in the short run.

Information about types is private: whether an agent is "unlucky," in the sense that her long-term asset is hit by a shock, is only observed by that agent. Finally, shocks to long-term investment are i.i.d. across consumers and there is no aggregate uncertainty, so λ is also the fraction of the domestic population that turns out to be unlucky.

Clearly, in the absence of shocks to illiquid investments, each domestic resident would borrow up to her credit limit f and invest all of her resources in the illiquid asset. On the other hand, if she knew in advance that she was unlucky, she would hold enough liquidity to finance the resource infusion i in period 1.[13]

As the appendix shows in some detail, this uncertainty makes the trade-off between

[12] Notice that the investment has a positive liquidation value regardless of whether it was hit by the shock. Assuming that only healthy investment has positive liquidation value would change nothing substantial, but would complicate algebra slightly.

[13] Hence shocks to long term investment play here a role analogous to preference shocks in models in the tradition of Diamond and Dybvig (1983).

holding or not sufficient liquidity very unattractive for the individual agent. She can do better by joining a bank, as we now see.

3.1. A Bank

What banks do is allow agents to take advantage of the law of large numbers to predict more accurately their needs for costly liquidity. The bank pools the resources of the economy (including the endowment a and the maximum credit level f belonging to each depositor) in order to maximize the welfare of its representative member. In doing so, it needs to respect resource constraints and informational constraints.[14]

Formally, the bank's problem is to maximize expected consumption subject to the following constraints. First, it must distribute the period 0 resources $w \equiv a + f$ to the long-term asset and the liquid asset, and hence it must respect the budget constraint

$$k + b \leq w \tag{3.1}$$

where b and k denote, respectively, investment in the liquid and illiquid assets. In period 1, the bank may or may not spend i to shore up each of the λ investments hit by a shock. In period 2 the bank collects the result of its investments, repays the external debt f, and pays c to each depositor.[15] Finally, these choices must satisfy the incentive compatibility

[14] In this sub-section we characterize the best that the bank can do for its members; the next sub-section deals with whether and how this solution can be decentralized.

[15] This is without loss of generality, although in principle the bank may pay different amounts to lucky and unlucky agents. With risk neutrality, this would not make any difference. As long as there is even a small degree of risk aversion, however, it becomes strictly optimal to pay the same to both types.

constraint

$$i \leq c \tag{3.2}$$

An explanation of 3.2 is in order. To simplify exposition, we assume that unlucky agents cannot lie about her types. In contrast, lucky agents can claim to have been hit by a bad shock, obtain i from the bank, and "abscond" with the payment. In that case, she cannot be caught but is entitled to no period 2 consumption.[16] To prevent absconding, c cannot be smaller than i.

To characterize the solution (whose values are denoted by "hats") ignore the incentive constraint for the moment. It can be shown that the bank will hold enough liquidity to shore up bad investments,[17] that is,

$$\hat{b} = \lambda i \tag{3.3}$$

which implies that consumption in period 2 is

$$\hat{c} = R\hat{k} + (\hat{b} - \lambda i) - f = R(w - \lambda i) - f \tag{3.4}$$

(It is easy to show that the equality in 3.3 must hold). Note that $\hat{c}$ is not only total consumption in period 2 but also the expected utility of depositors.

One still has to check that the incentive constraint $\hat{c} \geq i$ is satisfied, or

[16] Lucky agents cannot, however, withdraw i in period 1 and c in period 2. The implicit assumption is that types become public information at the beginning of period 2.

[17] It it were optimal for the bank to plan not to shore up bad investments, it would be optimal to set $b = 0$. Total consumption in period 2 (and also ex ante utility) would then be given by $[(1-\lambda)R + \lambda r]\, w - f$. But assumption A.1 in the appendix (necessary so that agents in autarky choose to be liquid) implies that this is less than $\hat{c}$ as defined by 3.4.

$$i \leq \frac{Rw - f}{1 + R\lambda} \tag{3.5}$$

which we assume from here on.

One can now check that $\hat{c}$ is greater than optimal consumption under individual autarky (the latter is derived in the Appendix). The bank improves matters over autarky; the reason is that the bank faces no uncertainty, and hence may plan to hold less liquidity than an individual in isolation.[18]

The optimal bank allocation differs from the autarky solution along several other dimensions. In particular, since the current account deficit in period 0 is given by $k - a$ and the amount k devoted to illiquid investments is larger under a bank, it follows that financial intermediation enlarges that deficit. It also changes the net foreign asset position of the economy as a whole. In period 1, the net foreign asset position is given by $b - f$; since financial intermediation reduces the amount b held abroad, the net foreign asset position is smaller with a bank than in autarky.[19]

3.2. Demand deposits and illiquidity

The previous subsection identified the best allocation that the coalition of depositors can achieve in principle. In practice, the bank may rely on alternative systems to attempt implementing the social optimum. Following much of the literature, the rest of the paper is concerned with the study of one such system, which we call *demand deposits*. Our focus on

[18]Compare 3.3 and A.2 in the Appendix.
[19]These assertions follow from the Appendix.

demand deposits makes sense not only because they are often observed in reality, but also because, as we shall see, they are able to implement the social optimum.

Given the optimal allocation $(\hat{c}, \hat{k}, \hat{b})$, a demand deposit system is a contract that works as follows. Each depositor agrees to surrender her endowment and her borrowing capacity to the bank at time 0. In period 1 she may withdraw i from the bank on demand, so that she can shore up her illiquid investment if necessary. (This resembles actual demand deposits in that depositors may withdraw i at their discretion.) In period 2, depositors have the right to withdraw $\hat{c}$, provided they have not absconded.

To finance its operations, the bank borrows f in period 0, invests $\hat{k}$ in the long-term asset and $\hat{b}$ in the world liquid asset. We shall assume, for the time being, that foreign debt contracted in period 0 is due for repayment in period 2 at a contractual interest rate of zero; the significance of this assumption will be discussed at the beginning of the next subsection. The bank agrees to use $\hat{b} = \lambda i$ to finance period 1 withdrawals, and $R\hat{k} = R(w - \lambda i)$ to repay the external debt and service withdrawals in period 2.

We impose two additional assumptions on this system. First, in period 1 the bank must service depositors on a "first come, first served" basis.[20] In period 1 depositors visit the bank in random order. Upon arrival to the bank, and assuming the bank is open, each depositor may withdraw i on demand. To service withdrawals, the bank liquidates its world asset $\hat{b}$ until exhausted, and then it proceeds to liquidate long-term investments. If all assets are liquidated while there are agents still in line attempting to withdraw, the bank goes

[20] Wallace (1996) derives this *sequential service constraint* from more primitive assumptions on the environment.

bankrupt and closes. Second, if the bank did not close in period 1, in period 2 output (if any) is collected, depositors and foreign creditors are paid, and any surplus is distributed to depositors. We shall assume that, in period 2, the bank services first those depositors that did not withdraw i in period 1. [21]

In the *demand deposit system* just described, depositors face a strategic decision of how and when to withdraw. In other words, depositors are engaged in an anonymous game, whose equilibria naturally characterize the outcomes of the system. We are now ready to describe those outcomes.

A first result is that the demand deposit system has an *honest* equilibrium, in which all depositors withdraw according to their true types, the bank honors all of its commitments to foreign creditors, and the socially optimal allocation is obtained. The intuition is simple. By construction, the demand deposit system is feasible if depositors act honestly. Then the incentive compatibility constraints ensure that lying about shocks and absconding cannot be profitable for lucky depositors.

The previous result implies that the demand deposit system can decentralize the preferred allocation. But this is not the only possibility. The problem is that, because holding liquidity is costly, the bank may choose to become illiquid in the short run (i.e. in period 1) in the sense that

$$\hat{b} + r\hat{k} < i \tag{3.6}$$

[21] For instance, suppose that in period 1 each depositor can either stand in line at the bank or walk to the "next day's" line and wait there.

This *international illiquidity* condition says that the *potential* short-term obligations of the bank may exceed its liquidation value. International illiquidity is crucial since it is necessary and sufficient for a *bank run* equilibrium to exist.

To see that international illiquidity is a sufficient condition for the existence of a bank run equilibrium, observe that a bank run occurs when all depositors withdraw i and lucky ones abscond. Given 3.6, this behavior will force the bank to liquidate all assets and close. As a consequence, depositors will not be paid anything in period 2, which in turn implies that it is individually optimal for each of them to run on the bank. Conversely, if 3.6 fails, then the bank will not exhaust its resources even if all depositors collect i in period 1. This, together with the assumption about seniority of claims, implies that lucky depositors that wait until period 2 will be able to collect at least the promised $\hat{c}$ from the bank. But then it cannot be individually optimal for them to participate in a run. [22]

Since 3.6 is equivalent to

$$r \leq \frac{(1-\lambda(1-r))i}{w},$$

a bank run will be possible if and only if liquidation of the long-term asset is sufficiently costly.

In short, a demand deposit system may emerge in this economy as a collective attempt to implement the social optimum. The system may succeed in this purpose if every depositor believes that all others will behave honestly. However, the system may also fail: self-fulfilling

[22] A formal proof is as follows. Let λ^r be the fraction of depositors reporting bad luck; in a run, $\lambda^r > \lambda$. The bank will be forced to liquidate $l = (\lambda^r - \lambda)i/r$ units of $\hat{k}$ in period 1. The bank will be able to repay $\hat{c}$ to the $(1-\lambda^r)$ depositors that wait if $R(\hat{k} - l) \geq (1-\lambda^r)\hat{c}$, or if $R\hat{k} \geq R(\lambda^r - \lambda)i/r + (1-\lambda^r)\hat{c}$. But this must be the case if 3.6 fails.

bank runs are possible because the social optimum may imply international illiquidity.

