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Bank–Firm Relationships and Contagious Banking Crises

This paper argues that in an open economy a banking system with close bank–firm relationships may be easily subject to contagious banking crises because it is difficult to distinguish between "crony capitalism" and "good" main bank relationships. I show that, if international investors cannot distinguish the bank type, the distinction between crony capitalism and good main bank relationships becomes very fuzzy. In particular, the model can explain sequences of bank defaults within a country, even if the insolvent banks are very few ex ante, as well as sequences of banking crises among countries that are equally rated by international investors, but indeed differ in the ex ante solvency of their banking system.

IN DEVELOPING COUNTRIES, external finance to firms is provided mainly by banks. Furthermore, bank–firm relationships are very close and borrowers usually rely on a single bank.[1] This situation is usually condemned for causing problems of crony capitalism and connected lending because banks would have incentives to fund negative-net-present-value projects (Dewatripont and Maskin 1995). Most importantly, it is considered the main factor behind the processes of accumulation of bad loans and, consequently, of banking crises (Diaz-Alejandro, 1985, Krugman, 1998, and Corsetti, Pesenti, and Roubini, 1999a and 1999b).

However, the corporate finance literature has emphasized a number of desirable features of close bank–firm relationships, often referred to as main bank relationships. Notably, these are considered to allow financiers to take a longer view on investments and to reduce financial constraints for firms in temporary difficulties (Rajan,

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1992, Hoshi, Kashyap, and Scharfstein, 1991). For this reason, main bank relationships have been proposed as a model for the development of the financial system in developing and transition economies (Aoki and Patrick 1994), where sources of external finance other than bank loans are limited.

This paper shows that in a small open economy, even if banks perform desirable functions and do not lend to negative-net-present-value projects, a banking system based on close bank–firm relationships may be easily subject to phenomena of contagion which undermine its stability.

The instability of financial systems where firms borrow predominantly from a main bank arises from the difficulty of distinguishing between insolvent and illiquid banks. On one hand, banks may renew loans to insolvent projects and, as a consequence, accumulate losses. On the other hand, banks may be only temporarily illiquid because they lend to projects in temporary difficulties, but that are solvent in the long run. In this case, close bank–firm relationships indeed allow financiers to take a longer view on investments (Rajan 1992) and must be assessed positively. However, if international investors cannot observe the quality of the investment opportunities funded by banks, the distinction between illiquid and insolvent banks becomes very fuzzy. Contagion may thus arise either between illiquid and insolvent banks within a country or across countries, because international investors, unable to distinguish across banks, demand the same interest rate on deposits whatever the bank type.

In this paper, I show that incomplete information provokes a uniformly low equilibrium interest rate in the aftermath of the liberalization of capital flows, when the lending boom starts, and an apparently sudden increase in the cost of funds, which causes the defaults of the insolvent banks, at a date to be endogenously determined in the model. Even if illiquid banks do not default immediately, revealing that they are not insolvent, the temporary increase in the interest rate burden may drive them to insolvency and cause them to default after a few periods.

These problems would not arise if firms had many financiers, as they do in advanced economies, because insolvent projects would not be financed (see, for instance, Hart, 1995 and Dewatripont and Maskin, 1995). In this case, even if investors do not observe a bank type, they know that banks are not renewing loans to insolvent projects. As a consequence, there are no sudden increases in the interest rate and the financial system is more stable.

Moreover, banking crises are expected to be more frequent after the liberalization of capital inflows and the deregulation of the banking system, as the empirical evidence confirms (Edwards 1998). In this case, the number of loans that can be renewed is no longer limited by domestic saving, and increased competition does not allow banks to use monopoly rents from profitable projects to offset the losses from insolvent ones.

The mechanism described in the model can explain the severity of banking crises within small open economies with bank-based financial systems. Even if just a few banks are actually insolvent, when the cost of funds rises other banks which are financing illiquid projects are also affected as a result of investors' incomplete

information. The failure of a few insolvent banks may be followed by widespread bankruptcies. Ex post, because of the high vulnerability of banks to a temporary increase in the interest rate burden, it is difficult to distinguish illiquid from insolvent banks.

Incomplete information can also explain contagion across countries that are rated equally by international investors. If international investors do not observe the average quality of the investment opportunities available in a country and, consequently, cannot distinguish whether a credit boom is driven by growing investment opportunities or by the accumulation of losses of domestic banks, there may be banking crises with very similar dynamics both in insolvent and illiquid countries. This may explain sequences of banking crises in countries that are rated equally by international investors, but actually have different investment opportunities.

The mechanism generating the sequences of banking crises is the following. Consider two countries A and B. In country A, due to the available investment opportunities, some banks become insolvent after the liberalization of capital inflows and have an incentive to run a Ponzi game. In contrast, in country B, there are just some illiquid projects: they need some time to recover the initial investment but are profitable. International investors believe that with some probability (equal in both countries) the credit boom is due to a Ponzi game. This implies that when the probability of banks' defaults becomes positive (the exact timing is to be determined endogenously in the model), the interest rate on deposits rises to the same extent both in A and B. In country A, this will provoke a banking crisis. If there is no crisis in country B (as happens under reasonable assumptions on the parameters of the model), international investors are able to rule out the possibility that country B's banks are actually insolvent. This should be good news for country B. However, even excluding the possibility of multiple equilibria,[2] it is not necessarily so. International investors' incomplete information has caused a temporary increase in the interest rate burden for country B's banks. This may be sufficient to make country B's banks insolvent and to cause a banking crisis few periods after the banking crisis in country A.

This line of reasoning may explain why financial crises are very correlated over time, especially in countries where financial markets are underdeveloped and which are considered similar by international investors because of their geographic proximity or their production structure. It also identifies a channel of contagion[3] that is different from those already described in the literature, which rely on herding behavior or on competitive devaluation.[4] Here, illiquid banks are affected by the crisis because of an informational spillover due to the mere possibility that some banks are accumulating losses.

