A MODEL OF FINANCIAL CRISES IN EMERGING MARKETS*

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We develop a model in which financial crises in emerging markets may occur when domestic banks are internationally illiquid. Runs on domestic deposits may interact with foreign creditor panics, depending on the maturity of the foreign debt and the possibility of international default. Financial liberalization and increased inflows of foreign capital, especially if short term, can aggravate the illiquidity of banks and increase their vulnerability. The primary role of illiquidity is consistent with the existence of asset price booms and crashes and of government distortions.

I. INTRODUCTION

Recent events in Mexico, Asia, Russia, and Brazil have underscored that a satisfactory explanation of financial crises in emerging markets remains elusive. Not too long ago, the prevailing view was that crises were the inevitable outcome of ongoing fiscal imbalances coupled with fixed exchange rates. But this *first generation* view, pioneered by Krugman [1979], has fallen out of fashion because in many crises the crucial fiscal disequilibria were absent. And, as Obstfeld [1994] has argued, currency crises have sometimes occurred even though central banks had more than enough resources to prevent them: witness much of Europe in the early 1990s.

Obstfeld put forward a *second generation* view in which central banks may decide to abandon an exchange rate peg when the unemployment costs of defending it become too large. This new perspective implied that crises could be driven by self-fulfilling expectations, since the costs of defending the peg may themselves depend on anticipations that the peg will be maintained. But Obstfeld's emphasis on mounting unemployment and domestic recession, while appropriate for the ERM 1992 crisis, was at odds with the facts in Mexico in 1994 and East Asia in 1997. Asian

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countries, in particular, were growing quickly until shortly before their financial meltdown.

Instead of fiscal imbalances or weakness in real activity, recent crises in emerging markets have featured troubled local financial institutions and sudden reversals of short-term international capital flows. In most cases, the currency crashed along with the financial system.[1] This suggests that a *third generation* model of crises should assign a key role to financial structure and financial institutions, especially the domestic banking system. The purpose of this paper is to develop a model in that spirit and investigate its implications.[2]

The model places *international illiquidity,* which may result in outright collapse of the financial system, at the center of the problem. Illiquidity, defined as a situation in which the financial system's potential short-term obligations exceed the liquidation value of its assets, may emerge naturally as an optimal response of the banking system to some features of the economic environment. However, it may also make the system vulnerable to costly runs.

Any model in which financial institutions issue demandable debt, therefore placing themselves in a potentially illiquid position, is a useful vehicle for our purpose. For concreteness we focus on an open economy version of the celebrated banking model of Diamond and Dybvig [1983].[3] In that model banks are essentially maturity transformers that take liquid deposits and invest part of the proceeds in illiquid assets. In doing so, they pool risk and enhance welfare, but also create the possibility of self-fulfilling bank runs.

The Diamond-Dybvig paper focused on the microeconomics of banking; our version embeds banks in a small open economy. This allows us to analyze the role of international factors on domestic financial vulnerability and the potential for crises. We find that domestic bank runs, understood as a panic by local depositors in the banking system, may interact with panics by foreign creditors. The nature of this interaction depends on the structure of international debt and on how strongly banks can commit to

1. This is consistent with Kaminsky and Reinhart's [1999] finding that banking troubles help predict currency crises.

2. Here the focus is on the nonmonetary aspects of the problem. We address implications for exchange rates and monetary policy in our companion paper [Chang and Velasco 2000a].

3. See also Bryant [1980].

repay their international obligations. There are situations, for instance, where a run by domestic depositors can occur in equilibrium only if foreign creditors run at the same time. Such results seem relevant to recent events.[4]

In addition to clarifying the role of foreign credit, our model is useful for studying several macroeconomic questions motivated by recent crises. Below, we show that financial liberalization may increase financial fragility and the incidence of crises even though it is ex ante welfare-enhancing. We also argue that crises driven by illiquidity are consistent with observed booms and crashes in asset prices. And we show that policy distortions, of the kind widely believed to have been present in Asia, can magnify the effects of adverse shocks, causing illiquidity and crises.

While illiquid banks exist in emerging and mature economies alike, our approach may be most relevant for emerging markets for two reasons. First, banks play a much larger role in emerging than in mature economies; this observation justifies a focus on banks to the detriment of other credit mechanisms such as debt or equity.[5] Second, focusing on illiquidity is natural for emerging markets because their access to world capital markets is limited. If banks in mature economies face a liquidity problem (as opposed to a solvency one), they are likely to get emergency funds from the world capital markets. In contrast, banks in Bangkok or Mexico City typically get plenty of international loan offers when things go well but none when they are being run on by depositors. The combination of fractional reserve (and hence illiquid) banks and external credit ceilings is potentially devastating. That is the focus of our model.

The financial aspects of currency crises have been the subject of several recent contributions. In particular, Caballero and Krishnamurthy [1998] and Krugman [1999] have argued that crises occur when a country loses access to capital markets, perhaps because of collateral problems.[6] Sudden changes in

4. For instance, Radelet and Sachs [1998] convincingly argue that it was the refusal of foreign lenders to roll over short-term credit that triggered the recent Asian crisis.

5. Diamond [1997] has shown that, if there is limited participation in non-bank financial markets, banks add liquidity to the system as a whole and perform a useful function. This suggests that it is natural to expect banks to play a large role in emerging economies, where markets for debt and equity are relatively shallow and illiquid.

6. See also the related paper by Aghion, Bacchetta, and Banerjee [1998], whose focus is not currency crises but cyclical movements in output and relative prices caused by collateral problems.

relative prices (such as a real devaluation) can render international collateral insufficient, either by lowering the market valuation of domestic assets or by causing bankruptcies and the consequent destruction of collateralizable assets. The real devaluation may, in turn, be caused by a capital outflow triggered by a self-fulfilling fear of insufficient collateral; in such a case, multiple equilibria may exist.[7] In this limited sense, those papers are related to our work. However, neither Caballero and Krishnamurthy [1998] nor Krugman [1999] focuses on banks as central to currency crises.

The next section presents our basic framework, derived under the strong but convenient assumption that domestic banks are committed to repay foreign debts under all circumstances. The consequences of relaxing this assumption, and the possibility of crises driven by pessimistic expectations of foreign creditors, are discussed in Section III. In that section we also examine the key role of the maturity structure of foreign debt. Section IV analyzes the effects of financial liberalization. Section V focuses on the interpretation of asset price booms and crashes in the context of our model. The combination of policy distortions and exogenous shocks is the subject of Section VI. Section VII concludes.