As we argued at the outset, in this model illiquidity and insolvency are closely related. We have stressed that a certain illiquidity condition must be satisfied for run to occur. But in that case the runs are self-fulfilling precisely because they lead to insolvency. Bank creditors who do not run (or who cannot run, like external creditors) get nothing in period 2 because all bank assets have been liquidated. And it is precisely the costly nature of this liquidation that turns an illiquid bank into an insolvent one.

3.3. The probability of crises

In the preceding subsection we ignored the fact that, if a bank run occurs, the external debt contracted in period 0 is defaulted on. This is consistent with our earlier assumption of zero interest rates on foreign borrowing only if foreign creditors believe, at $t = 0$, that a crisis will occur with zero probability. The analysis of the previous section may need to be modified if creditors are rational and crises occur with positive probability when they are possible. More generally, while we stated that runs may take place, we did not discuss the probability of such runs nor the effects that such a probability may have on the bank's problem.[23]

How to deal with this issue is controversial; our strategy follows Cooper and Ross (1998). We postulate the existence of a publicly-observed random variable that takes the value 1 with probability $p \in [0, 1]$ or 0 with probability $1 - p$. The nature of that random variable is arbitrary but immaterial, as long as depositors and creditors may condition their behavior

[23]In this subsection we keep the assumption that all foreign debt contracted in period 0 is due in period 2. This is only to simplify the exposition, but in fact the distinction between short term versus long term debt has been crucial in recent crises. We deal with that issue in the next section.

on its realization; however, we assume that payments promised at $t = 0$ cannot be made contingent on it. We also assume that p is sufficiently small so that $R(1-\lambda)(1-p) > 1$. Otherwise, the long-term asset is insufficiently productive (in an expected value sense), and it is optimal to invest everything in the liquid world asset.

The bank's problem is now to choose an allocation (c, k, b), to maximize the expected utility of its representative depositor taking into account the following observations. First, the allocation must be feasible if there is no crisis. Second, the allocation will determine whether or not a crisis can occur. The results of the previous section imply that a given allocation may result in a crisis if and only if

$$i > b + rk, \tag{3.7}$$

in which case we assume that a bank run occurs with probability p.

Second, if a bank run occurs, not every depositor will collect what she is owed by the bank. Our assumptions imply that in a run each depositor will be served (and thus be able to withdraw i) with probability $(b + rk)/i$.[24]

Finally, if a bank run occurs, foreign loans contracted in period 0 will be defaulted on. This implies that foreign creditors will demand an interest rate greater than zero on these loans in order to compensate for the probability of default. Denoting the interest rate on

[24]This follows since only a fraction $(b + rk)/i$ of all depositors will be served. Hence the probability that a particular depositor will be served equals the probability that a uniform $[0, 1]$ random variable is less than or equal to $(b + rk)/i$.

two-period loans to the bank by r_ℓ, it is readily seen that

$$r_\ell = \begin{cases} p/(1-p) & \text{if 3.7 holds,} \\ 0 & \text{if not} \end{cases} \tag{3.8}$$

In this simple model, the solution of the resulting problem is straightforward if p is small enough. If an allocation satisfies $b = \hat{b} = \lambda i$ (so that bad investments can be shored up) and 3.7 (so that a run is possible), period 2 total consumption conditional on no run taking place is

$$R(w - \lambda i) - (1 + r_\ell)f = \hat{c} - \frac{pf}{1-p} \tag{3.9}$$

and, hence, the expected utility of such an allocation is

$$\begin{aligned} c^* &= (1-p)\left[\hat{c} - \frac{pf}{1-p}\right] + p(\frac{b+rk}{i})i && (3.10) \\ &= (1-p)\hat{c} + p(\hat{b} + r\hat{k} - f) && (3.11) \end{aligned}$$

Note that c^* converges to $\hat{c}$ as p goes to zero, as should be expected.

On the other hand, runs will no occur if the inequality in 3.7 is reversed. This requires holding liquid assets at least as large as

$$b^{**} = \frac{i - rw}{1-r} \tag{3.12}$$

Since $b^{**} > \lambda i$ for r small enough, the expected utility of such a run proof allocation is

$$c^{**} = Rw - (R-1)b^{**} - \lambda i - f$$

Therefore, the bank will invest the socially optimal levels $(\hat{b}, \hat{k})$ and promise a last period payment of $[\hat{c} - fp/(1-p)]$ to depositors, leaving itself vulnerable to a run, if $c^* > c^{**}$. This requires the probability of a crisis to be less than

$$p^* = \frac{[i(1-(1-r)\lambda) - rw]\,(R-1)}{(1-r)\,[(R-r)\,(w-\lambda i) - \lambda i]} \tag{3.13}$$

A run will occur with probability p if and only if $p < p^*$.

It follows that the analysis of the previous subsection remains essentially valid if p is small enough. In this simple model, in fact, the bank's investment decisions will be exactly the same as with $p = 0$; hence, for the analysis of many questions it is legitimate to proceed as if p were in fact zero. On the other hand, allowing p to be positive will turn out to be informative in the analysis of some issues, such as the determination of asset prices and the structure of interest rates. We will exploit these degrees of freedom in the exposition that follows. It is to be understood that results obtained with $p = 0$ will carry over to the case in which p is small but strictly positive.

3.4. Why this model?

We now have a simple framework with some desirable attributes:

- Holding liquidity is costly, and international illiquidity emerges endogenously as the optimal response of agents to their environment. The consequence is that "bad equilibria" caused by self-fulfilling pessimistic expectations are possible.

- Financial institutions may choose to leave themselves illiquid and therefore vulnerable to crises even if such crises happen with positive probability. This does not imply that illiquidity and crises are always an inevitable outcome of an optimal plan: as we show below, distortions can affect allocations and hence vulnerability to crises.

- Domestic banks have two types of creditors: domestic depositors and foreign lenders. The interaction between them can give rise to a rich set of outcomes, with the size and maturity of loans from abroad mattering a great deal. This is particularly important in light of the recent Asian experience, in which capital inflows were large before the crisis and a "run" by foreign creditors triggered much (but not all) the trouble faced by domestic banks.

- Crises have real effects, unlike first and second generation models. Costly liquidation (or, more generally, projects that are left unfinished or not undertaken because of lack of funding) can cause illiquid banks to suffer real losses and become *de facto* insolvent.

- Government policy can matter here in two ways. First, policy can conceivably help agents relax some of the constraints placed by the environment –for instance, by using the government's power to tax and borrow, making resources available to the bank when they are needed most. Second, policy can attempt to offset distortions that lead to "too much borrowing" or "too little liquidity," if any exist.

Next we put this model to work for the analysis of several issues related to emerging markets crises.

4. Debt maturity and capital flows

Most accounts of the Asian crisis stress the role of short-term debt.[25] Countries affected were peculiar in that their foreign debts were mostly of short maturity, and crises occurred when foreign creditors panicked and refused to roll over their short-term loans [26]. Furman and Stiglitz (1998) write: "The ability of this variable, by itself, to predict the crises of 1997, is remarkable."

Banks and governments in emerging markets often justify their tendency to borrow short term "because it is cheaper." This sounds sensible enough. But the term structure of interest rates is determined by the riskiness of different debt maturities, and these should in turn reflect the possibility of a crisis associated with illiquid portfolios. Consequently, the role of short-term debt in generating a crisis can only be analyzed in a model of the *simultaneous* determination of debt maturity and the term structure of interest rates. In this section we propose one such model and derive its policy implications.[27]

[25] Among them Corsetti, Roubini and Pesenti (1998a), Radelet and Sachs (1998) and Furman and Stiglitz (1998).

[26] For arguments of this sort in the context of the Asian crisis, see Radelet and Sachs (1998) and Chang and Velasco (1998c).

[27] This section largely follows Chang and Velasco (1999), except for the analysis of externalities which is new. Obstfeld (1994) has also discussed the role of debt maturity in generating self fulfilling crises, although he did not endogenize the choice of maturity.

4.1. The term structure of interest rates

Consider the model of the previous section, now allowing the bank to take both short and long-term debt. Let d_ℓ be the amount the bank borrows for two periods starting in period 0, and d_s the amount it borrows for in period 0 to be repaid with interest in period 1; of course, under appropriate conditions this loan can be rolled over in period 1. The two amounts must satisfy the credit ceiling

$$d_\ell + d_s \leq f \tag{4.1}$$

We know from 3.8 what the contractual return is on two-period loans. What about r_s, the contractual return one-period loans? If the loan is renewed in period 1, the net interest rate must be zero. But starting in period 0 for loans repayable in period 1, two cases are possible. If the bank chooses an allocation in which a run is not possible, there is zero probability of default and r_s must be zero. But if the allocation is such that a run may happen, lenders may not receive full payment, and this will be reflected in the interest premium they charge. The seniority of claims in the event of a run will determine the size of this premium. For the sake of brevity, we study here only the simplest case in which all short-term claims are equally senior in period 1: in the event of a run domestic depositors and foreign creditors all "get in line" at the bank, with their place in line being determined randomly.

Given any allocation, total liquid resources available to the bank in the event of a run equal $b+rk$. A straightforward extension of the analysis of the previous section implies that a run is possible if and only if

$$i + (1 + r_s)d_s > b + rk \tag{4.2}$$

which is the appropriate international illiquidity condition.[28]

If a run is possible, it will happen with probability p, and in that case each short-term creditor will collect the promised repayment only with probability

$$q = \frac{b + rk}{(1 + r_s)\, d_s + i} \tag{4.3}$$

Since creditors are risk neutral and have a zero opportunity cost of funds, r_s will be determined by the condition that the expected net return on a short loan be zero. That is,

$$(1 + r_s)\,(1 - p + pq) = 1 \tag{4.4}$$

This implies that if a crisis is possible, $r_s < p/(1 - p) = r_\ell$. Hence a *term structure* of interest rates emerges endogenously, and in this term structure short-term debt is less expensive (in the contractual sense) than long-term debt. The intuition is that, in the event of a crisis, the default on long debt is complete, while under our assumptions short debt will be at least partly honored.