Most importantly, such a model can account for the high vulnerability of developing countries' banking systems to apparently external shocks and may help explain the experience of East Asian economies, in particular.[5]

Other papers in the literature on financial contagion have pointed out the importance of the banking system. However, they have focused on different aspects. In Allen and Gale (2000), a negative liquidity shock to banks in a region spreads to

other regions because there are interregional bank claims and bank–firm relationships are not addressed at all. Interbank relationships are the origin of systemic risk also in Freixas, Parigi, and Rochet (2000).

The importance of incomplete information for financial contagion has been addressed in the literature on political contagion (Drazen 1999), but previous contributions refer to uncertainty about the policymakers' commitment to defend a fixed exchange rate rather than to uncertainty on the investment opportunities of a country. In this paper, instead, incomplete information on the quality of banks' assets creates a sort of lemon problem in the market for deposits, like in Akerlof (1970), and this makes contagion possible.

The remainder of the paper is organized as follows. Section 1 presents the model and discusses its main assumptions. Section 2 describes the equilibrium before the banking crisis. Section 3 discusses why financial systems based on close bank–firm relationships are relatively more subject to financial contagion, and Section 4 concludes.

1. THE MODEL

Close bank–firm relationships are modeled by assuming that firms borrow from a single bank. As made clear below, this arrangement has important implications for the stability of the banking system, because if there are multiple lenders, banking crises and contagion do not arise.

In order to take into account that close bank–firm relationship can be either good or bad, the model generalizes Dewatripont and Maskin (1995) and Giannetti (1999 and 2000) which show, respectively, the existence of a soft-budget constraint distortion and its relation with banking crises. These papers show that the financing bank may have an incentive to renew loans to insolvent projects, which were initially funded because of adverse selection, if large amounts of funds are available (because of capital inflows, for instance). In this context, close bank–firm relationships cause overlending and must be judged negatively. This can be considered a formalization of crony capitalism alternative to the ones already existing in the literature, which rely on moral hazard problems due to the existence of guarantees on deposits or on looting phenomena.[6]

In contrast to the other explanations, the soft budget constraint model can be easily generalized by considering that banks can also lend to illiquid projects which are profitable only in the long run. This allows me to analyze the subtle difference between insolvency and illiquidity in financial systems where banks entertain close relationships with firms. When firms are just illiquid, the renewal of loans by the main bank is desirable because it allows the firms to overcome liquidity problems. However, if there is incomplete information on the quality of bank assets, the dividing line between illiquid and insolvent banks becomes fuzzy and contagion of banks that have funded illiquid projects arises.

The structure of the model is as follows. There are three types of agents: project managers, domestic banks, and international investors. I abstract from the existence of domestic depositors, who can be thought as having the same information as international investors and as making deposits exclusively for speculative purposes.

International investors provide capital by making deposits in domestic banks. The domestic banks decide whether or not to finance managers, who have the option to start a project at $t = 0$ and need external financing. To continue production, projects need to be refinanced in any subsequent period.

There are two levels of asymmetric information. First, the quality of a project is initially private information of the project manager. Even if after one period the banks can determine the quality of a project, because they observe if the project manager paid back the loan or not, international investors do not know which kind of project has been financed by their bank.[7] Second, international investors do not observe the country type, which depends on the average quality of the investment opportunities available in the country, as will be explained later while describing the loan demand. That is to say, international investors do not observe the average productivity of capital in a given country. This is a very plausible assumption, because it is difficult, and the subject of dispute, to precisely estimate factor productivity in emerging markets as the debate on the determinants of growth in the East Asian economies between Young (1998) and Hsieh (1997) strikingly confirms. On one hand, if total factor productivity is growing, expanding investment opportunities could drive the increasing loan demand. On the other hand, growth could also be sustained by increasing investment in low productivity and unprofitable projects. Since the economics profession is often unable to distinguish between these two situations, it seems plausible to assume that investors have incomplete information about the average quality of projects in a country, and, ultimately, about the origin of the lending boom.[8] Not only is incomplete information plausible, it is also extremely relevant. In a recent article on East Asian Economies, *The Economist* (2000) notes that "although there are distinct differences in these economies, few investors are still around to notice. That alone is one of these economies' biggest problems." Moreover, the lack of transparency on the positions built up by borrowers and lenders has been considered an important determinant of the intensity of recent crises in the policy debate (see, for instance, Fischer, 1999). In marked contrast, imperfect information does not play any role in the existing explanations of financial crises, which rely either on moral hazard or on multiple equilibria and liquidity problems (Chang and Velasco 1998).

A more detailed description of each type of agent follows.

1.1 The Projects

Country types differ in the average return to capital of domestic projects. These cross-country differences in the average return to capital result from a different mix of heterogeneous projects. In what follows, I first describe the investment opportunities; then, I specify their availability in different country types.

In each country there is a continuum of project managers of mass 1 who can start a project at $t = 0$. The project managers are risk neutral and their payoff is equal to the project output remaining after reimbursing the loan, if this is non negative (because of limited liability), plus some unobservable private benefits, such as perquisites or the enhancement of human capital and reputation. All the assumptions on project output and private benefits are based on Dewatripont and Maskin (1995).

The project output is homogeneous and tradable, and its price in foreign currency is equal to 1. The project managers need loans from domestic banks to start their projects.

The projects can be either fast (F) or slow (S). Slow projects, in turn, may be either insolvent (type 1) or illiquid (type 2). No agent in the economy, with the exception of the project manager, can distinguish the project type ex ante.

Fast projects generate y_F units of output after one period, if L units of the good have been invested. If the project is refinanced in each period, production can go on forever.[9] The return on solvent projects is higher than the international interest rate, i^*: $y_F > (1 + i^*)L$. Moreover, the private benefits for a project manager running a solvent project, E_F, are always positive. Hence, a solvent project is always started if it receives a loan.

On the other hand, slow projects do not generate any output in the first period, even if L has been invested at $t = 0$. Slow projects can be either insolvent (type 1) or illiquid (type 2).