II. The Basic Framework

A. The Environment

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

Domestic residents are born with an endowment of $e > 0$ dollars each. They also enjoy access to a constant returns *long-term* technology whose yield per dollar invested at $t = 0$ is $r < 1$ dollars in period 1, and $R > 1$ dollars in period 2. That is to say, the long-term technology is *illiquid*: it is very productive if the

7. A similar mechanism was anticipated by Calvo [1995], although there the source of multiplicity was not related to collateral, but to output losses in the event of bankruptcy.

investment is held for two periods, but early liquidation causes a net loss of $(1 - r) > 0$ per unit invested. Only domestic residents have access to this technology.

There is a world capital market where one dollar invested at $t = 0$ yields one dollar in either period 1 or period 2. Domestic agents can invest as much as they want in this market, but can borrow a maximum of $f > 0$ dollars. While we will treat the credit ceiling as exogenous, it could be justified by many theories of international borrowing under sovereign risk. It can alternatively be thought of as the result of domestic restrictions.

Clearly, domestic consumption will be increasing not only in e but also in f, because the long-term investment has a higher return than the world interest rate. For instance, by initially borrowing up to the credit ceiling f and investing the loan proceeds plus her endowment in the domestic technology, an agent can, after holding the investment for two periods, consume as much as $eR + f(R - 1)$ dollars in period 2.

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

Let c_1 and c_2 denote, respectively, the typical agent's consumption in period 1 if she turns out to be impatient, and in period 2 if she turns out to be patient. Then the expected utility of the representative agent is

$$\lambda u(c_1) + (1 - \lambda)u(c_2), \tag{1}$$

where $u(c) = c^{1-\sigma}/(1 - \sigma)$. Assuming CRRA preferences is stronger than we need, but yields closed-form solutions and simplifies exposition.

In this setup, the uncertainty about the timing of consumption and the pattern of asset returns are such that domestic agents would only invest in the world market if they knew they were impatient, and in the illiquid technology if they knew they were patient. A main departure from Diamond and Dybvig [1983] is that domestic agents can borrow abroad. This turns out to be a source of rich results, as will become apparent below.

B. A Commercial Bank

Clearly, the absence of aggregate uncertainty implies that domestic agents may profit from pooling their resources and acting collectively rather than in isolation. Accordingly, we assume from now on that they form a coalition, which will be called a "bank" for reasons that will be clear shortly.

The objective of the bank is to maximize the welfare of its representative member *(depositor)* by choosing an investment-borrowing strategy and a consumption stream to each depositor contingent on the realization of her type. The set of such *allocations* is restricted not only by resource constraints but also by the fact that type realizations are private information. This implies that the bank must find some way of eliciting such information.

While examining all of the bank's options would be exceedingly complex, the Revelation Principle[8] implies that attention can be restricted to feasible type contingent allocations that give no agent an incentive to misrepresent her type. As a consequence, the best allocation attainable by the bank (the *social optimum*) must solve a relatively simple *social planning problem.* Let d and b denote net foreign borrowing in periods 0 and 1, respectively, and let k be the amount invested in the long-term asset, all in a per depositor basis. The social optimum maximizes (1) subject to

$$k \leq d + e \tag{2}$$

$$\lambda c_1 \leq b + rl \tag{3}$$

$$(1 - \lambda)c_2 + d + b \leq R(k - l) \tag{4}$$

$$d \leq f \tag{5}$$

$$d + b \leq f \tag{6}$$

$$c_2 \geq c_1 \tag{7}$$

$$c_1,\ c_2,\ k,\ l \geq 0, \tag{8}$$

where l denotes liquidation of the long-term asset in period 1.

8. The Revelation Principle applied to the bank's problem ensures that the Bayesian Nash equilibria of any game that the depositors may play can be replicated by the truthful equilibria of a game in which each depositor is asked to report her types. See Myerson [1991] for an excellent introduction to the Revelation Principle.

Constraint 2 restricts long-term investment to be no larger than the endowment plus initial borrowing from abroad. The feasibility constraint in period 1 is given by (3): the bank may finance the consumption of the impatient by borrowing abroad and possibly by liquidating some portion of the long-term asset. The period 2 feasibility constraint, (4), the external credit ceiling constraints, (5) and (6), and the nonnegativity condition (8) are self-explanatory.[9]

Constraint (7) is the *incentive compatibility* or truth-telling constraint for patient agents, derived under the assumption that the commercial bank can monitor each agent's transactions with the domestic banking system but not her consumption or her world transactions.[10] By lying about her type, a patient agent may obtain c_1 dollars in period 1; given the assumption just stated, the best she can do then is to invest them in the world market to buy c_1 units of period 2 consumption. On the other hand, she is entitled to c_2 units of period 2 consumption if she tells the truth; hence (7) ensures that patient depositors will not lie.

We use tildes to identify the social optimum; its main features can be derived as follows. Clearly $\tilde{l} = 0$; that is, there is no early liquidation of the long-term investment. This should be obvious, since the bank faces no aggregate uncertainty, and premature liquidation of long-term assets is costly. Also, (3) must bind, and so $\tilde{b} = \lambda \tilde{c}_1$; as a consequence, (5) cannot bind. Now, the credit ceiling (6) must bind, which together with (2), (3), and (4) (which must hold with equality) yields

$$R\lambda \tilde{c}_1 + (1 - \lambda)\tilde{c}_2 = eR + (R - 1)f \equiv Rw, \tag{9}$$

where $w = e + f(R - 1)/R$ can be thought of as the economy's wealth.

Maximizing (1) subject to (9) now yields optimal consumption:

$$\lambda \tilde{c}_1 = \theta w, \quad (1 - \lambda)\tilde{c}_2 = (1 - \theta) Rw, \tag{10}$$

where $\theta \equiv [1 + (1 - \lambda)/\lambda R^{(\sigma - 1)/\sigma}]^{-1}$ is a coefficient in the unit interval. The solution is completed by noting that, since $\tilde{l} = 0$, (6)

9. This way of writing the constraints implicitly assumes that the bank's holdings of the world asset are zero. In this section this entails no loss of generality as long as the bank is a net debtor to the rest of the world. However, see subsection III.A.