[28]For the "only if" part, we modify the seniority assumption of subsection 3.2 in a natural way: if the bank is alive in period 2, it honors first the claims of those depositors and foreign short term creditors that did not collect in period 1.

4.2. Endogenous maturity structure

The bank's problem is now to choose its investment portfolio and the optimal maturity structure of its foreign debt in order to maximize the welfare of its representative depositor. The analysis of this problem reduces to that of two simpler subproblems. First, suppose that the bank had to solve the above problem respecting the additional constraint that no crises be possible. Then the constraint $i + d_s \leq b + rk$ would have to be respected. Since it is easy to see that the implicit cost of that constraint is minimized by setting $d_s = 0$, the value of such subproblem would just be given by c^{**}, as derived in subsection 3.3. Note that the subproblem, and hence c^{**}, do not depend on p.

Alternatively, suppose that the bank had to choose an allocation consistent with crises. In that case, it can be shown that it is optimal to set again $b = \hat{b} = \lambda i$, and $\hat{k} = w - \lambda i$. If no crisis occurs, therefore, total period 2 consumption will be given by $R\hat{k} - (1+r_s)d_s - (1+r_l)(f - d_s)$. Hence the value of this subproblem is

$$\bar{c} = Max_{d_s}\ (1-p)\left[R\hat{k} - (1+r_s)d_s - (1+r_l)(f-d_s)\right] + pqi \qquad (4.5)$$

subject to 4.3 and 4.4.

Clearly the overall bank's problem can now be solved by solving the above two subproblems and comparing their values. This implies that the value of the bank's problem is given by the maximum of $\bar{c}$ and c^{**}. But $\bar{c}$ must be at least as large as c^{*} as derived in subsection 3.3; hence it must also be larger than c^{**} for p small enough. In other words, for p small the best allocation will be such that a crisis is possible, and we shall focus in that case.

What is the optimal level of short-term debt when the bank chooses to make itself vulnerable? In this simple model with linear preferences and technology, the answer is simple (in fact, too simple): $\bar{c}$ turns out to be the same for all d_s in $[0, f]$, and hence the optimal debt structure is indeterminate.[29] The intuition is that, while short-term debt is contractually less expensive than long-term debt, the cost difference only compensates foreign creditors for the partial defaults associated with the two kinds of debt. As a consequence, the choice between short-term debt and long-term debt is immaterial for final consumption, which coupled with risk neutrality explains the result.

However, if the model is amended so that domestic residents are even mildly risk averse, optimal debt maturity is pinned down: we show in the Appendix that the bank will find it *strictly* optimal to set $d_s = 0$. The intuition is that, while the choice between short and long-term debt does not affect expected consumption, it changes the allocation of risk. Taking short-term debt increases expected consumption conditional in a crisis not happening at the expense of reducing the probability that domestic depositors will be served when a crisis happens. This is cannot be optimal if depositors are risk averse.

It follows that, in this model, short-term borrowing is indeed suboptimal. How can one reconcile this result with the observed bias towards short-term borrowing emphasized in the recent literature? One possibility is that the bias towards short-term borrowing reflects some distortion not captured by our assumptions. We discussed this next.

[29] The determination of $\bar{c}$ and of the optimal debt maturity is analyzed in the Appendix.

4.3. Market failure

There may be many reasons why debt choices by individual borrowers might be distorted, so that private and social incentives do not coincide. One of them is that individual borrowers fail to take into account the fall in country risk ratings that may result from their own higher borrowing. A related reasons is that, because of informational limitations, foreign lenders cannot distinguish across borrowers from the same country, and treat them all as equally risky. Indeed, the policy of *sovereign ceilings* followed by rating agencies, in which no single company can have a rating higher than the government of its country, suggests that this may well be so.[30]

To illustrate, consider a simple case in which the short maturity of foreign debt is due to the fact that banks fail to internalize the social effects of reducing their liquidity. Suppose that there are not one but many banks, each of which solves the same problem as in the previous subsection but with one crucial difference: each banks takes the interest rate r_s (instead of the arbitrage condition 4.4) as given in its optimization problem. Of course, 4.4 must hold in equilibrium.[31]

In the appendix we show that, under our benchmark assumption of risk neutrality, equilibrium requires that $d_s = f$ —that is, all debt is be *short* term. The intuition is, obviously, that if banks were indifferent as to their debt maturity structure when they correctly evaluated the cost of short-term borrowing, they must strictly prefer short-term to long-term

[30] See Furman and Stiglitz (1998) for additional reasons as well as an extended discussion.

[31] More precisely, an equilibrium of this model is given by an allocation and a short interest rate such that (i) the allocation is optimal for each bank when it takes interest rates as given, and (ii) the allocation and the short interest rate satisfy the arbitrage condition 4.4.

debt when that cost is underestimated.

This result is extreme due to risk neutrality, but the point is general: the prevalence of short-term borrowing may be reflecting an externality of the kind just discussed. If that is in fact the case, government intervention to discourage short-term borrowing is justified.[32] Our analysis implies, however, that while optimal intervention would reduce short-term borrowing, it would *not* eliminate the possibility of crises: if policy was successful in eliminating the effect of the externality discussed here, it might be still optimal for banks to choose an internationally illiquid allocation and be subject to crises.

4.4. Policy implications: crisis prevention

Given that short-term debt is a potential cause of liquidity problems, and if there is "too much" of it because of the kind of market failure just discussed, there may be a case for policies that lengthen the maturity of that debt. A natural candidate is tax on short-term capital inflows, such as that used by Chile and Colombia. Soto and Valdés-Prieto (1996), Larrain, Laban and Chumacero (1997), Cárdenas and Barrera (1997) and Montiel and Reinhart (1997) estimate that a shift in composition toward longer foreign debt maturities is precisely what the taxes seem to have accomplished in both countries. But such a conclusion is subject to two important caveats:

In our model, as in the real world, short-term debt serves some useful functions. Here, it serves to "share" some of the risk of runs between domestic and foreign creditors, and hence

[32] In this model, however, the externality causes no distortion and there is no welfare loss. This is clearly a consequence of our strong assumptions; in general, the externality will decrease welfare.

lower the contractual cost of borrowing. The same would be true in a world with stochastic shocks to exogenous variables. Alternatively, short-term debt may serve as a commitment device, as in the models of Jeanne (1998) and Rodrik and Velasco (1999). Policies that make short-term debt prohibitive, regardless of circumstance, need not enhance social welfare.

The other very important caveat is that foreigners are not the only short-term creditors. Hence, abolishing short-term debt is neither a necessary nor a sufficient condition for ruling out crises. As Krugman (1998) has stressed, that still leaves all holders of domestic claims on the commercial and central banks ready to run. Policies other than limits on short-term inflows are necessary to deal with this problem. We examine some of those policies below.

4.5. Policy implications: crisis management

Short-term debt makes a *coordination failure* among lenders possible. A main task of crisis management is to attempt to coordinate their behavior on the "good" outcome. Of course, this is easier said than done. In this model, the key is to avoid the real costs (liquidation and others) imposed by early repayment. Hence, a simple suspension of payments that preserves the present value of the creditors' claims makes everyone better off. This kind of logic leads Kenen (1998) to wonder whether in recent policy debates "there has been too much talk of the need for permanent debt workouts as distinct from short-term suspensions of debt service payments."

In practice lenders are weary of such responses. From New York or London it is hard to distinguish the payments moratoria that are justified by liquidity considerations from those that are veiled attempts at default. When in doubt, bankers are likely to suspect the latter. There is also the logistical problem of coordinating the actions of many bond-holders (the norm for most capital flows today) rather than a few banks.

But the fact that the task is hard should not keep policymakers from trying. Payments reprogrammings that are accompanied by serious macroeconomic policies and signals of orthodoxy (such as fiscal retrenchment) may prove more palatable. In Korea, for instance, American, European and Japanese banks jointly agreed in December 1997 to an orderly rollover of existing short-term loans. Major creditor countries helped by anticipating the disbursement of a fraction of the bailout package the IMF had just approved. Those two measures effectively ended the financial panic that had gripped Korea for several months.[33]

In our model, a good part of the problem comes from the bank's inability to sell rather than liquidate its illiquid assets in the event of a squeeze. That assumption is realistic insofar as, in a crisis situation, there are few domestic agents with the cash in hand to buy the real capital. But foreigners are in a different position. Everyone would be better off if through foreign direct investment liquidation could be avoided –even if the price is that of a fire sale, below the present value of capital's real yield in the future.[34] Hence, FDI should be encouraged for these purposes. Debt-equity swaps involving foreign creditors played a role in the resolution of the 1980s debt crisis, and could be useful again in the current context.

[33]This description follows Corseti, Roubini and Pesenti (1998b). They also note that the rescheduling of loans was a much more daunting task in Indonesia, where there were large numbers both on the lenders' and the borrowers' side.

[34]Because the world rate of interest is zero and one unit of healthy capital yields R units of the tradeable good in period 2, the "fundamental" price is R. But any price smaller than R and bigger than r makes the bank and its creditors better off, while giving the foreign investor an abnormally high rate of return.

Multilateral lenders can also help. They can lend "into arrears" when appropriate to strengthen confidence in the borrower's prospects. They can also encourage the adoption of clauses in international bond covenants that facilitate negotiations between debtors and creditors even when debt service is suspended. As Kenen (1998) points out, such proposals where endorsed by the G-10 back in 1995, but have yet to be implemented in full.