An insolvent slow project generates output, y_{S1}, from the second period on, if L has been invested and, like a fast project, it can be continued forever. However, the expected surplus of an insolvent project is negative at $t = 0$, even if the cost of funds is equal to the international interest rate and the project is never discontinued. This implies that the following condition holds:

$$\sum_{t=1}^{\infty} \frac{y_{S1}}{(1 + i^*)^t} < \sum_{t=0}^{\infty} \frac{L}{(1 + i^*)^{t-1}}. \tag{1}$$

This condition implies that $y_{S1} - L(1 + i^*) < L(1 + i^*)i^*$. That is to say, the surplus generated by an insolvent project cannot recover the first-period loss because it is not sufficient to cover the interest rate burden of the initial period loan. Therefore, if the type of project were observable, no bank would be willing to finance insolvent projects at $t = 0$, whatever the capital availability. However, once the first-period loan has been lost, it is advantageous to refinance insolvent projects, if the cost of funds is sufficiently low. In fact, if the real interest rate on domestic loans is equal to the international interest rate, the following condition holds:

$$\sum_{t=1}^{\infty} \frac{y_{S1}}{(1 + i^*)^t} > \sum_{t=1}^{\infty} \frac{L}{(1 + i^*)^{t-1}}. \tag{2}$$

This implies that $y_{S1} - L(1 + i^*) > 0$. These assumptions on insolvent slow projects follow Dewatripont and Maskin (1995), who show the existence of a soft-budget constraint distortion (i.e., that banks are unable to credibly commit not

to refinance insolvent projects once investment costs are sunk and that, as a consequence, ex ante demand for investment increases, because too many unprofitable projects are started) in a two-period model.

Also illiquid slow projects do not generate output in $t = 1$. However, if refinanced they produce output, y_{S2}, that is sufficient to cover the first-period loss, if the cost of funds remains equal to the international interest rate. Formally, this implies that the following condition is satisfied:

$$\sum_{t=0}^{\infty} \frac{y_{S2}}{(1 + i^*)^t} > \sum_{t=1}^{\infty} \frac{L}{(1 + i^*)^{t-1}}. \tag{3}$$

The private benefits of project managers running slow projects are positive only if the project is refinanced at $t = 1$ and has a chance to produce positive output. In this case, the private benefits for its manager are $E_{S/R} > 0$. In contrast, running a firm without producing any output has a stigma effect on the project manager and, therefore, if the project defaults after the first period, the manager's private benefits are negative $E_{S/D} < 0$. This implies that a manager with a slow project will not start the project, if he expects that it will not be refinanced at $t = 1$.

At the aggregate level, depending on the available investment opportunities, a country may be crisis prone or not. A country is crisis prone (type I) if it is endowed with a positive mass of insolvent slow projects ($\theta^{I}_{S1} > 0$; $\theta^{I}_{S2} > 0$; $\theta^{I}_{F} > 0$); it is type II if it has only solvent projects, which can be either fast or illiquid ($\theta^{II}_{S1} = 0$; $\theta^{II}_{S2} > 0$; $\theta^{II}_{F} > 0$). Of course, it is $\theta^{i}_{S1} + \theta^{i}_{S2} + \theta^{i}_{F} = 1$, for both the country types.

Besides being more productive, type II countries also have growing investment opportunities: new fast projects become available in each period so that loan demand grows at the same rate, whatever the country type, if the cost of funds is equal to the international interest rate. In this way, capital inflows to a country are not informative about the country type, even if observed by the international investors. Total lending may be increasing for very different reasons, and investors cannot distinguish whether the accumulation of foreign debt and the current account imbalances are due to capital flowing to the most advantageous investment opportunities or to an overlending syndrome. This is in marked contrast with the existing literature which assumes either that current account imbalances are bad because they are driven by an accumulation of losses in the private sector, as in Krugman (1998), or that capital inflows are good because they finance high-yield investment opportunities in low-saving countries (Obstfeld and Rogoff 1995). Incomplete information on the country type can capture the widespread lack of transparency in international lending, due to the poor accounting standards of the private sector and the lack of disclosure to international investors.

Finally, to ensure banks' viability, I assume that at $t = 0$ the expected return on investment in type I countries is higher than the international interest rate, even if the first-period investment in insolvent projects is not productive and there is

probability $\theta^{I}_{S1} + \theta^{I}_{S2}$ of not recovering the loan. In terms of the parameters of the model, this implies $\theta^{I}_{F} y_F > (1 + i^*)L$.

The prior of international investors, who do not observe the country's average return on investment, is that a country is type I (i.e., it has a mass θ^{I}_{S1} of insolvent projects) with probability φ_I and type II with probability $\varphi_{II} = 1 - \varphi_I$.

The assumptions on the information set of international investors imply that they cannot observe the output of the projects funded by the banking system.[10] This can be justified on two grounds. First, developing countries' statistics are often imprecise and unreliable. The growth of the output, even if observed, may not be easy to interpret because the liberalization of capital inflows that is often accompanied by the liberalization of other sectors of the economy represents a structural change. This makes it more difficult to distinguish between a bubble, which artificially increases the output by inflating the cost of nontraded goods, and an actual improvement in efficiency. Second, any production process involves random factors that are left out of the model for simplicity's sake and output, if observed, could be at most a noisy signal of the country type. Even if international investors could observe such a signal and update their beliefs on the country type using its probability distribution, all the results of the paper would hold, as all the agents are risk neutral. The only relevant difference in the results would be that the date of the crisis, to be determined below, is stochastic (i.e., a crisis would be delayed by a sequence of positive shocks to the output).

Table 1 summarizes the information about country characteristics and investors' beliefs.

1.2 The Domestic Banks

Domestic banks maximize their net wealth, are risk neutral, and operate at no cost. They offer deposits to international investors at the interest rate, i^{d}_{t}, and lend to project managers at an interest rate $i^{l}_{t,k}$, which varies according to the project type, k, and which cannot be observed by the international investors. For simplicity's

TABLE 1

COUNTRY TYPES

	Type I (Insolvent)	Type II (Illiquid)
Priors about the country's type	φ_I	φ_{II}
Fraction of fast projects	θ^{I}_{F}	θ^{II}_{F}
Fraction of illiquid slow projects (output after the first period = y_{S2})	θ^{I}_{S2}	θ^{II}_{S2}
Fraction of insolvent slow projects (output after the first period = y_{S1})	θ^{I}_{S1}	0
Average return on investment after the first period	$\dfrac{\theta^{I}_{F} y_F + \theta^{I}_{S2} y_{S2} + \theta^{I}_{S1} y_{S1}}{L}$	$\dfrac{\theta^{II}_{F} y_F + \theta^{II}_{S2} y_{S2}}{L}$

sake, I assume that deposits and loans are denominated in foreign currency, but results would be invariant if they were denominated in domestic currency.