10. Other impatient agents do not derive utility from late consumption, their incentive compatibility constraint is trivially satisfied.

and (4) imply that $\tilde{k} = [(1 - \lambda)\tilde{c}_2 + f]/R$, and that $\tilde{d} = \tilde{k} - e$, from (2).[11]

It can be shown that the value of the social planning problem is superior to the value of autarchy. This is because liquidity is less costly for the bank than for individuals, thanks to the bank's ability to perfectly forecast liquidity needs. In particular, the social optimum prescribes no long-term investments to be liquidated prematurely; in contrast, an isolated individual may plan to liquidate her long-term assets early if she turns out to be impatient.[12]

C. Demand Deposits and Bank Runs

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

Demand deposits are contracts that stipulate that, in period 0, each agent must surrender to the bank her endowment and her capacity to borrow abroad. The bank agrees to invest $\tilde{k}$ in the long-term technology and to borrow $\tilde{d}$ in period 0 and $\tilde{b}$ in period 1. In return, the agent is given the right to withdraw, at her discretion, either $\tilde{c}_1$ units of consumption in period 1 or $\tilde{c}_2$ in period 2.

We shall impose two additional assumptions on the mechanism. First, the bank must respect a *sequential service constraint* which requires, loosely speaking, that the commercial bank attend to the requests of depositors on a first come-first served basis. The existence of sequential service constraints can be justified by more primitive features of the environment, as suggested by Wallace [1996].

Second, in this section we will assume that the bank is committed to repay any foreign debt under all circumstances.

11. The solution procedure just outlined assumes that $\tilde{d} > 0$, which holds if f is sufficiently large. However, the analysis can easily be amended if that assumption fails. Note also that the incentive compatibility constraint (7) holds strictly at the optimum.

12. This is the case if $R = (1 - r)\lambda/(1 - \lambda)$. Also, one difference with Diamond and Dybvig [1983] is noteworthy. In that model, moving from autarky to the social optimum reduces illiquid investment if $\sigma > 1$ (which is the interesting case since it is necessary for the existence of runs). This is not the case here. The main reason for this difference is that Diamond and Dybvig assume, effectively, that there are no liquidation costs, so that it is a dominant choice for isolated agents to invest only in the illiquid asset.

This is mostly for the sake of clarity: while not realistic, this assumption allows us to abstract, until the next section, from the possibility of foreign creditor panics. To ensure that the foreign debt is always repaid, the bank must limit any possible period 1 liquidation of the long-term investment to[13]

$$l^{+} = (R\tilde{k} - f)/R. \tag{11}$$

As a result of these assumptions, the timing of events is as follows. In period 1 depositors arrive at the bank in random order. Upon arrival, each depositor may withdraw $\tilde{c}_1$ if the bank is still open. The commercial bank services withdrawal requests sequentially, first by borrowing abroad (up to $\tilde{b} = f - \tilde{d}$), then by liquidating the long-term investment up to the maximum l^{+}; if withdrawal requests exceed the maximum liquidation value of the bank, given by $\tilde{b} + rl^{+}$, the bank closes and disappears. Finally, if the bank did not close in period 1, in period 2 the bank liquidates all of its remaining investments, repays its external debt, and pays $\tilde{c}_2$ dollars plus any profits[14] to agents that did not withdraw their deposits in period 1.

Given the *demand deposit system* just described, depositors face a strategic decision about when to withdraw their funds; in other words, they are players engaged in an (anonymous) game. Hence the outcomes of a demand deposit system are given by the *equilibria* of such a game; an equilibrium is a description of the strategies of depositors and of aggregate outcomes such that the aggregate outcomes are implied by the depositors' strategies and each depositor strategy is optimal for her given the aggregate outcomes.[15]

We can now discuss the outcomes of a demand deposit system. A first result is that the game has an *honest equilibrium* in which each agent withdrawal decision corresponds to her true type: in period 1 only impatient depositors retire $\tilde{c}_1$ dollars, the bank does not fail, and pays $\tilde{c}_2$ to patient depositors in period 2. Verifying that honest behavior is an equilibrium entails only

13. The constraint (4) implies that l^{+} is the most the bank can liquidate in period 1 while still having enough period 2 revenue to pay back loans totaling f.

14. While the social optimum implies no bank profits, bank profits can be nonzero if the equilibrium of the game that, as described below, is induced by the demand deposit system.

15. This definition is intentionally vague. This is because we have assumed a large number of depositors, each of measure zero. An appropriate equilibrium concept must accordingly ensure that depositors view their impact on aggregate outcomes as negligible. See Schmeidler [1973].

checking that honesty is consistent with the bank's solvency (which is true by construction) and that each depositor finds it optimal to tell the truth about her type (which follows easily from the fact that the social optimum satisfies incentive compatibility).

This result clarifies the role of banks in an open economy: demand deposits *may implement the social optimum.* Banks may emerge, in particular, to improve upon what each agent could achieve in isolation.

However, the banking system may attain such an improvement only by holding *internationally* liquid assets that are smaller than its implicit liabilities. Consequently, the banking system may be subject to a *run.* In particular, suppose that all depositors attempt to withdraw their deposits in period 1, each expecting all others to do the same. That collective behavior turns out to be individually optimal, as it can be easily checked, if it forces the bank to run out of resources and fail before the bank can meet all the claims made on it. Now, if all depositors attempt to withdraw $\tilde{c}_1$ in period 1, the bank will fail if

$$z^+ \equiv \tilde{c}_1 - (\tilde{b} + rl^+) > 0; \tag{12}$$

that is, if the *potential* short-term obligations of the bank (given by $\tilde{c}_1$) exceed its liquidation value. Hence z^+ is a measure of the bank's *illiquidity* and plays a crucial role in our analysis.

The preceding argument implies that illiquidity is a sufficient condition for the existence of a run equilibrium. Since the converse can also be proved true, *a bank run equilibrium exists if and only if the bank is illiquid,* in the sense of (12).

Expression (12) is a condition on the social optimum. To obtain an equivalent condition in terms of the fundamentals of the economy, one simply replaces the values of $\tilde{c}_1$, $\tilde{b}$, and l^+ in (12) to arrive at

$$R^{(\sigma-1)/\sigma} > r. \tag{13}$$

If $\sigma \geq 1$, then (13) is always satisfied because $R > 1$ and $r < 1$ by assumption. Only if $\sigma < 1$ can runs be ruled out. Hence runs may or may not occur, but the run condition is satisfied for many plausible parameter values.