5. Bank regulation

In this section we study how changes in regulation or in the availability of deposit insurance can affect the banks' vulnerability to runs.

5.1. Financial liberalization

Both casual observation of recent crises and formal econometric work suggest the existence of important links between financial liberalization and crises. The econometric work of Kaminsky and Reinhart (1996) and Demirguc-Kunt and Detragiache (1998) has shown that financial liberalization precedes financial crises. Similar "stylized facts" have emerged from case studies of many notorious crisis episodes, including Chile in 1982, Sweden and Finland in 1992, Mexico in 1994, and Asia in 1997.[35]

Lowering reserve requirements on commercial banks is a common liberalization move. Mexico, for instance, lowered required reserves on peso sight deposits all the way to zero in the first half of the 1990s. The rationale is usually that such reductions enhance the

[35]See Velasco (1987, 1992), Dornbusch, Goldfajn and Valdes (1995), Sachs, Tornell and Velasco (1996b) and Radelet and Sachs (1998).

efficiency of financial intermediation. Our analysis implies that the conjecture is correct, but also that there is a side effect: lower reserve requirements increase banks' vulnerability to runs.

To fix ideas, assume that $f = 0$, and consider a polar policy of *narrow banking*, in which intermediaries are required to keep liquid assets in an amount equal to potential liquid liabilities: $b \geq i$. Clearly, no self-fulfilling runs can take place. But, at the same time, there is a loss in welfare relative to the no-run equilibrium. In fact, in this very simple model, narrow banking is equivalent to autarky; requiring it does away with all the benefits of financial intermediation (this is not necessarily true in more complex models –see Chang and Velasco 1998b). This captures in a nutshell a result that turns up several times through this paper: making yourself liquid is easy, but it is also potentially expensive. Not any policy to enhance liquidity will do.

Another popular liberalization policy is to lower barriers to entry into the banking sector (whether by domestic or foreign banks), presumably enhancing competition and efficiency. But the problem is that the additional competition may also encourage greater risk-taking by banks. Typically the argument is phrased in terms of "franchise values" which presumably fall with competition, so that banks have less to lose and therefore behave less prudently. Garber (1996), for instance, writes: "...the sudden admission of foreign banking competition into a system with low capital can further reduce the franchise value of domestic banks and lead to a crisis within a few years as domestic banks compete to retain market share."

Models like the one in this paper can deliver similar results. While we have treated the bank as a coalition of individual agents bent on maximizing their joint welfare, an alternative interpretation of our model is that the bank is a perfect competitor in a banking market into which there are no barriers 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.

To assess the effects of liberalization, one may analyze how a less competitive banking system would behave in this context. We study that question in Chang and Velasco (1998b), using a related model that draws directly on Diamond and Dybvig (1983). There we find that a monopoly bank is less prone to runs than competitive banks; the greater fragility of competitive banking arises from the larger rate of return it offers short-term depositors. Relative to competitive banks, the monopoly will reduce payments to depositors. This hurts depositors, but in general it also implies that the potential short term obligations of the bank are smaller. This means that the monopoly bank will be *less* illiquid. The implication is that enhanced competition in the financial sector may improve depositors' welfare if no runs take place, but at the same time it may make crises possible.

5.2. Deposit insurance

It is a plausible conjecture that self fulfilling crises would disappear if governments of emerging economies established adequate deposit insurance institutions. Presumably, if domestic deposits were guaranteed by the government depositors would have no incentive to run on commercial banks. In addition, this would seem to entail no cost, since the insurance funds would not be needed in equilibrium. In this subsection we examine this conjecture. Deposit insurance funds may indeed eliminate crises, provided that they are of sufficient size. But deposit insurance is not costless and may result, at best, in the implementation of a suboptimal allocation.

Here and in the rest of the paper we assume, for simplicity, that $p = 0$. Consider the simple setup of subsection 3.1, except that the government requires the bank to pay a lump sum amount z in period 0 in order to finance an insurance fund of the same size. The government agrees to keep z in liquid form, and to take over the servicing of deposit withdrawals in period 1 in case the commercial bank runs out of resources in that period; otherwise, z is returned to the bank in period 2.[36]

The bank's planning problem is the same as in subsection 3.1, except that the resources it can invest in period 0 are given by $w-z$ instead of w, and that it will anticipate a lump sum transfer z in period 2. Hence, if z is not too large, the solution is very similar as in subsection 3.1: the bank will hold just enough liquidity, λi, to keep alive the unlucky long-term assets, and invest the rest, now $k' = w - z - \lambda i$, in illiquid assets. Expected and total consumption in period 2 will now be

$$c^{+} = Rk' - f + z = \hat{c} - (R-1)z \tag{5.1}$$

The last expression implies that building the insurance fund is costly and necessarily results in a suboptimal allocation. The intuition is that the insurance fund must be kept in liquid

[36]Readers familiar with Chang and Velasco (1998a) will recognize that this definition of deposit insurance is similar to the "war chest" policy of central banks.

form, whose opportunity cost is $(R-1)$ per unit.

Assume now that the bank implements its desired allocation via a demand deposit system. If

$$b + rk' + z = \lambda i + r(w - z - \lambda i) + z \geq i, \tag{5.2}$$

it should be intuitively obvious there cannot be an equilibrium run on the bank. Indeed, in a run a lucky depositor would receive i by withdrawing i in period 1 and absconding, while she would receive c^{+} in period 2 by not withdrawing i in period 1. But then it cannot be optimal her to participate in the run. Hence an insurance fund large enough would eliminate the possibility of runs, but cannot be optimal.

It is also of interest to analyze what would happen if 5.2 failed, that is, if the insurance fund were insufficient. In that case, a run would clearly be possible, in the sense that it would be an equilibrium for all depositors to attempt to withdraw i from the bank. The interesting observation about such a crisis is that it would be expressed as a failure *of deposit insurance*, since it would be the insurance fund that would not be capable of honoring its commitments.

A related point is that, in order for deposit insurance to eliminate crises, the insurance fund must be sufficient to cover the risk of a *generalized* banking panic, not only *bank specific* risk. To see this, suppose that depositors are equally allocated not to one but two banks called A and B, and that there are two symmetric states of nature. In one state, the fraction of illiquid assets hit by a bad shock is $\psi > \lambda$ in bank A and λ in bank B, and viceversa in the other state. Hence there is no aggregate uncertainty, although there is bank specific risk. Suppose now that there is an insurance fund of size $z = (\psi - \lambda)i$ to be used to help a bank if it has to service more than λ depositors in period 1. Then, clearly, there is an honest equilibrium in which all depositors withdraw according to their true type and the insurance fund is used to help fund unlucky long-term investments. But if 5.2 fails, a bank run is clearly an equilibrium. This may be the reason why deposit insurance institutions that perform well in "normal" times seem underfunded in times of crisis.

The main conclusion: for a country to "self-insure" its banking system is possible, but costly. Can it be done better by purchasing such insurance abroad? After all, if lenders can diversify away the risk of country-specific bank runs, such insurance need not be expensive. This is presumably the logic of the Argentine policy of contracting a line of credit (for which a premium is paid annually) to be used in case of bank troubles.

The idea is appealing, but not without potential difficulties. First, if there is regional or global contagion, the risk of bank runs need not be easily diversifiable for lenders. Second, the obvious potential for moral hazard makes such contracts hard to write and enforce. Third is the issue of size: press accounts put the Argentine line of credit at U.S. $6 billion, which is a small fraction of M2. Whether larger amounts may be provided by the market at a reasonable premium is unclear.

5.3. Policy implications

Furman and Stiglitz (1998) write that "the evidence that financial liberalization increases the vulnerability of countries to crises is overwhelming." The examples we have just examined suggest precisely the same. It would seem, then, that the case for strengthening supervision and carrying out liberalization very carefully is also very strong. And indeed, one finds such advice being freely dispensed in the *post mortems* to the recent crises.

But one should not put too much stock on financial regulation alone as the panacea of crisis prevention. As we have seen, mandating institutions to remain liquid is not cheap. There is also the issue of design and enforceability of financial regulation. Regulators have been overwhelmed, and financial crises have occurred, in countries as advanced as Japan, Sweden and the United States. Why should emerging markets do any better?

And macroeconomic conditions, if sufficiently severe, can overwhelm even the best managed financial system. Developed country banks might not have survived the massive depreciations and external credit squeezes that financial institutions in Thailand, Korea or Brazil have had to face. This suggests that most financial crises are also macroeconomic. To that issue we now turn.

6. The real exchange rate

So far in the analysis, all real consequences of financial distress have come from the early and costly liquidation of investment. Interpreted in a literal sense, such liquidation can also account for only a small part of the output losses that we observe in Mexico or Thailand. A broader interpretation, which included projects left unfinished or not undertaken for lack of finance, would take us farther. But, as Krugman (1999) has argued "...the main channel though which financial panic has turned good assets into bad involve not so much physical liquidation or unfinished projects as macroeconomic crisis: companies that looked solvent before the crisis have gone under because collapsing investment has produced a severe recession, or because capital flight has led to currency depreciation that makes their dollar debts balloon..."

Accordingly, we are led to explore how our framework can be extended to account for such endogenous liquidation effects, and therefore provide a more realistic account of crises. The key, as conjectured by Krugman (1999) and earlier by Calvo (1998), is the behavior of the real exchange rate. Indeed, real depreciation may be crucial to make bank runs possible and multiply their deleterious real effects.

Take the same model as before, recalling that we are imposing $p = 0$, but adding a non-traded good. This good is produced by many competitive firms with a simple technology: a dollar invested in period 0 yields $A > 1$ of the nontradeable in period 1. This output is then stored and consumed in period 2, along with tradeables' consumption.