There is a continuum of banks of mass 1, which are ex ante identical. The distinction between insolvent and illiquid banks emerges only ex post in the model, when banks and projects managers are randomly matched.

Banks compete à la Bertrand in the loan market bidding the interest rate to get customers. This assumption is commonly made in the literature to characterize a situation of strong competition in the banking sector. It captures well the fact that the liberalization of capital inflows is almost always accompanied by the deregulation of the banking sector that makes the environment highly competitive.

In equilibrium, managers do not change financing bank.[11]

The assumptions on bank competition imply that the interest rate for fast projects is: $i^{l}_{t,F} = i^{d}_{t}$. In contrast, banks can appropriate the project's profits if previous loans have not been completely repaid (that is equivalent to say $i^{l}_{t,S1} = y_{S1}/L$ and, until when the first-period loss has not been recovered, $i^{l}_{t,S2} = y_{S2}/L$).

At $t = 0$, since bank–firm relationships are not yet established, all banks offer the same interest rate to project managers who are indistinguishable ex ante. Because of the assumptions on bank competition this interest rate must be such that banks' expected profits are equal to zero.[12]

For simplicity's sake, I assume that at $t = 0$ each bank finances a project. If banks behave competitively, this assumption is totally irrelevant for the results of the model, because in equilibrium losses from slow projects cannot be offset by profits from fast projects.[13] In type II countries, the new projects that become available are financed by one of the existing banks.

In what follows, I show that the long-term horizon of bank–firm relationships helps to explain their vulnerability to an increase in the cost of funds. Banks that financed illiquid projects expect to break even in the long run rather than period by period, as banks usually do in market-based financial systems. As a consequence bank-based financial systems are extremely vulnerable to changes in the cost of funds, even if bank lending policies are perfectly rational.

1.3 The International Investors

International investors make deposits in domestic banks. They are risk neutral and are interested in the foreign currency return of their investment. Hence, they invest in the economy only if their expected return is at least as high as the international interest rate, i^*.

Each international investor lends an amount of capital that is small compared to the total demand for deposits, but the number of international investors is large with respect to the investment opportunities of a country.

International investors simultaneously announce the lowest interest rate at which they would hold deposits. Since they behave competitively, they have no extra profits and their expected return must be equal to the international interest rate. If this condition is satisfied and there are no restrictions to capital movements, any amount of foreign capital can flow into the economy. Therefore, for a given level

of the interest rate, the amount of capital inflows is determined by the aggregate demand for loans.

Since with some probability international investors have made deposits in an insolvent bank, the equilibrium interest rate on deposits must compensate them for the default risk, as will be shown below.

1.4 The Timing

The timing of events within each period t is as follows:

- The output of projects financed in $t - 1$ is realized and sold, the project manager appropriates profits, $\pi_{tk} = y_k - (1 + i^{l}_{tk})L$, if previous-period loans have been paid back. Otherwise, the financing bank appropriates profits.
- Banks supply deposits to international investors in order to finance loans. Based on their beliefs about the aggregate losses of domestic banks and the probability of bank defaults, international investors announce the minimum interest rate, i^{d}_{t+1}, at which they will make deposits in domestic banks.
- After observing i^{d}_{t+1}, banks decide whether or not to renew the loan to the project they funded. Only banks that funded fast projects are always able to pay back previous-period deposits, if they do not renew the loans. In contrast, banks that funded slow projects always default, if they do not renew the loans. The assets of defaulting banks are equally distributed among investors.
- If the financing bank does not default, the production continues until the following period; otherwise, the project is terminated.

The economy described above is in equilibrium if all the agents maximize their objective functions, their beliefs are confirmed and loan and deposit markets clear.

The assumption that bank assets are equally distributed among investors in case of default ensures that there are no incentives for bank runs, like in Diamond and Dybvig (1983), and rules out the possibility of multiple equilibria due to coordination problems. In fact, investors who made deposits in insolvent or illiquid banks cannot limit their losses by withdrawing early. In contrast, in this model, even if an investor expects that all the other investors are not making deposits, there is always a positive probability that a bank is solvent and liquid and therefore there exists an interest rate such that she wants to hold a deposit because she has positive expected profits.

The next two sections describe the equilibrium of the above economy and how the banking crisis unfolds.

2. THE PRECRISIS DYNAMICS

2.1 Banks' Lending Decisions

The dynamics of the model depend on the aggregate losses in the banking system. These, in turn, depend on the losses of individual banks.

The losses of a bank that financed a slow project are a state variable, and their dynamics are described by a difference equation that varies according to the project

type, k, where $k \in \{S1, S2\}$. The losses of a bank that financed a project of type k at time t, x_t^k, depend on losses at $t-1$, x_{t-1k}, on the interest rate on deposits at $t-1$, i_t^d, and on the level of output, y_k. In particular, current period profits, $[y_k - (1+i_t^d)L]$, decrease next period losses. The dynamics of losses can be described by the following difference equation: $x_t^k = (1+i_t^d)x_{t-1k} + [(1+i_t^d)L - y_k]$, as long as $x_{t-1k} > 0$. Afterward, profits are distributed to the project manager and, therefore, losses remain equal to zero. Of course, the losses of banks financing fast projects are always zero.

Banks choose whether or not to refinance a slow project maximizing their net wealth, which is equivalent to minimizing the present value of their losses.[14] In particular, a bank always chooses to renew a loan if the present value of losses at $t+1$ is less than the losses at time t: $x_{t+1}^k/(1+i_{t+1}^d) < x_t^k$.[15] This yields a very simple sufficient condition for the renewal of a loan: a loan is always renewed if the following-period surplus from the project is positive, that is, $y_k - (1+i_t^d)L > 0$. Otherwise, an insolvent slow project will be discontinued because an increase in following-period losses implies a permanent increase in their present value. In contrast, a bank that funded an illiquid slow project may find it optimal to renew the loan, even though current-period profits are negative, if losses are decreasing over time after the temporary increase in the cost of funds (i.e., after the bank has revealed it is not insolvent). Formally, this happens if $x_{t+1S2} < \bar{x}_{S2}$, where $\bar{x}_{S2}$ is the steady state of the difference equation describing the losses of an illiquid bank. In fact, as long as the current losses are at the left of the steady state, these are decreasing over time.