D. Summing Up

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

As in other models with multiple equilibria, which equilibrium prevails is indeterminate and may depend on extraneous uncertainty or features of the environment that would otherwise be irrelevant.[16] This implies, in particular, that in our model bank and currency crashes may come as relatively unexpected events. This is consistent with recent crises.[17] Yet runs may occur only if the financial system is illiquid. Adverse expectations are not, by themselves, sufficient for a run to occur: the fundamentals of the economy must also be "fragile."

One caveat to the analysis of this section is that demand deposits would implement the social optimum without runs if the bank suspended payments to depositors in period 1 after λ withdrawals. We believe, however, that focusing on demand deposits while ruling out such suspensions is defensible on several grounds. While demand deposits are commonly observed in practice, suspensions are not as clearly prevalent. This may be because unmodeled features of the environment, such as informational frictions, make it undesirable or too difficult to allow for payments moratoria when banks are still able to service deposits. In practice, for instance, a moratorium to confront a run may be indistinguishable from a banker's attempt to default on its commitments and must be ruled out. Moreover, suspending payments may be costly if λ is uncertain.

Ruling out suspension of payments may seem inconsistent with a different assumption of this section: that early liquidation of long-term assets cannot exceed $l^+ > 0$, which means that, in a run, the bank stops servicing withdrawals when its liquidation value is still positive. However, this assumption was made only to simplify the exposition; in fact, its relaxation implies not only that suspension of payments is less useful in our model, but also

16. A concomitant issue, first noted by Postlewaite and Vives [1987], is that the social planning problem does not take into account that a run may occur. Rational expectations then require, strictly speaking, that the probability of a run be zero. An alternative interpretation, which is more in line with Diamond and Dybvig [1983], is that the occurence of a run may depend on a "sunspot" variable. In this case, Cooper and Ross [1998] showed that the social planning problem can be taken as an approximation to the "true" problem, although then the probability of a sunspot must be small. In Chang and Velasco [2000b] we apply Cooper and Ross's arguments to extend our model to allow for sunspots, but at the cost of substantial additional complexity.

17. See Sachs, Tornell, and Velasco [1996a] for evidence that the Mexican 1994 collapse was not anticipated by investors. Radelet and Sachs [1998] argue that the same was the case in the 1997 Asian collapse.

that foreign creditors play a more active role. We now turn to this issue.

III. The Role of Foreign Credit

If the bank cannot commit to always preserve enough resources to repay its foreign debt, foreign lenders may panic in the same way as domestic depositors. In this section we examine this possibility and how the size and kind of foreign borrowing can affect the vulnerability of domestic financial intermediaries. Two factors play a crucial role. The first is the response of foreign lenders to a bank run, and in particular whether they refuse to extend new loans. The second is the maturity of external debt. We will see that, in accordance with conventional wisdom (but not to traditional academic literature), both factors affect financial fragility.

A. Ongoing Lending

Under the assumptions of the previous section, constraint (4) on the social planning problem specifically allowed it to borrow up to $f - d$ dollars in period 1 to finance the withdrawals of impatient agents. In addition, we assumed that those additional loans would be extended even in the event of a run. Because the bank was committed to liquidate capital only up to l^+, the new loans were always repaid, even if the bank failed. In other words, *ongoing lending* always took place and was rational from the perspective of foreign creditors.

In contrast, consider a scenario in which ongoing lending may fail to take place in the event of a run. Assume that the bank is committed never to liquidate its long-term assets beyond

$$l^a = \tilde{k} - \tilde{d}/R. \tag{14}$$

This liquidation limit ensures that, if a run occurs, the bank will honor its initial debt $\tilde{d}$ in period 2. Now, suppose that the bank is unable to borrow $\tilde{b}$ if a run occurs in period 1. Then, if a run occurs, the bank will be unable to service all of its depositors if

$$z^a \equiv \tilde{c}_1 - rl^a = \tilde{c}_1 - \{r\tilde{k} - (r/R)\tilde{d}\} > 0. \tag{15}$$

Since l^a is larger than l^+, $z^a > z^+$ or, in words, the run condition (15) is more stringent than (12). Hence the bank is *more* vulnerable to runs if foreign creditors fail to engage in ongoing lending in the event of a run. The intuition is, clearly, that the inability to borrow $\tilde{b}$ as planned reduces the liquid resources that the bank has access to in the event of a run.

Can it be rational for foreign lenders not to engage in ongoing lending? Suppose that (15) holds and that foreign lenders are "small." If every foreign creditor refuses to lend to the bank *and* depositors panic, the bank will have to liquidate all of the long-term asset, except what is necessary to repay the initial debt $\tilde{d}$ in period 2—and any debt above and beyond $\tilde{d}$ could not be repaid then. Hence no individual creditor will find it profitable to lend to the bank in period 1.

One implication is that the behavior of international lenders may, by itself, cause a depositors' run: if parameters are such that (15) holds but (12) does not, a run on deposits is possible *if and only if* external creditors refuse to extend additional loans in period 1. In such a case, creditors may stop lending because they fear that a bank run will occur, which makes the bank run possible.

Two aspects of this argument warrant further discussion. The first is that we have implicitly assumed that the bank waits until period 1 to borrow the resources needed to finance the withdrawals of impatient depositors. An alternative strategy would have the bank borrow the full f dollars in period 0, to be repaid in period 2, and buy $\tilde{b}$ dollars of the liquid asset, which in real-world parlance corresponds to having $\tilde{b}$ dollars of "reserves." In period 1 it would use the $\tilde{b}$ dollars to finance the consumption of impatient depositors. By following this strategy, the bank would not be vulnerable to confidence crisis by creditors. This suggests that international reserves may play a useful role in crisis prevention. It should be noted, though, that the alternative strategy may not be feasible in practice. Foreign lenders may not be willing to disburse the full f at first, especially if a portion is to be used for consumption, not investment. Moreover, the borrowing rate at which the bank could get the f dollars abroad may be much higher than the deposit rate at which it could keep the $\tilde{b}$ dollars in liquid form; this interest rate wedge could render this scheme's cost prohibitive.[18]

The second point that deserves attention is that we have allowed the bank to liquidate assets all the way to l^a, rather than stopping at the stricter limit l^+. This may seem sensible ex post

18. Endogenizing such interest rates would require having a nonzero probability of a run. See Chang and Velasco [2000b].

since, if a run occurs, liquidating up to l^a still allows the bank to service its debt of $\tilde{d}$. But notice that, if the bank could precommit to liquidate only up to l^+, then it would always have enough dollars in period 2 to repay creditors who had kept on lending in period 1; then ongoing lending must take place in equilibrium. Hence the lack of precommitment by domestic financial institutions is crucial in generating the multiplicity of equilibria identified in this subsection.[19]

B. Short-Term Debt

So far, we have not been explicit about the maturity of the debt incurred by the bank in period 0. In fact, it made no difference whether it was a one-period bond that was rolled over in period 1 or a two-period bond that matured in period 2, for we implicitly assumed that a one-period bond was automatically renewed, and in the same conditions, in the middle period. Now we shall be more explicit and assume that the initial debt indeed consists of one-period loans. What happens if international creditors refuse to roll over the debt in period 1?