Firms in the nontradeable sector must borrow the dollars needed to invest in period 0 from the commercial bank. Clearly, for the bank to be indifferent between lending to the nontradeable good firms and investing in tradeable goods, the rate of interest paid by the nontradeable producers must be the same as the marginal return earned by tradeable production: R.

It follows that the profits, denominated in dollars, earned by the representative non-tradeables producer are $Ah/e - Rh$, where h is the amount invested by the typical non-tradeables firm, and e is the price of tradeables in terms of non-tradeables –that is, the *real exchange rate.* The zero profit condition ensures that this relative price is given in equilibrium by

$$\bar{e} = \frac{A}{R} \tag{6.1}$$

where overbars denote equilibrium values.

The composition of output is determined on the demand side. Assume that consumers have Cobb-Douglas preferences and allocate a fixed portion θ of total consumption expenditure in period 2 to non-traded goods, and a portion $(1 - \theta)$ to traded goods. Since resources allocated by the bank to domestic investment are $w - b$, the amount going to production of tradeables is $w - b - h$. It follows that output and consumption of tradeables is $R(w - b - h)$, while output and consumption of non-tradeables is Ah. Consumer optimality conditions then dictate that

$$\theta R (w - b - h) = (1 - \theta) \frac{A}{e} h \tag{6.2}$$

But, in equilibrium, the real exchange rate is expected to be $\bar{e} = A/R$. Inserting this value into 6.2 and solving the resulting equation implies that total investment in the non-tradeables sector is $\bar{h} = \theta (w - b)$ and, correspondingly, investment in the tradeables sector is $\bar{k} = w - b - \bar{h} = (1 - \theta)(w - b)$.

It only remains to check whether it is optimal for the bank to hold enough liquidity to shore up distressed investments in tradeables. If so, the dollar value of total expected consumption is $R(w-\lambda i)-f$; if not, it is $[(1-\lambda)R+\lambda r](1-\theta)w+R\theta w-f$. The first option dominates provided that

$$w(1-\theta)(R-r)>Ri \tag{6.3}$$

which we assume.[37] As a consequence, $\bar{b}=\lambda i$.

We conclude that investment in tradeables is $\bar{k}=(1-\theta)(w-\lambda i)$, and investment in nontradeables is $\bar{h}=\theta(w-\lambda i)$. The dollar value of total output accruing to the bank in period 2 from the two sectors, given the real exchange rate in 6.1, is therefore simply $R(w-\lambda i)$.

Consider now how this allocation can be decentralized by means of a demand deposit system, in which agents depositors surrender their endowments for the right to $R(w-\lambda i)$ dollars in period 2 plus i dollars in period 1 if unlucky. Using arguments identical to those in earlier sections one can show that, if the incentive compatibility constraint 3.5 is satisfied, there is an honest equilibrium to the game among depositors, in which everyone reports truthfully.

It is also possible to have self-fulfilling bank runs, as in earlier sections. However, there is a mechanism here that was not present before. The key observation is that the dollar resources at the bank's disposal in period 1 are its liquid asset holdings λi, plus the liquidation value of tradeables investment $r\bar{k}$, *plus* the dollar market value of the repayment of the loan made

[37] In the model with only one good the equivalent condition was $w(R-r)>Ri$, which was guaranteed by our assumptions. Here an amended version of that condition would read $(1-\theta)\lambda(R-r)w\geq[R-(1-\lambda)]i$. That would guarantee that in this two-good model agents in autarky held positive liquidity, and that so does the bank (condition 6.3 would always hold).

to non-tradeables' production. But this last quantity varies with the real exchange rate. Indeed, we saw above that a relative price of $\bar{e}$ guarantees zero profits for the borrower, which then transfers the whole value of his revenue –equal to $A\bar{h}/\bar{e} = R\theta\,(w - \lambda i)$– to the bank. At a more depreciated real exchange rate (a higher e), on the other hand, the non-tradeables firm is broke, and cannot repay the whole amount owed to the bank. Indeed, for $e > \bar{e}$ the bank will get only $(A/e)\bar{h}$ dollars, which is less than it is contractually entitled to.

Now, if there is a bank run the total supply of tradeables in the economy is only $\lambda i + r\,(1-\theta)\,(w-\lambda i)$ which, by 6.3, is smaller than the $R\,(1-\theta)\,(w-\lambda i)$ units that would have been supplied with no run. Hence, the real exchange rate is now given by a condition similar to 6.2 but evaluated at the new output and consumption levels[38]

$$e^r = \left(\frac{A}{R}\right)\frac{(1-\theta)\,R\,(w-\lambda i)}{\lambda i + r\,(1-\theta)\,(w-\lambda i)} > \frac{A}{R} \tag{6.4}$$

It follows that in a run the bank can at most have access to $A\bar{h}/e^r + r\bar{k} + \lambda i$ dollars to meet withdrawals in period 1. The illiquidity condition that is necessary and sufficient for a run to be an equilibrium is therefore

$$i > \frac{A}{e^r}\bar{h} + r\bar{k} + \bar{b} \tag{6.5}$$

[38] Notice that no consumption takes place until period 2. But all output to be consumed in period 2 reaches the public already in period 1. Hence, one can assume that all trades take place in period 1, satisfying the consumption optimality conditions that must prevail in period 2. During trade the real exchange rate e is determined.

which, using 6.4 and the definitions of $\bar{h}$, $\bar{k}$ and $\bar{b}$, can be written as

$$r \leq \frac{(1-\lambda-\theta)i}{(w-\lambda i)(1-\theta)}. \tag{6.6}$$

As in the case of the model with one good, a sufficiently small r is necessary to make self-fulfilling runs possible.

The crucial part of the argument is that the liquidation value of the bank is now *endogenous.* It depends on the real exchange rate, through the value of the loans to the nontradeables sector; in turn, the real exchange rate is determined by whether a crisis happens. This can be seen most clearly if $A\bar{h}/e^r + r\bar{k} + \bar{b} < i < R\bar{h} + r\bar{k} + \bar{b}$. In this case, a crisis can happen if and only if a real depreciation is expected in period 1.

One might have thought that the presence of non-traded goods would give the government greater latitude in dealing with crises. After all, it is traded goods that are "scarce" in period 1 when the economy is internationally illiquid. But as long as the withdrawal of size i that agents can make is denominated in tradeables, that conjecture is incorrect.[39] For instance, giving the government the right to borrow from the non-tradeables sector in period 1 does not help. The proceeds of the loan still would have to be converted into tradeable goods, because it is such goods that are needed to stop an incipient bank run. And since only $\bar{b}$ such goods are available, liquidation would still have to take place.

The main point of this section is that introducing a second good gives macroeconomic phenomena a role both in producing financial crises and magnifying their effects. In this

[39] We analyze below the case in which this liability is denominated in terms of non-tradeables.

setup, the coefficient θ is the share of the traded sector in the economy. Since this is also the sector in which capital is illiquid, θ is also a proxy for the extent to which liquidation is the source of the real costs of a financial crisis. The coefficient θ does not to be particularly large for 6.6 to be satisfied and crises to be possible.[40] This implies that a good chunk of the fall in bank income in a crisis may come from the real depreciation and the resulting bankruptcy of non-tradeables producers, and not from the physical liquidation of assets.

From a modelling point of view, real effects here result from the interaction of a financial sector inefficiency and the behavior of the real exchange rate. In that sense, this model is similar to those by Calvo (1998) and Krugman (1999). The only difference is in the assumed financial problem: Calvo assumes bankruptcy costs and Krugman collateral constraints, while we have costly liquidation in the tradeable sector.

6.1. Policy implications: crisis prevention

Forcing domestic banks that borrow in dollars to lend in the same currency is a popular way to minimize risk. Our analysis suggests that policy is largely useless. In the preceding subsection, all bank borrowing and lending was in terms of tradeable goods (loosely, in terms of foreign currency), but that did not insulate the bank. The reason is that the real devaluation risk is simply passed on to firms in the nontradeable sector, who default partially on their loans when the relative price of their output falls unexpectedly.

What would work in this context is to have both loans to the non-tradeable sector and

[40] For instance, 6.6 shows that if $r = 0$, it is sufficient that $\theta > 1 - \lambda$.

at least some bank liabilities denominated in terms of the non-tradeable good. To see this more formally, imagine that the contract now requires the bank to pay unlucky depositors the tradeables equivalent of $\bar{e}i$ units of non-tradeables. That is to say, the portion of the contract covering period 1 payments now denominates these withdrawals in non-tradeables but continues to make them payable in tradeables. Clearly, this does not affect the properties of the honest equilibrium: a measure λ of depositors still withdraw $\bar{e}i/\bar{e} = i$ units of tradeables, which allows them to restore damaged investments. But, as one can readily show, the illiquidity condition for a run equilibrium to be possible changes to

$$i\frac{\bar{e}}{e^r} > \frac{A}{e^r}\bar{h} + r\bar{k} + \bar{b} \tag{6.7}$$

Since $(\bar{e}/e^r) < 1$, the preceding condition is more stringent than the one for the case in which allowable withdrawals are denominated in tradeables, 6.5. Hence, changing the denomination of bank liabilities makes the bank less vulnerable to a run.

The intuition is simple: in the event of a run the relative price of non-tradeables falls, which reduces the number of units of tradeables the bank must hand over to those who visit in period 1. Notice that this logic could be extended to foreign debt contracts, which we have neglected to consider here. If foreign loans were denominated in terms of non-tradeables, their service cost would also fall in the event of a run-induced real depreciation, further alleviating the liquidity position of the bank.