It follows from the previous discussion that, as long as the interest rate on deposits remains equal to the international interest rate, it is optimal to renew the loan to a slow project, whether it is solvent or not, because by assumption $y_k - L(1+i^*) > 0$. Anticipating this, managers with insolvent projects ask for funding in $t=0$.

The dynamics of losses are very different for banks with illiquid and insolvent projects. The assumptions on the parameters imply that, when the interest rate on deposits is equal to the international interest rate, losses are increasing for the insolvent slow projects and decreasing for the illiquid ones. In fact, the initial-period loss of insolvent slow projects is always at the right of the steady state of the difference equation describing losses' dynamics; that is: $\bar{x}_{S1} \equiv [y_{S1} - (1+i^*)L]/i^* < x_0 \equiv (1+i^*)L$. The contrary is true for illiquid slow projects. Intuitively, losses are increasing over time for banks that financed an insolvent project because profits are not sufficient to cover the interest rate burden on the first-period loss, even if the interest rate remains equal to the international interest rate. Banks do not take this into account because, when they make the decision whether or not to renew the loan, they look at the present value of their losses.

Figure 1 represents the dynamics of the losses of illiquid and insolvent projects in the phase antecedent to the crisis, when international investors do not require any risk premium to hold deposits.

It is important to note that bank capitalization, since it affects the net losses of the banking system, affects whether or not banks accumulate losses. In fact, if a

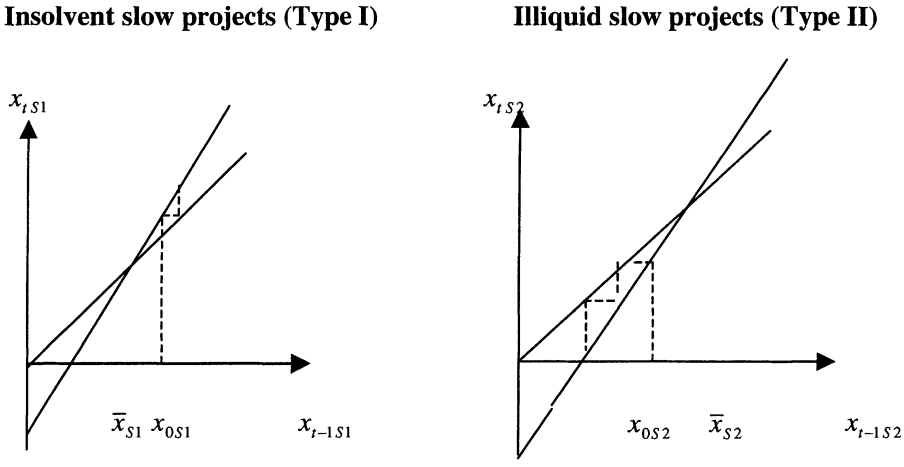

FIG. 1. Insolvent Slow Projects (Type I); Right: Illiquid Slow Projects (Type II)

bank has capital, K, its initial-period loss that must be refinanced with deposits is $x_{0k} = (1 + i^*)L - K$. Banks' capital decreases the level of the initial net loss for banks that funded an insolvent project and may eventually move the initial condition to the left of the steady state. In this case, no processes of accumulation of losses would occur, even if the soft-budget constraint distortion persisted. In what follows, I assume that the level of capitalization of the banking system is such that processes of accumulation of losses can occur in equilibrium and, without loss of generality, I set $K = 0$. I discuss below how capital requirements can improve financial stability by reducing contagion.

Note also that the soft budget constraint distortion arises only if the cost of funds remains relatively low when the supply of deposits increases. This could not happen, for instance, in a closed economy, where domestic saving imposes a constraint on the amount of deposits that can be financed in equilibrium. In this case, any increase in the supply of deposits would imply an increase in the interest rate and would make the refinancing of insolvent projects less likely. This explains why financial systems based on close bank–firm relationships appear relatively stable when there are restrictions to capital inflows, and show signs of instability only after their liberalization.

2.2 Aggregate Losses

The dynamics of the aggregate losses of the banking system mimic those of the individual losses and are described by a deterministic difference equation, which varies according to the country type, k. This depends on the quality of available projects, as has been described above.

The aggregate losses of the banking system in type I countries, where both insolvent and illiquid projects are available, are equal to the integral of individual

losses and are described by the following difference equation:

$$X_{t\,\mathrm{I}} = (1 + i_t^{\mathrm{d}})X_{t-1\,\mathrm{I}} + [(1 + i_t^{\mathrm{d}})L - y_{\mathrm{S1}}]\theta_{\mathrm{S1}}^{\mathrm{I}} + [(1 + i_t^{\mathrm{d}})L - y_{\mathrm{S2}}]\theta_{\mathrm{S2}}^{\mathrm{I}}\,, \tag{4}$$

with $X_{0\mathrm{I}} = (1 + i^*)L(\theta_{\mathrm{S1}}^{\mathrm{I}} + \theta_{\mathrm{S2}}^{\mathrm{I}})$.

In contrast, in type II countries where no insolvent projects are available, the aggregate losses are described by the following difference equation:

$$X_{t\,\mathrm{II}} = (1 + i_t^{\mathrm{d}})X_{t-1\,\mathrm{II}} + [(1 + i_t^{\mathrm{d}})L - y_{\mathrm{S2}}]\theta_{\mathrm{S2}}^{\mathrm{II}}\,, \tag{5}$$

with $X_{0\,\mathrm{II}} = (1 + i^*)L\theta_{\mathrm{S2}}^{\mathrm{II}}$.

As a consequence of the assumptions on project returns and of the dynamics of the losses of individual banks, losses are always decreasing in type II countries. They may be either decreasing or increasing in type I countries, where both illiquid and insolvent projects are available. However, it is always possible to determine a date after which losses are definitively increasing. In fact, the losses of banks with illiquid slow projects become zero at some point; after this date the dynamics of aggregate losses are due only to the losses of insolvent banks and, consequently, losses are necessarily increasing.