Assume that the bank cannot commit not to liquidate fully the long-term investment in case of need, and focus on equilibria in which no short-term credit is extended in period 1 if there is a run. In a run, therefore, the bank becomes bankrupt if its short-term obligations, which now include the sum of its demand deposits *and* its short-term external debt, exceed the liquidation value of the long-term investment. This will be the case if

$$z^b \equiv \tilde{c}_1 + \tilde{d} - r\tilde{k} > 0. \tag{16}$$

Clearly, assuming that $\tilde{d}$ is nonnegative, $z^b > z^a > z^+$. That is to say, under the assumptions in this subsection, financial fragility is greatest if lenders refuse to roll over short-term debt in the event of a run.

Notice that, if (16) holds, it is rational for creditors to refuse to roll over short-term debts because, if they act in that way, the bank will in fact be unable to repay its debt. Hence foreign pessimism may turn out to be a self-fulfilling prophecy as in the case of ongoing lending.

Note also that, if (16) holds but (15) does not, a run is possible *if and only if* external holders of bonds panic and demand pay-

19. This is similar to Obstfeld's [1994] arguments on self-fulfilling attacks.

ment in period 1. In those circumstances, a panic by the creditors is necessary for a self-fulfilling run by both depositors and creditors; the resulting bank collapse could not have happened if the creditors had behaved differently.[20]

C. The Size of Capital Inflows

Is it true that "larger" capital inflows aggravate bank fragility? Consider the case of the preceding subsection; then a crisis can only take place if (16) holds. Now, after dividing both sides by $w = e + (R - 1)f$, (16) reduces to $\theta/\lambda + \tilde{d}/w - e\tilde{k}/w = \theta/\lambda + (1 - r)\tilde{d}/w - er/w > 0$. Since w increases with f, the term er/w falls when f increases. Perhaps more importantly, $\tilde{d}/w$ is increasing in f; in other words, an increase in f implies higher foreign indebtedness relative to wealth.[21] Both effects act in the same direction: a higher credit ceiling and the implied larger capital inflows, ceteris paribus, increase the vulnerability of the bank to runs.[22]

But while a larger f can make a crisis possible when the bank contracts short-term debt in period 0, it need not affect the vulnerability to a crisis if period 0 debt is long term. This is because the sign of z^+ or z^a, which determines whether crises are possible in the latter case, depends on f only through the maximum liquidation value (l^+ or l^a) of the long-term technology; this effect is small[23] if liquidation costs are large. In this sense, it is not simply the ready availability of foreign loans that poses a danger, but a large loan volume contracted at short maturities.[24]

Three further remarks are warranted before leaving this section. The possibility of foreign creditor panics implies that domestic depositors may themselves panic even if demand deposits include a suspension of payments clause. In the setting of the previous subsection, in particular, suppose that all depositors attempt to withdraw $\tilde{c}_1$ early but only the first λ are allowed to do

20. This result is reminiscent of Calvo [1995], in which short-maturity debt can give rise to multiple equilibria and self-fulfilling debt crises. See also Alesina, Prati, and Tabellini [1990], Obstfeld [1994], and Cole and Kehoe [1996].

21. This can be easily checked from the definitions of $\tilde{d}$ and w.

22. The intuition is as follows. An increase in the credit ceiling f is beneficial because the return on illiquid assets is higher than the world interest rate. To take advantage of this opportunity, the bank must increase illiquid investments faster than the resulting increase in w. The associated increase in initial borrowing, therefore, aggravates illiquidity, provided that such borrowing is short term.

23. In fact, it vanishes in the limit as r tends to zero.

24. This conclusion is consistent with Sachs, Tornell, and Velasco's [1996b] finding that the maturity of capital inflows was a helpful predictor of vulnerability to the Tequila effect, while the size of those inflows was not.

so: the bank will still fail if $\lambda\tilde{c}_1 + \tilde{d} - r\tilde{k} > 0$. Hence, suspension of payments, by itself, is less useful here than in a closed economy.[25]

Policy implications for managing debt maturity and helping prevent crises are clear-cut. Imagine that the domestic authorities required that all foreign borrowing by the bank were no less than two periods in maturity. Then, the bank's optimal response would be to borrow the full f dollars in period 0, while holding $\tilde{b}$ dollars of "reserves." Under this arrangement the bank would not be vulnerable to foreign creditor panics, because in period 1 it would have no short-term debt to roll over nor a need for new lending. The intuition, obviously, is that if the presence of short-term debt or the need for ongoing lending increases vulnerability, policies to lengthen debt maturity must reduce it.[26]

In our model, short-term debt makes a *coordination failure* among lenders possible. An implication for crisis management is that attempting to coordinate lenders' behavior on "good" outcomes is key. Negotiated debt rollovers or reprogrammings may achieve this, in particular if accompanied by prudent macro policies, privatization, and other investor-friendly signals.[27]

IV. Financial Liberalization and Fragility

Both casual observation of recent crises and formal econometric work suggest the existence of important links between financial liberalization and financial turmoil.[28] Clearly, explaining these links has become crucial for the design of public policy.[29] Accordingly, this section focuses on how financial deregulation can affect the banks' vulnerability to runs. Our conclusion is

25. We are grateful to an anonymous referee for noting this point.

26. However, this message needs to be interpreted with caution given that we have assumed away other reasons why *short*-term debt may be desirable. These reasons may include informational or incentive issues; for a recent exploration see Jeanne [1998] and Rodrik and Velasco [1999].

Capital controls may then be effective in reducing vulnerability if they lengthen the maturity of foreign debt. That capital controls do result on longer debt maturities has been argued on empirical grounds by Valdés-Prieto and Soto [1996] and Cárdenas and Barrera [1997].