How to achieve this in practice? One possibility is to restrict the domestic bank to borrow only from local lenders. This is plausible if national savings are high and the domestic capital market deep (Chile is often lauded on these grounds, partly because of its privatized pension system). But capital-poor emerging economies will still typically want to run current account deficits and import capital from abroad; if banks are not allowed to do this, someone else (like Indonesian corporates) probably will. An alternative is to encourage foreign lenders to lend in domestic currency, and hence share with local borrowers some of the exchange risk. Loans in nominal pesos are unlikely, but loans indexed to the domestic price level have more of a ring of plausibility. Again, Chile has made some progress along these lines, encouraging a nascent market for indexed foreign loans.

6.2. Policy implications: crisis management

In this model the real exchange rate depreciates because output and consumption of tradeables falls relative to that of non-tradeables, so the relative price of the former must rise. The best way to deal with this, of course, would be to get real resources to the hands of the bank before it liquidates its investment, thereby preventing the fall in tradeables' output. An equivalent policy would be to extend emergency non-bank loans of credit to firms in the tradeable sector, so that they could repay their loans to local banks without having to cut down trees or padlock factories.

In practice neither policy is likely to be very useful. Getting the money to the right place quickly enough is difficult. Informational asymmetries (why would foreign banks lend to firms that are being refused local credit?) and the potential for moral hazard make matters even more complicated.

Straight balance of payments support might be easier and just as effective. The problem here is that local output of tradeables falls and so does their consumption. But tradeables can also be imported, propping up consumption levels and hence avoiding real depreciation. Foreign lenders and multilaterals may frown at the thought of emergency loans to finance consumption, but in that context that is exactly what is needed. And a penny of support may do a pound of good: high levels of tradeables consumption prevent bankruptcies in the non-tradeables' sector, and prevent a harmful multiplier effect from kicking in.

7. Government debts and deficits

In the so called "first generation" models of crises (Krugman 1979), balance of payment crises were ultimately caused by ongoing fiscal deficits. However, fiscal accounts were essentially in balance before the Mexican 1994 and the Asian 1997-98 crashes, and hence "first generation" models have fallen a bit out of fashion. This does not mean that fiscal debts and deficits are irrelevant to recent crises but, instead, that the relevant channel is not what the earlier literature stressed. The channel from deficits to crises runs not through the monetization of government financing gaps; the problem has more to do with the effects that government debt –especially if short-term– has on the overall liquidity position of the country's financial system. Calvo (1995) was the first to recognize this.

The role of the infamous Tesobonos in the Mexican 1994 crisis –upon which Calvo's observations were based– is now well known; a more recent example is Brazil. Bevilaqua et al. (1998) report that by year-end 1996, the Brazilian government had approximately

US \$150 billion in outstanding domestic securities, with an average maturity of 180 days. While data on the precise maturity structure is not available, this number alone is cause for concern: on average, US \$75 billion had to be rolled-over by the Brazilian government every semester. By contrast, international reserves were only slightly above US \$58 billion at the end of 1996. This potentially explosive situation suggests why Brazil was the Latin economy hardest hit by the reverberations of the Asian meltdown in the second half of 1997. In November of that year a speculative attack against the real forced the authorities to increase interest rates to 42 percent (at a time when domestic inflation was running at less than 5 percent per annum) and to announce cuts amounting to 2 percent of GDP from the government budget. The cuts were never implemented and the astronomical real interest rates created a sharp monetarist arithmetic problem. A second and more dramatic package was launched in late 1998, this time with IMF blessing, but the currency collapsed anyway in January 1999. At the time of writing, real interest rates remain high, and debt dynamics are still explosive or close to it. Domestic debt has risen to over 54 percent of GDP. With massive rollovers necessary every month, Brazil remains vulnerable.

Suppose that the government has to raise some funds in period 0. Specifically, suppose that it needs to finance some expenditure that costs g dollars, and it has decided to hold x dollars in liquid form –say, for deposit insurance purposes– that will be transferred to the commercial bank if there is no need to fight a run.

One way to finance the required amount $T = (g + x)$ is to tax domestic residents in period 0. From the viewpoint of the commercial bank, its planning problem is the same as in subsection 3.1, except that the resources that it can invest in period 0 are given not by w but by $w - T$, and that the bank will receive a transfer x in period 2. It is not hard to show that the expected utility for consumers of this option is

$$c_a = R(w - T - \lambda i) - f + x = \hat{c} - (R-1)x - Rg$$

Relative to the social optimum $\hat{c}$, this option implies a cost of holding liquidity, $(R-1)x$; in addition there is the cost of paying for government expenditure, Rg.

Suppose now that there is an alternative: the government can borrow T in international markets. In order to repay its debt, suppose that the government can levy a tax, whose rate is τ, on the return to long-term investment in period 2. The commercial bank's problem is the same as in subsection 3.1, except that the perceived return to long-term investment is $R(1-\tau)$, instead of R, and that it will receive a transfer x in period 2. Hence expected consumption will be

$$c_b = R(1-\tau)(w - \lambda i) - f + x \tag{7.1}$$

Now, for the government to be able to repay its debt, it must be that

$$\tau R\hat{k} = \tau R(w - \lambda i) = T \tag{7.2}$$

Combining the two previous expressions we obtain

$$c_b = R(w - \lambda i) - T - f + x = \hat{c} - g, \tag{7.3}$$

implying that $c_b > c_a$. Hence it is efficient for the government to borrow in order to finance its needs in period 0.

We have, therefore, a situation in which it is good for the government to be in deficit. However, a crucial point is that, while fiscal deficits may not be bad per se, they may create problems because of their *financing.* To see this, suppose that the government borrows a fraction σ of the T dollars needed in period 0 as a short-term loan. The reader can check that, if all foreign creditors roll over their loans in period 1 and all depositors withdraw honestly, there is no panic and consumption is given by 7.3. However, suppose that foreign creditors refuse to roll over their loans to the government, and that domestic depositors also panic. Then, if

$$i + \sigma T > x + \hat{b} + r\hat{k}, \tag{7.4}$$

expectations of a crisis must be self fulfilling: all assets of the economy will be liquidated, and the commercial banking system will become bankrupt.[41]

Why would foreign creditors stop lending to the government? Because the crisis implies that all of $\hat{k}$ will be liquidated in the period 1, and hence there will be no fiscal revenue in period 2. In order words, the expectation of a fiscal crisis would trigger the refusal of foreign lending, which itself creates the fiscal crisis.

This all assumes that the crisis happens with zero probability. If it happened with positive probability, then risk-neutral foreign lenders would ask to be compensated for the loss in the

[41]We are making an implicit assumption that in period 1 the government and the commercial bank's balance sheet can be effectively consolidated. Such would be the case if, for instance, the government were able to tax the bank in period 1 in order to finance the difference between T and x.

event of run. Contractual interest rates on loans to the government would exceed world rates –again, we would have a term structure of interest rates, and high rates all around. None of which, of course, bodes well for stability. High rates increase the servicing cost of debt, and can easily lead to a monetarist arithmetic problem (in fact, this is a plausible interpretation of Brazil's recent travails). But if the government tries to lower servicing costs by resorting to short-term debt (increasing σ), vulnerability is increased.[42]

One other aspect deserves attention. Condition 7.4 may be satisfied even if the insurance fund x seems sufficient to cover systemic risk, that is, 7.4 and $i \leq x + \hat{b} + r\hat{k}$ may hold simultaneously. In this case, a crisis cannot be possible unless foreign creditors refuse to roll over their short-term loans.

7.1. Policy implications: crisis prevention

The strongest implication of the preceding analysis is that the fiscal authority's short-term debt position should be taken into account when trying to measure the degree of potential illiquidity of a country. Measures like M2 over reserves or short-term private debt over reserves typically fail to do this. By late 1994 Mexico had U.S. $29 billion in liquid Tesobonos, and only U.S. $6 billion in cash reserves (plus another $6 billion in credit lines from Nafta partners). Hence, net of government short-term dollar commitments, Mexico had negative reserves.[43]

[42]Of course, the problem would disappear if σ were zero, that is, if all government debt was long term. But the government, just as the bank whose problem was discussed in section 3 above, may find it optimal to borrrow short term.

[43]Notice that, if the exchange rate is fixed, such netting out should include all short-term public debt, not just dollar debt. This point, which was mentioned in section 2, is implied by the analysis of the next section.

7.2. Policy implications: crisis management

A very controversial point in recent discussions is the degree to which IMF disbursements should have been conditional on sharp fiscal retrenchment by the troubled countries. Many critics have accused the fund of worsening the crisis by insisting on fiscal austerity as a precondition for lending. Our model lends some support to this criticism. Suppose that T is a loan not from private creditors but from an international institution, such as the IMF. Suppose also that, in keeping with current practice, disbursement of T in period 1 is conditional on prospective fiscal discipline. In an honest equilibrium, fiscal revenue in period 2 is large, and justifies the release of the T dollars in period 1. But in a run equilibrium, tax revenue in period 2 is destroyed and T is not released. *Ex post*, it will look like the international agency's decision to withhold T was justified. But clearly the crisis would have not occurred if the agency had committed T *unconditionally*. Of course, there are many other reasons for conditionality. And fiscal adjustment may indeed be needed, especially if debt has built up and the costs of bank bailouts are mounting. But in advocating such conditionality one should be mindful of the potentially self-defeating mechanism highlighted here.

Also, the discussion in section 3 of how to deal with coordination failure by lenders remains applicable. In the event of a crisis lenders are panicking, and everyone would be better off if their actions could be coordinated. Negotiated debt rollovers and similar strategies are clearly of use here as well.

8. The exchange rate regime

Our analysis so far has abstracted from monetary considerations. Yet they are clearly crucial for policy purposes. Only after extending the model to introduce domestic currency one can discuss the proper role of central banks in providing credit, regulating the money supply, or managing exchange rates.