2.3 The Cost of Funds

The economy described in the previous section experiences a banking crisis only if it is no longer optimal for domestic banks to renew loans to insolvent projects. This case only arises if the interest rate the international investors demand on deposits rises high enough to make defaults optimal. Below I show that under the assumptions of the model this rises only when a substantial amount of losses has been accumulated.

International investors are risk neutral and the risk premium they require to hold deposits depends on their beliefs about the level of the aggregate losses that determine the probability of losing the deposit, and the expected probability that banks actually default.

Risk neutrality implies that the expected return on deposits must always be equal to the international interest rate; therefore, the following condition must be satisfied:

$$(1 + i^*) = (1 + i_t^{\mathrm{d}}) \times (1 - \mathrm{Prob}\{\text{bank default} \mid i_t^{\mathrm{d}}\})\,. \tag{6}$$

The probability of bank defaults, in turn, depends on the interest rate on deposits because it must be optimal not to renew the loan in equilibrium.

To determine when the probability of bank defaults actually becomes positive, I apply the methodology of Flood and Garber (1984) and define two shadow interest rates on deposits. These are, respectively, the interest rate on deposits compensating international investors for the risk of default of insolvent banks at time t ($\tilde{i}_t^{\mathrm{d}}$), and the interest rate on deposits compensating international investors for the risk of default of both insolvent and illiquid banks at time t ($\tilde{\tilde{i}}_t^{\mathrm{d}}$):

$$(1 + \tilde{i}_t^{\mathrm{d}})\left(1 - \theta_{\mathrm{S1}}^{\mathrm{I}}\varphi_{\mathrm{I}}\frac{x_{t\,\mathrm{S1}}}{D_t}\right) = (1 + i^*)\,, \tag{7}$$

and

$$(1 + \tilde{\tilde{i}}_t^{\,d})\left(1 - \theta_{S1}^{I}\varphi_I \frac{x_{tS1}}{D_t} - (\theta_{S2}^{I}\varphi_I + \theta_{S2}^{II}\varphi_{II}) \frac{x_{tS2}}{D_t}\right) = (1 + i^*) . \tag{8}$$

The probability of not recovering a deposit depends on the fraction of deposits, D_t, at insolvent banks ($\theta_{S1}^{I}\varphi_I (x_{tS1}/D_t)$) and at illiquid banks ($(\theta_{S2}^{I}\varphi_I + \theta_{S2}^{II}\varphi_{II})$ (x_{tS2}/D_t)), respectively.

Both shadow interest rates depend on the level of the losses in the banking system, and, therefore, vary over time. Moreover, $\tilde{i}_t^{\,d}$ is definitively increasing, as it depends on the losses of insolvent banks which, as shown above, are increasing over time. In contrast, $\tilde{\tilde{i}}_t^{\,d}$ may be non-monotonic because it depends on the losses of both insolvent and illiquid banks. Of course, when banks with illiquid projects recover their initial loss, $\tilde{\tilde{i}}_t^{\,d}$ becomes equal to $\tilde{i}_t^{\,d}$.

The actual interest rate on deposits, i_t^d, remains equal to the international interest rate, i^*, as long as the two following conditions are satisfied:

1. $y_{S2} - (1 + \tilde{\tilde{i}}_t^{\,d})L > 0$ and [16]
2. $y_{S1} - (1 + \tilde{i}_t^{\,d})L > 0$.

Condition 1 implies that even if the interest rate on deposits internalizes the risk that illiquid and insolvent banks are not able to pay back depositors at date t, illiquid banks have an incentive to renew the loan and do not declare default. Consequently, in equilibrium the probability that illiquid banks default is zero, and no risk premium is required for the possibility of having made a deposit in an illiquid bank. This is sufficient to rule out that the equilibrium interest rate on deposits is equal to $\tilde{\tilde{i}}_t^{\,d}$. Furthermore, if Condition 2 is also satisfied, insolvent banks still have an incentive to renew the loan if the interest rate internalizes the risk of their default. Therefore, the probability of observing bank defaults is zero and the interest on deposits remains equal to the international interest rate.

In order to have a soft budget constraint distortion, I assume that Conditions 1 and 2 are both satisfied at $t = 1$. This implies that there must be a sufficiently high probability that banks have funded a fast project.

Since international investors believe that with some positive probability they have made deposits in insolvent banks, whose losses are increasing over time, $\tilde{i}_t^{\,d}$ is increasing over time (and $\tilde{\tilde{i}}_t^{\,d}$ eventually is). Therefore, it is always possible to determine a date $\hat{t} - 1$, when the interest rate on deposits becomes equal to $\tilde{i}_t^{\,d}$ (or $\tilde{\tilde{i}}_t^{\,d}$) and insolvent banks (or both insolvent and illiquid ones) actually default at $\hat{t}$. The manner in which the banking crisis unfolds is analyzed in the next section.

3. THE SEVERITY OF BANKING CRISES IN BANK-BASED FINANCIAL SYSTEMS

3.1 Contagion among Banks within a Country

First, I analyze contagion among illiquid and insolvent banks within a country. For simplicity's sake I assume that $\varphi_{II} = 0$.

Let $\hat{t}$ be the first date when the surplus from refinancing insolvent slow projects becomes negative. I first analyze the case when at $\hat{t}$ the following conditions on the parameters are satisfied:

3. $y_{S1} - (1 + \tilde{i}^{d}_{\hat{t}+1})L < 0$ and
4. $y_{S2} - (1 + \tilde{i}^{d}_{\hat{t}+1})L > 0$.

The previous two inequalities imply that at $\hat{t}$ it is optimal to discontinue only insolvent projects, while illiquid slow projects are continued. Conditions 3 and 4 are satisfied at $\hat{t}$ if the productivity levels of illiquid and insolvent projects are sufficiently different.

In equilibrium, at $\hat{t} - 1$, the interest rate on deposits becomes equal to the shadow interest rate, $\tilde{i}^{d}_{t} : i^{d}_{t} = \tilde{i}^{d}_{t} \equiv (1 + i^{*})/(1 - \varphi_{I}\theta^{I}_{S1}(x_{\hat{t}S1}/D_{t}))$.