27. However, in practice lenders may be skeptical of such policy responses, since it is hard to distinguish the payments deferrals that are justified by liquidity considerations from those that are thinly veiled attempts at default.

28. See, in particular, Kaminsky and Reinhart [1999].

29. For recent discussions see Velasco [1987], Dornbusch, Goldfajn, and Valdes [1995], Sachs, Tornell, and Velasco [1996b], and Radelet and Sachs [1998].

that a more "market-oriented" policy improves welfare in the absence of runs but may also make runs more likely.

Our focus will be on a change in the degree of competition in the banking sector.[30] So far we have treated the bank as a coalition of individual agents bent on maximizing their joint welfare. As a result, the bank earns no profits, and manages assets and liabilities to maximize the expected utility of the representative depositor. An alternative interpretation is that the bank is a perfect competitor in a banking market into which there are no barriers to entry. Free entry would ensure that equilibrium profits are zero and, in order to attract customers and not be undercut by competitors, banks would have to offer contracts promising depositors as high a level of expected utility as possible.

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

$$(17) \qquad [b + rl - \lambda c_1] + [R(k - l) - (1 - \lambda)c_2 - b - d],$$

subject to constraints (2), (5), (6), (8), (3), (4), (7), and the requirement that the expected utility of agents be no lower than the expected utility associated with individual autarchy, denoted by v:

$$(18) \qquad \lambda u(c_1) + (1 - \lambda)u(c_2) \geq v.$$

The first-order conditions of this problem, whose solution is identified by circumflexes, yield the following implications.[31] Constraints (3) and (18) will always be binding; the latter implies that the monopolist will give depositors exactly the value of autarchy, which is intuitive. The constraint (4) need not hold with equality. That is to say, bank income in period 2 (given by $R\hat{k}$) will be larger than bank outlays in the same period (given by $(1 - \lambda)\hat{c}_2 +$

30. Of course, "financial liberalization" can mean different things. In Chang and Velasco [1998] we showed that a policy of lowering reserve requirements has effects similar to the ones emphasized below: it enhances the efficiency of banks but also exacerbates their illiquidity.

31. The complete solution is straightforward and can be found in Chang and Velasco [1998].

f).[32] The intuition is that, given his risk neutrality and the high yield of the long-term investment, the monopoly banker will choose to concentrate all of his profits in period 2.

Not surprisingly, the monopoly bank is bad for depositors: it holds them to their autarchy values, leaving them worse off relative to the competitive case. It is more interesting to compare the vulnerability to runs under monopoly and competition.

Assume, for simplicity, that the monopolist can commit never to default on his external debts, as in Section II. Then his maximum liquidation level will be $l^m = \hat{k} - f/R$, and he may be subject to a run equilibrium if and only if potential withdrawals exceed the bank's liquidation value in period 1:

$$\hat{c}_1 > \hat{b} + rl^m; \tag{19}$$

or, since $\hat{b} = \lambda\hat{c}_1$,

$$\frac{(1-\lambda)\hat{c}_2}{R\hat{k} - f} > R^{(1-\sigma)/\sigma}r. \tag{20}$$

The left-hand side is simply the period 2 ratio of payments to depositors to bank income net of interest paid abroad; it must be strictly less than one because the monopoly bank has positive profits in period 2. In contrast, the condition for a run to be possible in the competitive case, given by (13), is the same as (20) except that tildes replace circumflexes, implying that the left-hand side is equal to one (the competitive bank earns no profit in either period). Hence, the condition for the existence of a run equilibrium is *less* stringent for a competitive than for a monopoly bank. The intuition is that the monopolist pays less to depositors than a competitive bank. This reduces his short-term potential obligations and, accordingly, his vulnerability to runs relative to competitive banking.

What are the welfare implications? As already noted, abolishing the monopoly increases depositors' welfare if a run does not happen. But it also widens the range of circumstances in which bank runs can take place. In particular, if (13) holds but (20) does not, the competitive bank is prone to a run while the monopoly bank is not. In this case, enhanced competition may result, ex post, in lower welfare *if* a run occurs.

In spite of increased fragility, financial liberalization must be

32. Of course, liquidation will be zero at the monopoly optimum, just as for the competitive bank.

beneficial ex ante. This is obvious unless (13) holds while (20) does not. In that case, the competitive case has two equilibria, and expected welfare depends on the probability that the run equilibrium obtains. Competitive banking clearly implies higher expected welfare for depositors if the run probability is small, as assumed in our analysis.

The case in which the run probability is "large" is more complex, but leads to the same conclusion. In that case it is necessary to amend the analysis to see how the competitive bank's decisions depend on the probability of a run. If the bank correctly takes into account such a probability, as in Cooper and Ross [1998] and Chang and Velasco [2000b], it will always give depositors at least the expected value of autarchy (which equals the value to them of the monopoly allocation). This should be obvious since the autarchy allocation is ex ante feasible for the bank. Hence, competitive banking dominates the monopoly bank ex ante irrespective of whether the run probability is small or large.

In short, financial liberalization increases the expected welfare of depositors, but may also exacerbate the fragility of the financial system. Our analysis is consistent with the evidence provided by Demirguc-Kent and Detragiache [1998] and suggests that the recent troubles experienced by banks in many emerging markets may be traced back to attempts at enhancing competition. Liberalization may not be a "mistake" in an ex ante (expected value) sense, but it surely can be costly ex post.

V. Asset Prices, Booms, and Busts

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

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

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

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

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

The bank can buy land in period 0 at a competitively determined price of p_0 per unit. The bank's planning problem is now to maximize $\lambda u(c_1) + (1 - \lambda)u(c_2)$ subject to

$$k + p_0 a \leq e + d \tag{21}$$

$$\lambda c_1 \leq b \tag{22}$$

$$(1 - \lambda)c_2 \leq R(a)k - (b + d), \tag{23}$$

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

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

$$p_0 R(a^*) = R'(a^*)k^* = \frac{R'(a^*)[(1-\lambda)c_2^* + f]}{R(a^*)} \tag{24}$$

$$\left(\frac{c_1^*}{c_2^*}\right)^{-\sigma} = R(a^*) \tag{25}$$

$$\lambda c_1^* + \frac{(1-\lambda)c_2^*}{R(a^*)} = e + \left[\frac{R(a^*) - 1}{R(a^*)}\right] f - p_0 a^*. \tag{26}$$

The interpretation is straightforward. Consider the optimal choice of land. By purchasing an additional unit of land in period 0, the bank obtains $R'(a)k$ units of consumption in period 2. Alternatively, it can invest p_0 in the long-term asset and obtain $p_0 R(a)$ in period 2. At the optimum, the bank must be indifferent between these two options: this is the first equality in (24). The second equality follows from the fact that (23) and the credit ceiling must bind at the optimum. The other conditions have usual interpretations. Equation (25) equates the slope of the bank's indifference curve with the slope of its transformation curve; the latter is given by (26) and is conditional on the optimal choice of land.