In this section we modify the basic model of section 3 to allow for the existence of domestic and foreign money.[44] As suggested in that section, assume that there is an international currency ("dollars"), and that the dollar price of a unit consumption in the world market is fixed at one. With this trivial extension, the analysis of previous sections can be interpreted as applicable to an economy that is completely "dollarized."[45]

In order to allow for other possibilities, assume that there is a domestic currency, referred to as "pesos." Pesos are costlessly issued by a domestic Central Bank. A demand for pesos can be introduced in several ways, but for the sake of simplicity assume here that there is a legal restriction that forces domestic banks to pay its depositors in pesos.

Since the bank's sources of funds are in dollars, there must be some arrangement by which the Central Bank provides pesos to the commercial bank. Since depositors receive peso payments from the commercial bank but need dollars to buy consumption in the world market, there must be some system by which the Central Bank sells dollars to depositors. These arrangements are what we call a *regime.* Different assumptions about the Central

[44] This section is based on Chang and Velasco (1998a).

[45] While this observation is trivial from a theoretical perspective, it has nontrivial consequences in practice, in particular for the ongoing debate on replacing Latin American currencies with the US dollar.

Bank's credit policy, or about its exchange rate policy, give rise to the study of different regimes.

8.1. A currency board

The simplest regime is a currency board. In a currency board, the Central Bank stands ready to sell or buy pesos for dollars at a fixed exchange rate, which we shall fix at one. (It is useful to think of the Central Bank as a vending machine, which gives one peso for each dollar deposited in it, and conversely.)

Given a currency board (and in fact given also the other regimes we shall study) the bank's planning problem is the same as in section 3.1. The interesting question is: how successful is a demand deposit system in implementing the social optimum in the different regimes? In order to answer it, we need to alter the assumptions of subsection 3.2 to accommodate the use of different currencies. It is simplest to modify the sequential service constraint in the following way. As in subsection 3.2, at the beginning of period 1 depositors visit the commercial bank in random order. Each depositor may, upon her arrival at the bank, withdraw i pesos on demand, assuming the bank has not gone bankrupt. The main assumption is that, after visiting the bank, depositors join a second "line," this time at the Central Bank, to exchange whatever pesos they may hold for dollars at the fixed exchange rate. The commercial bank, in turn, services withdrawals by liquidating its assets and selling the resulting revenue (which is in dollars) for pesos at the Central Bank.

Given the timing of events, the Central Bank cannot run of dollars to honor its exchange rate commitment; in other words, in a currency board there cannot be a *balance of payments crisis.* However, there may still be a *banking* crisis: as before, the commercial bank goes bankrupt in period 1 if, after liquidating all of its assets, there are still depositors in line attempting to withdraw i.

If the bank did not close in period 1, in period 2 the bank liquidates all of its investments, and repays foreign creditors and depositors; the latter are paid in pesos that the bank obtains from selling dollars to the Central Bank. Depositors then visit the Central Bank to exchange their pesos for dollars which can be used to buy consumption.

This completes the description of a currency board regime. Aside from the fact that the commercial bank pays deposits in pesos that depositors exchange back for dollars, the model is essentially the same as in subsection 3.2. As a consequence, a currency board regime implies the same outcomes as in that subsection. There is one honest equilibrium in which the social optimum is obtained. But also, there a run equilibrium in which all agents attempt to withdraw i pesos and the commercial bank goes bankrupt in period 1 if and only if the illiquidity condition 3.6 holds.

In short, the analysis of a completely dollarized economy in previous sections applies to a currency board. More important, the currency board is no panacea: while balance of payments crises are not feasible, bank crises may still occur. This is, in modern language, a conclusion that economists have known at least since Bagehot: systems that tie the central bank's hands and prevent it from printing money, also prevent it from coming to the rescue of banks at times of trouble. Under a currency board or the gold standard, the domestic banking system has no domestic lender of last resort. The price of low inflation may be endemic financial instability.

Not everyone feels this is a problem. Dornbusch (1998) has recently written: "The counter argument that currency boards or full dollarization sacrifice the lender of last resort function are deeply misguided... Lender of last resort can readily be rented, along with bank supervision, by requiring financial institutions to carry off-shore guarantees." But how exactly does one rent such a lender? We argued in the discussion on deposit insurance that credit lines Argentine-style are a step in the right direction, but they are unlikely to be large enough to cover the bulk of the liquid liabilities of a country's financial system. A currently fashionable alternative is to encourage foreign ownership of domestic banks, hoping that equity holders abroad will serve as lenders of last resort. Again, this is probably a good idea, but a completely untested one. Will Citibank U.S. ride to the rescue every time that Latin or Asian bank in which it has a 10 percent equity stake gets into trouble? Perhaps. But hanging a whole financial system's health on that conjecture seems risky indeed.

8.2. Fixed rates with a lender of last resort

The rules of a currency board prevent the Central Bank from assisting the commercial bank in the event of a run. This may suggest that crises may be avoided if the Central Bank lent enough pesos to the commercial bank to prevent its failure. There is much evidence that monetary authorities have done precisely this at times of recent trouble. The problem is that, by doing so, they have also precipitated the end of many a fixed exchange rate. Díaz-

Alejandro (1985) and Velasco (1987) argue that it was precisely a money-financed bank bailout that caused the end of the Chilean *tablita* (and then fix) of the late 1970s and early 1980s. Sachs, Tornell and Velasco (1996a) claim that it was the fragility of the banking system that prevented Mexican authorities from raising interest rates in 1994 to defend the peg. In Asia the problem recurs. Corsetti, Pesenti and Roubini (1998b) write: "Well before the onset of the crisis, several governments were engaged in an extensive policy of bailing out financial institutions. Such a policy was by itself a source of monetary creation... As it turned out, it eventually induced a continuous spiral of currency depreciations..."

To examine this issue, assume that the Central Bank grants a credit line to the commercial bank to be used in case of an attack —that is, if more than λ depositors attempt to withdraw i. In such case, the Central Bank agrees to lend, at a zero interest rate, as many pesos as needed for the commercial bank to service further withdrawals. In exchange, the Central Bank obtains temporary control over the remaining assets of the commercial bank, including the right to liquidate them as necessary to honor its exchange rate commitment. The latter assumption implies that the Central Bank is committed to defending the fixed exchange rate for as long as it is feasible.

Consider what may happen in period 1. Depositors arrive to the commercial bank in random order and may withdraw i. The bank services withdrawals first by liquidating $\hat{b}$, and then by borrowing pesos from the Central Bank. Hence the commercial bank cannot go bankrupt. After all depositors have visited the commercial bank, the Central Bank starts buying pesos back, first with the dollars bought from the commercial bank, and then with dollars obtained from the liquidation of the bank's long-term assets. If the Central Bank completely runs out of assets while there are depositors attempting to exchange pesos for dollars, it closes its window, and we say that there is a *balance of payments crisis.*

Somewhat surprisingly, this regime has essentially the *same* outcomes as a currency board. There is an honest equilibrium, that results in the social optimum and the emergency credit line turns out to be unnecessary. But also there is a balance of payments crisis equilibrium if and only if the same illiquidity condition 3.6 holds. In a balance of payments crisis, all depositors attempt to withdraw i pesos and exchange it for dollars at the Central Bank, and in which the Central Bank liquidates all of its assets and has to close its window. To see that this can be an equilibrium, suppose that all depositors withdraw i pesos and attempt to exchange them for dollars at the Central Bank. To honor its exchange rate commitment, the Central Bank will have $\hat{b}$ dollars obtained from the commercial bank; in addition, it can raise $r\hat{k}$ more dollars from exercising its right to liquidate the long-term asset. So the Central Bank will not be able to honor its commitment if i exceeds the resulting sum, $\hat{b} + r\hat{k}$; but this is precisely the international illiquidity condition 3.6.

The intuition is that, with fixed exchange rates, the ability of the Central Bank to act as a lender of last resort is limited by its own international liquidity. While the Central Bank can print pesos freely, it cannot print dollars. With fixed rates each peso is a potential dollar liability, and a balance of payments occurs when depositors realize that the Central Bank's potential dollar liabilities exceed its liquidation value.

It is remarkable that, under fixed exchange rates, the possibility of a crisis depends only on the underlying international illiquidity of the economy. It does not depend on whether the Central Bank acts as a lender of last resort, which only determines how the crisis becomes manifest: as a bank failure or a currency collapse.

8.3. Flexible exchange rates

If the combination of fixed rates and potentially unstable rates seems to be dangerous, what about a regime in which the Central Bank acts as a lender of last resort but allows exchange rates to be flexible? The easiest way to model this situation is to retain the assumptions of the previous subsection, except that there is no "line" at the Central Bank. Instead, the exchange rate is determined, after depositors have visited the commercial bank, by an auction in which the Central Bank offers some amount of reserves and depositors offer their holdings of pesos.

To be concrete, suppose that in period 1 the Central Bank fixes its supply of dollars at the auction at $\hat{b} = \lambda i$, the amount of dollars previously bought from the commercial bank. Then, if λ^r is the fraction of depositors withdrawing i in period 1, equality of supply and demand in the auction amounts to

$$\lambda^r i = E\lambda i$$

where E is the exchange rate (pesos per dollar). It follows that $E = \lambda^r/\lambda$: naturally, pesos lose value if more depositors withdraw i in period 1.

What are the outcomes of this regime? It should be intuitively obvious that honesty is still an equilibrium. Indeed, if only unlucky agents withdraw i, E must be one, and our previous arguments imply that it is individually rational for lucky depositors not to withdraw early. Hence, flexible rates may implement the socially optimal allocation.

But now a run *cannot* occur. To see this, notice that for a run to occur, λ^r must exceed λ; hence E must be greater than 1. By withdrawing i and absconding, a lucky depositor can consume $i/E < i$. But it can be shown[46] that the bank will be able to pay the promised $\hat{c}$ to each of the $(1 - \lambda^r)$ depositors that do not run. Hence it cannot be optimal for lucky depositors to participate in a run.