Under the assumptions of the model, this is the unique equilibrium and the interest rate on deposits rises only one period before the first bank defaults. Propositions 1 and 2 prove these results.

PROPOSITION 1: UNIQUENESS OF EQUILIBRIUM. *The date $\hat{t}$ when a crisis can occur in a type I country is unique.*

PROOF: By contradiction, assume that international investors continue to make deposits at the international interest rate until $\hat{t} - 1 > \hat{t}$ and that they expect bank defaults to take place at $\hat{t}$. In this case, the interest rate they require on deposits at $\hat{t} - 1$, $i^{d}_{\hat{t}}$, must take into account that bank defaults occur with probability $\varphi_{I}\theta^{I}_{S1}$. Moreover, at $\hat{t} > \hat{t}$, the expected loss is larger, since insolvent banks have accumulated more losses (i.e., $X_{\hat{t}1} > X_{\hat{t}1}$). This implies that $i^{d}_{\hat{t}} > i^{d}_{\hat{t}}$. But then $y_{1} - (1 + i^{d}_{\hat{t}})L < 0$ and banks default at $\hat{t} - 1$, rather than at $\hat{t}$. Therefore, in equilibrium it should hold that $i^{d}_{\hat{t}-1} > i^{*}$. Moreover, either $\hat{t} - 1 = \hat{t}$ and, hence, a crisis occurs at time $\hat{t}$ or $\hat{t} - 1 > \hat{t}$. In this case, $i^{d}_{\hat{t}-1} > i^{d}_{\hat{t}}$ and therefore a crisis should occur at $\hat{t} - 2$. Working backward, I prove that the latest time a crisis can happen is $\hat{t}$.

Furthermore, a crisis cannot happen before $\hat{t}$, because $y_{1} - (1 + \tilde{i}^{d}_{t})L > 0$, if $t < \hat{t}$ and banks do not find it optimal to default. □

PROPOSITION 2: *The interest rate on deposits rises only one period before the crisis. Formally, this means that $i^{d}_{t} = i^{*}$ if $t < \hat{t}$.*

PROOF: A crisis happens when the interest rate on deposits required to compensate for the probability of bank defaults is so high that the condition for loan renewals to insolvent projects is not satisfied, that is if $y_{I} - (1 + i^{d}_{t})L < 0$. If the risk premium implies a lower interest rate, it is still advantageous to renew loans to insolvent projects. Hence, there are no defaults. Since investors are rational agents, $\text{Prob}\{\text{bank default} \mid i^{d}_{t}\} = 0$ if $t < \hat{t}$. Competition among atomistic investors implies $i^{d}_{t} = i^{*}$ if $t < \hat{t}$. □

When the interest rate on deposits rises, the banks that funded insolvent projects default. In contrast, if Condition 4 is satisfied, illiquid projects and fast projects experience a temporary contraction in profits. Most importantly, by observing bank

defaults, investors learn that nondefaulting banks are solvent. One would expect that this is good news and, since there is no multiplicity of equilibria in the model, it should be sufficient to guarantee the stability of the banking system. In fact, it is not, as the temporary increase in the interest rate on deposits may have led illiquid banks to become insolvent. This happens if the temporary increase in the interest rate on deposits increases the interest rate burden up to the point where the present value of future profits is not sufficient to cover the interest rate expenditures on the initial period loss of illiquid slow projects. Formally, this happens if, after $\hat{t}$, the new value of the losses of banks with illiquid projects, $x_{\hat{t}+1\,S2}$, is to the right of the steady state of the difference equation describing their dynamics; that is: $x_{\hat{t}+1\,S2} > \bar{x}_{S2}$. In this case, after a few periods from the first bank defaults, ex ante illiquid banks default as well. Moreover, the mechanism leading to their default is identical to the one that led to the defaults of insolvent banks a few periods before.

Such a mechanism may well explain the generalized banking crises that hit countries whose financial systems were based on close main bank relationships. Not necessarily all the bank–firm relationships were examples of crony capitalism. Indeed, most of them could have been good for allocational efficiency. However, the sudden increase in the cost of funds due to depositors' incomplete information might have made illiquid banks no longer viable.

In contrast, banks that finance fast projects are not subject to the risk of a sudden increase in the cost of funds because fast projects are always able to reimburse the loan at the end of each period. This situation may well represent financial systems where banks have arm's length relationships with borrowers. These are not necessarily more efficient (Rajan 1992), but according to the results of the model they are less subject to problems of financial instability.

If Condition 4 is not satisfied $(y_{S2} - (1 + \tilde{\tilde{i}}^{d}_{\hat{t}+1})L < 0)$, there is no difference between illiquid and insolvent banks. When the cost of funds rises, both types default and, even ex post, investors are unable to distinguish them.[17]

Of course, the generalized banking crisis is not the only possible outcome. Depending on the parameters of the model, if $x_{\hat{t}+1S2} < \bar{x}_{S2}$, the only effect of the temporary increase in the interest rate on deposits is a temporary squeeze in the profits, and no bank defaults are observed after $\hat{t}$. This condition is more likely to be satisfied and, consequently, an increase in the interest rate has no major consequences on the solvency of illiquid banks, if the difference in productivity between liquid and insolvent projects is large enough. This is because, in this case, the current profits of illiquid projects would remain positive. Formally, this is true if $y_{S2} - y_{S1}$ is sufficiently large.[18] Alternatively, even if current profits become temporarily negative, solvency is less likely to be impaired, the lower the losses illiquid banks have to recover at $\hat{t}$. In this case, the increase in the interest rate on deposits does not imply a significant increase in the interest rate burden. This is more likely to arise if international investors attribute a small probability to the country's being type I (φ_I small) or if the expected share of insolvent banks is small (θ^{I}_{S1} small), that is if the country has developed a reputation for financial stability. In this case, the shadow interest rate on deposits is lower, and the amount of losses that a

type I country must accumulate before i_t^d increases sufficiently to cause banks to default is larger. Therefore, $\hat{t}$ is larger and so when the cost of funds rises the banks with illiquid projects have recovered most of the initial losses.