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

$$p_0^* = \left(\frac{R'(\alpha)}{R(\alpha)}\right) k^* > \pi, \tag{27}$$

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

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

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

$$z^c = c_1^* - b^* - rl^c - \pi\alpha > 0, \tag{28}$$

where l^c denotes, as usual, the maximum liquidation of capital consistent with repaying all external debt; clearly (28) may hold if r and π are small enough. To see why (28) is the relevant condition, recall that if a run occurs the bank must pay c_1^* to depositors in period 1. It can meet these obligations by borrowing up to its credit limit, by liquidating the long-term asset (and obtaining rl^c) and by selling the land. But once the long-term asset is liquidated, the price of the land in period 1 must be equal to π, its yield in isolation.

If there is a run, therefore, the price of land crashes to its "fundamental" value π; but clearly this meaning of "fundamental" *is conditional on the occurrence of a run.* Such a price is unnecessarily low, since a higher price (and associated higher welfare) would have prevailed if a run had not taken place.[33]

VI. Bad Policy, Overinvestment, and Exogenous Shocks

There is considerable debate as to whether financial crises are in fact caused by self-fulfilling expectations. Skeptics have maintained that this view is at best a theoretical *curiosum* and that actual crises are triggered by exogenous shocks to fundamentals, by inappropriate policies, or a combination of the two. Accordingly, there have been some recent attempts at modeling emerging markets crises as the consequence of "bad" government policies that had to come to an end because of unfavorable shocks.[34] Such a perspective has strong normative implications. A financial crisis of that sort is salutary, since it implies the end of bad policies and causes asset prices to fall to their "true" values.

33. Our argument assumed that the bank's demand for land in period 0 is determined by its planning problem, which ignores the possibility of a run. If a run may happen with positive probability, this would affect the bank's behavior; however, an obvious extension of the arguments of Cooper and Ross [1998] implies that the results would be essentially the same.

34. See, in particular, Krugman [1998] and Corsetti, Pesenti, and Roubini [1998].

Accordingly, international bailouts are a mistake, for they only postpone the day of reckoning.

To examine the above argument, this section investigates a combination of bad policies and unfavorable shocks in the context of our model. To do this, we consider the basic setup of Section II with two changes. First, the government subsidizes the rate of return on the long-term investment. Let the rate of the subsidy be denoted by η. The subsidy is paid in period 2; hence the bank is entitled to receive ηR units of consumption per unit of the long-term asset it has in period 2. To finance the subsidy, the government imposes a lump sum tax τ on the bank in period 0, and invests the tax proceeds in the long-term asset.

Since in this model there is no rationale for subsidizing the long-term investment, the proposed tax-transfer policy is purely distorting. In particular, a positive η will clearly induce overinvestment in the illiquid asset.

The second modification is that the world interest rate between periods 0 and 1 is assumed to be stochastic (many shocks would have similar effects, but this is the simplest to model). If that rate is denoted (in gross terms) by ρ, we will assume now that $\rho = \rho_s$ with probability q_s, $s = 1, \ldots, S$. We assume that $0 < \rho_s < R$ for all s, and that the realization of ρ is observed at the beginning of period 1.

The commercial bank's planning problem can now be written as

$$\max \sum_s q_s[\lambda u(c_{1,s}) + (1 - \lambda)u(c_{2,s})], \tag{29}$$

subject to

$$k \leq e - \tau + d \tag{30}$$
$$d \leq f,$$

and, for each s,

$$\lambda c_{1,s} \leq b_s \tag{31}$$

$$(1 - \lambda)c_{2,s} \leq R(1 + \eta)k - b_s - \rho_s d \tag{32}$$

$$b_s + d \leq f \tag{33}$$

$$c_{1,s} \leq c_{2,s}, \tag{34}$$

and the obvious nonnegativity constraints.

Expression (30) denotes the period 0 budget constraint, which includes the initial tax τ. Notice that d and k, decided upon at this time, are not state contingent. In period 1, after observing ρ_s, the bank chooses how much more to borrow, b_s, so as not to violate the credit ceiling (33). This decision determines the payoffs to impatient and patient agents, $c_{1,s}$ and $c_{2,s}$, by the usual budget constraints (31) and (32); the latter includes the effect of the subsidy to investment. Finally, (34) is the appropriate incentive compatibility constraint.

Let the resulting planning allocation (the *second best*) be denoted by overbars. From the bank's viewpoint the effect of the investment subsidy is to reduce its endowment by the amount of the lump sum tax in period 0, and to increase the rate of return on the long-term asset by ηR. In addition, the tax τ must be enough to cover the cost of the subsidies. This requires, since the tax proceeds are invested in the long-term asset, that $R\tau$ be equal to $R\eta\bar{k}$, or $\tau = \eta\bar{k}$, where $\bar{k}$ denotes, as before, the bank's long-term optimal investment (which is now conditional on τ and η).

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

Also, if $\bar{d}$ is positive—which, as we saw earlier, will be the case if the credit ceiling is sufficiently high—a large realization of ρ is an unfavorable shock: it increases the interest burden on outstanding debt and implies reduced consumption. To see this, suppose that at the optimum the credit ceiling (33) binds in all states.[35] Then, $\bar{c}_{1,s} = \bar{b}_s/\lambda = (f - \bar{d})/\lambda$, which does not depend on s, for $\bar{d}$ (as well as $\bar{k}$) is set at time 0 before the shock is realized, and hence depends on the distribution of the shock instead of on its realization. On the other hand,

$$(35) \quad \bar{c}_{2,s} = \frac{R(1+\eta)\bar{k} - \bar{b}_s - \rho_s\bar{d}}{1-\lambda} = \frac{R\bar{k} + \tau - f - (\rho_s - 1)\bar{d}}{1-\lambda}.$$

35. From the first-order conditions of the bank's problem, one can show that (if η is small) there are only two possibilities for the solution: (i) the credit ceiling always binds, or (ii) the credit ceiling binds for interest rate realizations below a threshold rate, and it does not bind if ρ is higher. Whether (i) or (ii) obtains depends on the parameters of the problem.