In short, flexible rates implement the social optimum *uniquely*. In this model, dropping the commitment to a fixed exchange rate allows the Central Bank to provide assistance to the commercial bank in case of a run, and at the same time prevent the inefficient liquidation of the long run assets of the economy. The latter ensures that domestic deposits will ultimately be honored, while the accompanying devaluation punishes early withdrawals. Rational depositors will then understand that it does not pay to run.

In a situation of potential for bank runs, flexible exchange rates appear to be a mechanism superior to fixed rates. But there are a number of qualifications to this statement. It applies only to a *regime* of floating, not to the sudden depreciation that typically happens when the authorities throw in the towel. And flexible rates "work" only if complemented by the appropriate monetary policy: in particular, the Central Bank must be willing to act as a lender of last resort.

[46] To see this, note that in period 2 the bank will have $(1 - \lambda)R\hat{k}$ dollars available from its illiquid investments. Now, $(1 - \lambda)R\hat{k} - (1 - \lambda^r)\hat{c} = (1 - \lambda)(R\hat{k} - \hat{c}) + (\lambda^r - \lambda)\hat{c} > 0$, which means that the bank will be able to pay the promised $\hat{c}$ to each of the $(1 - \lambda^r)$ agents that did not withdraw in period 1.

These results also depend crucially on the assumption that deposits must be paid in pesos. If there are no local currency claims, movements in the nominal exchange rate cannot affect their real value. This is a reason to discourage, as Sachs (1997) has advocated, the "dollarization" of deposits. Notice that flexible rates cannot help dealing with the panics of foreign creditors, since in practice foreign loans are denominated in foreign currency. The key operational question then is what are the proportions of foreign (dollar) and local (peso) claims on the local bank. If the latter are a sufficiently large share, flexible rates can be stabilizing.

9. And the rest of the world?

We have tried to provide what Feldstein (1999) terms *A Self-Help Guide for Emerging Markets.* When analyzing the effect of different policies on illiquidity and the potential for crises, we have asked not what the world can do for emerging economies, but what each emerging economy can do for itself.

But this does not mean that the rest of the world is off the hook. We have seen that the trade-offs faced by countries are unattractive and a policy regime, however stringent, is almost always potentially vulnerable to a collapse of confidence by domestic and foreign investors. This means that there is much room for what is nowadays known as the *world financial architecture* to help nations help themselves.

The absence of an effective international lender of last resort is particularly serious. If financial crises such as those in East Asia were at least partially caused by self fulfilling liquidity squeezes on banks, an international lender of last resort has a positive role in overcoming 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.

A. Appendix

A.1. Autarky

Consider a depositor who attempts to maximize long run consumption acting in isolation. She can, in period 0, borrow up to her credit limit and divide her total resources, $w \equiv a + f$, between the liquid and illiquid assets. Thus she faces the constraint 3.1 in the text.

We assume that it is optimal for initial investment in liquid assets to be enough to finance i. This requires

$$\lambda(R - r)w \geq [R - (1 - \lambda)]\, i \tag{A.1}$$

which we assume. In that case we have

$$\tilde{b} = i \tag{A.2}$$

since $R > 1$ implies that the depositor cannot profit from holding more liquidity than strictly necessary. Tildes denotes autarky optimal values; correspondingly, $\tilde{k} = w - i$. In that case, the agent's consumption will be $R\tilde{k} + \tilde{b} - f$ if lucky and $R\tilde{k} - f$ if not, which implies that her expected consumption will be

$$\tilde{c} = \lambda(R\tilde{k} - f) + (1 - \lambda)(R\tilde{k} + \tilde{b} - f) = R(w - i) + (1 - \lambda)i - f \tag{A.3}$$

A.2. Short-term Debt

Consider, first, the case of risk neutrality. As argued in the text, for small p the problem reduces to the determination of $\bar{c}$. But the maximand in 4.5 is

$$\begin{aligned} & (1-p)[R\hat{k} - (1+r_s)d_s - (1+r_l)(f-d_s)] + pqi \\ = \; & (1-p)R\hat{k} - (1-p)(1+r_s)d_s - (f-d_s) + pqi \\ = \; & (1-p)R\hat{k} - f + pq[(1+r_s)d_s + i] \\ = \; & (1-p)R\hat{k} - f + p(\hat{b} + r\hat{k}) \end{aligned}$$

where the first equality follows from the definition of r_l, the second from 4.4, and the third from the definition of q. It follows that the value of $\bar{c}$ is the same for all d_s in $[0, f]$, as claimed in the text.

Consider now the case of risk aversion. For p small, the bank's problem is to maximize

$$(1-p)u(c) + pqu(i) \tag{A.4}$$

subject to 4.4, 4.3,

$$\begin{aligned} k + b &\leq a + d_s + d_l \\ d_s + d_l &\leq f \\ \lambda i &\leq b \end{aligned}$$

$$c + (1 + r_s)d_s + (1 + r_l)d_l \leq Rk + b - \lambda i$$

and incentive constraints. The function u is assumed to be strictly increasing, strictly concave, continuously differentiable, and satisfies $u(0) = 0, u'(0) = \infty$.

This is a standard constrained maximization problem and the Kuhn Tucker theorem applies. The first order conditions for this problem can be written as

$$\begin{aligned}
(1-p)u'(c) &= \mu_2 \\
\mu_0 - \theta - \mu_2(1+r_s) + q_3[pu(i) + \gamma(1+r_s)p] &\leq 0, \quad = 0 \text{ if } d_s > 0 \\
\mu_0 - \theta - \mu_2(1+r_l) &\leq 0, \quad = 0 \text{ if } d_l > 0 \\
\mu_0 &= R\mu_2 \\
-\mu_0 + \mu_1 + \mu_2 + q_1[pu(i) + \gamma(1+r_s)p] &= 0 \\
\gamma(1-p+pq) &= \mu_2 d_s + q_2[pu(i) + \gamma(1+r_s)p] \\
k + b &= a + f = w \\
c + (1+r_s)d_s + (1+r_l)d_l &= Rk + b - \lambda i \\
\lambda i &\leq b, \quad = b \text{ if } \mu_1 > 0 \\
d_s + d_l &= f
\end{aligned}$$

where $q = q(b, r_s, d_s)$ is given by 4.3 and θ, γ, and the $\mu's$ are nonnegative Lagrange multipliers. To simplify notation, we have assumed that $r = 0$; this is not essential as long as r is sufficiently small.

The interested reader can now verify that there is a solution of these conditions such that $d_l = f$ and $d_s = 0$. The key part is to check the first inequality in the preceding set; one may proceed as follows. If $d_l = f > 0$, $\mu_0 - \theta = \mu_2(1 + r_l)$. Also, if $d_s = 0$, the fourth equality above yields $\gamma = 0$. Using these facts, the inequality in question reduces to

$$\mu_2(r_l - r_s) - q(1 + r_s)\frac{pu(i)}{i} \leq 0 \tag{A.5}$$

which, after using 4.4 and $\mu_2 = (1 - p)u'(c)$ reduces to $u'(c) \leq u(i)/i$. But this must hold, by the assumptions on u and the fact that $c \geq i$.

Finally, assume again risk neutrality but suppose that there are many banks that take r_s, not 4.4, as given. The reasoning at the beginning of this appendix implies that each bank must choose d_s to maximize

$$-(1 - p)(1 + r_s)d_s - (f - d_s) + p\frac{\hat{b} + r\hat{k}}{i + (1 + r_s)d_s}i \tag{A.6}$$

Let $F(d_s)$ denote the above expression, as a function of d_s. Now,

$$F'(d_s) = -(1 - p)(1 + r_s) + 1 - \frac{piq}{i + (1 + r_s)d_s}(1 + r_s) \tag{A.7}$$

In equilibrium, 4.4 must hold, and inserting it in the above expression we obtain

$$F'(d_s) = pq(1 + r_s)\left[\frac{(1 + r_s)d_s}{i + (1 + r_s)d_s}\right] \tag{A.8}$$

The above expression is greater than zero for any $d_s > 0$. This implies that $d_s = f$ is an equilibrium, and that it is the only equilibrium with positive d_s. Finally, d_s cannot be zero in equilibrium. While the first order condition A.8 equals zero at $d_s = 0$, $F'' > 0$ for all d_s, as the reader can verify from A.7. Hence d_s is a local minimum of F.

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Table 1
Short Term Foreign Debt/International Reserves

	Indonesia	Korea	Malaysia	Philippines	Thailand
Jun-90	2.21	1.06	0.22	3.18	0.59
Jun-94	1.73	1.61	0.25	0.41	0.99
Jun-97	1.70	2.06	0.61	0.85	1.45
	Argentina	**Brazil**	**Chile**	**Mexico**	**Peru**
Jun-90	2.09	2.63	0.89	2.24	3.87
Jun-94	1.33	0.70	0.51	1.72	0.38
Jun-97	1.21	0.79	0.45	1.19	0.50

Source: BIS, IMF

Table 2
M2 as a Multiple of International Reserves

	Indonesia	Korea	Malaysia	Philippines	Thailand
1993	6.09	6.91	2.09	4.90	4.05
1994	6.55	6.45	2.47	4.86	3.84
1995	7.09	6.11	3.33	5.86	3.69
1996	6.50	6.51	3.34	4.50	3.90
	Argentina	**Brazil**	**Chile**	**Mexico**	**Peru**
1993	3.30	1.85	1.73	4.44	1.91
1994	3.73	2.30	1.52	12.63	1.27
1995	3.64	2.22	1.75	4.37	1.31
1996	3.41	2.75	1.91	4.65	1.24

Source: IMF