Hence (assuming henceforth the "normal case" of positive $\bar{d}$), the consumption of patient agents must fall when the interest rate increases.[36]

As before, the bank may attempt to implement its optimal plan via demand deposits; in contrast with previous cases, now the withdrawal options offered to depositors are stochastic and depend on ρ_s. In other words, demand deposits now require each depositor to surrender her endowment and her opportunities for investment and borrowing to the bank, in exchange for the right to withdraw $\bar{c}_{1,s}$ units of consumption in period 1 or $\bar{c}_{2,s}$ units in period 2.

Clearly, if depositors act honestly in all states, the demand deposit system will implement the second best. In this case, the investment subsidy is costly, but only mildly so as discussed above. However, there is a more ominous possibility: that the policy may be associated with a greater likelihood of a bank run. This may be the case even if the government is committed to helping the bank in case of trouble.

To see this, assume that in case of a bank run the government transfers the liquidation value of its investment to the bank. Then a bank run is possible in state s if and only if the illiquidity condition,

$$z_s = \bar{c}_{1,s} - \bar{b}_s - r(l_s^+ + \tau) > 0, \tag{36}$$

holds, where l_s^+ is given by

$$l_s^+ = \bar{k} - ((\rho_s \bar{d} + \bar{b}_s)/R). \tag{37}$$

Consider again the case in which the credit ceiling (33) is binding in all states. Then, $\bar{c}_{1,s} = (f - \bar{d})/\lambda$, and, in addition, $\bar{k} = (e - \tau) + \bar{d}$ and $\tau = \eta\bar{k}$ imply that $\bar{k} = (e + \bar{d})/(1 + \eta)$. Using these facts and (37) in (36) imply that

$$z_s = \left(1 - \lambda + \frac{\lambda r}{R}\right)\bar{c}_{1,s} + \left[\frac{r}{R}(\rho_s - 1)\right]\bar{d} - re.$$

The above expression shows that the subsidy policy affects the bank's illiquidity in two ways. First, it reduces the consumption assigned to impatient depositors, which improves liquidity in every state of the world. Second, it increases $\bar{d}$, which implies

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

more illiquidity if $\rho_s > 1$, i.e., in unfavorable states.[37] The net effect is ambiguous in general and depends on the parameters of the model. But it should be clear that z_s may increase in some states as a result of the subsidy.[38] A consequence is that a bank run may be possible in states that would have been free of runs without the subsidy. The intuition is that the investment subsidy encourages investment in the long-run asset, and consequently borrowing in period 0 increases. If the interest rate on that borrowing turns out to be large, there is a larger external debt burden, the liquidation value of the bank falls, and the bank becomes less liquid.

Our analysis thus shows that the combination of bad policies and unfavorable shocks can indeed make crises possible. However, such a combination matters largely because it results in increased illiquidity and greater financial vulnerability, and not because of the resulting investment distortions.[39] In the event of a crisis, the vast cost in terms of inefficient liquidation and wealth loss are added to the welfare-reducing effects of the investment subsidies.

VII. Final Remarks

Of the simplifying assumptions imposed on our model, four deserve special comment. The first is that the limit on foreign borrowing is exogenously given and takes a particularly simple form which includes all forms of borrowing. While we have seen that this assumption is necessary in our model, the possibility of crises and the associated default on debts may itself be one reason for the existence of credit limits. Hence a complete theory should endogenize such limits. In addition, such a theory may or may not result in credit limits of the form we imposed in this paper. A deeper examination of this issue is clearly warranted.

A second simplification is that we ignore foreign direct investment (FDI).[40] In our model, FDI would be tantamount to the sale by domestic agents to foreigners, in period 1, of promises to

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

38. This has to be the case in states s for which ρ_s is sufficiently large.

39. The point that shocks can displace an economy into a region of the fundamentals where self-fulfilling runs are possible has been made in the context of "second generation" currency crises models. See Obstfeld [1996].

40. We thank a referee for mentioning this issue.

the period 2 yield on illiquid investments. We implicitly treated such sales in the same way as debt—subject to the credit limit f—which effectively ruled them out. But that assumption is not innocuous. Indeed, if FDI were possible, and if FDI sales were not part of the credit limit f, our model would look quite different: a domestic resident would be able to consume $Re + (R - 1)f$ regardless of her type realization.

Aside from simplicity, there are two reasons why we treat foreign investment the way we do. First, in a model of the Diamond-Dybvig type such FDI would make domestic banks redundant, so that it must be ruled out if one is to preserve an interesting role for local banks.[41] Second, and more fundamentally, the FDI objection presumes that, if FDI sales were allowed, the period 1 price of the long-term asset would be the discounted value of its period 2 yield. But such a presumption is neither obvious nor necessary, and would be wrong under some plausible conditions. In particular, collecting the yield of the long-term asset may require the participation of the local banker, perhaps because of human capital specificities as in Hart and Moore [1994]. Then, if forced to sell the long-term asset early to foreigners, the banker would like to promise to help collecting the last period yield; but such a promise may be unenforceable, implying that the FDI sale would result in strictly less than the discounted long-term return. The long-term asset would be illiquid, just as assumed in our analysis. We conclude that while FDI is an important extension, it can be included in our model in a plausible manner without substantially changing our arguments.

A third important simplification is that our analysis has abstracted from incentive issues, and in particular from moral hazard questions. We have focused on liquidity considerations, and they permeate the policy implications of our analysis. But moral hazard may also be an important issue in practice. This is most clearly manifest, perhaps, when considering the implications of our paper for the role of an international lender of last resort. In our model, the availability of such a facility would prevent unnecessary credit crunches and costly liquidation of investment, unambiguously increasing welfare. But international assistance should not be too readily forthcoming, or its cost

41. The reason is, precisely, that a domestic resident would be able to consume $Re + (R - 1)f$ regardless of her type realization, so that she would gain nothing from joining a bank.

too low; otherwise this assistance could create dangerous incentive problems.

The fourth simplification is that this paper has abstracted from monetary issues. A monetary extension is clearly warranted; it would allow, in particular, for the analysis of how banking crises interact with currency crises, and what role the exchange rate regime plays in all of that. We refer the interested reader to Chang and Velasco [2000a].

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