3.2 Contagion across Countries and Sequences of Banking Crises

A mechanism similar to the one described in Section 3 may lead to sequences of banking crises among countries that are considered similar by international investors, even if countries offer different investment opportunities.

Let Conditions 3 and 4 still be satisfied and assume $\varphi_{II} > 0$. Consider two countries A and B. Country A is type I and the banks that have financed negative-net-present-value projects accumulate losses. In contrast, country B is just illiquid and banks, which financed illiquid projects, progressively recover the initial-period loss, while credit is growing thanks to new investment opportunities that become available over time. However, the international investors cannot distinguish between these two situations and believe that countries A and B may be experiencing a process of accumulation of losses with the same probability, φ_I.

At date $\hat{t}$, when the cost of funds rises and country A experiences a banking crisis if Conditions 3 and 4 are satisfied international investors can rule out that country B is type I because it is known not to have any insolvent projects. Hence, the updated probability of having financed a type II country is: $\text{Prob}\{k = II \,|\, t \geq \hat{t}\} = \varphi_{II}/(1 - \varphi_I) = 1$. Although investors can rule out the possibility of being depositors at insolvent banks, this is not sufficient to exclude the possibility of a crisis in country B. The reason is the same as above: the interest rate increase may be harmful for illiquid banks. Under the same conditions on parameters described in the previous section (that is, if $x_{\hat{t}+1\,S2} > \bar{x}_{S2}$), a banking crisis in country A is followed by a banking crisis in country B. This happens because the temporary increase in the interest rate on deposits has permanent effects on the liabilities of illiquid banks and drives them to insolvency.

Sequences of banking crises arise in the model because banks of different types and countries that are considered similar by international investors share the same interest rate. The model shows that contagion across countries may occur simply because investors believe that these are similar, although there are neither financial or real linkages nor multiple equilibria. A necessary condition for banking crises and contagion to arise is that the amount of outstanding loans that are illiquid is large and that the economies are highly leveraged. This is strongly confirmed by the empirical evidence (Kaufman, 1999, Pomerleano, 1998, and Hunter, Kaufman, and Krueger, 1999). Indeed, during the Asian crisis, the countries where the outstanding bank liabilities and firm and bank leverage were lower (notably, Taiwan) were spared by the banking crisis, notwithstanding the increase in the cost of funds.

However, although when leverage is high a temporary increase in the interest rate on deposits may provoke banking crises, the renewal of loans to slow projects must be regarded positively in country B since it allows illiquidity problems to be overcome. Indeed, the financing of illiquid but profitable projects is often considered one of the benefits of relationship based financial systems, and credited for allowing

financiers to take a longer view on investment.[19] Notwithstanding this observation, a financial system based on relationship banking may be easily destabilized since a temporary increase in the interest rate may provoke a banking crisis. This kind of mechanism can account for the rapid spread of the crisis among East Asian economies, and helps to explain why this model of bank–firm relationship suddenly imploded and started to be called crony capitalism.

3.3 Policy Responses

Are there any institutional arrangements that can weather financial systems where close bank–firm relationships prevail from financial contagion?

An increase in capital requirements can avoid the contagion of illiquid banks. By reducing the amount of losses that must be refinanced through deposits, it reduces the effects of a given increase in the interest rate on deposits on banks' balance sheets, and makes it less likely that an increase in the interest rate burden drives illiquid banks to insolvency. In fact, as noted in Section 2.1, this has the effect of reducing the value of existing losses and makes the condition $x_{\hat{t}+1\,S2} < \bar{x}_{S2}$ more likely to be satisfied. However, capital requirements cannot eliminate the soft budget constraint distortion and do not avoid the increase in the interest rate and the consequent contraction in profits. Therefore, even if sequences of bank failures and contagion are avoided, an increase in capital requirements can never bring about an efficient allocation of funds.

Interestingly, all the results of the model hold in the presence of guarantees of deposits. In this case, the government has a maximum amount of resources it can credibly pledge to cover eventual losses of the banking system, as taxation cannot credibly be increased beyond a certain level.[20] If, in case of a banking crisis, losses are expected to be distributed equally among depositors, all the previous analysis can be repeated using the losses of the banking system net of the resources pledged by the government. It emerges that the interest rate increases only after the expected losses of the banking system increase above the resources the government can credibly pledge to depositors. Although the definition of the shadow interest rates varies slightly and the date of the crisis is delayed, it is still possible to determine a date at which the interest rate on deposits increases both for illiquid and insolvent banks and, therefore, contagion cannot be excluded (see Giannetti, 2000 for a more detailed analysis of guarantees on deposits in this context). From this it follows also that the explicit consideration of domestic lenders and deposits denominated in domestic currency would not affect the conclusions at all. Even if domestic lenders were interested in the domestic currency value of their deposits (rather than in the return in foreign currency), the eventual monetary expansion needed to guarantee the nominal value of deposits would be likely to cause inflation and reduce their purchasing power, which is what domestic depositors are ultimately interested in.

The only possible way to protect efficiently illiquid banks from an increase in the interest rate seems to be to increase transparency. Obviously, if investors could discriminate across countries and across banks within a country, the interest rate

on deposits would differ across types and contagion would not arise. Furthermore, insolvent projects would not be funded in equilibrium as the cost of funds for insolvent banks would be infinity if their type were common knowledge.

Although it may be very difficult to achieve the elimination of incomplete information, a marginal improvement in transparency may also be beneficial because it could help the development of bond markets, and enable firms to receive funds from many lenders. In fact, the existence of a soft budget constraint distortion depends crucially on the number of financiers of a firm and on the relative size of their loans. If firms have a large number of financiers who hold claims of similar size, no one has an incentive to renew loans to insolvent projects (see Hart, 1995 and Giannetti, 2000) and managers with insolvent projects do not ask for funds. Investors can exclude that banks are accumulating losses and, as a consequence, contagion does not arise.

4. CONCLUSIONS

This paper shows that banks can be easily subject to problems of contagion in financial systems where they have close relationships with banks. In fact, if there is incomplete information about the solvency of the projects financed by the banking system, banks are vulnerable to sudden increases in the cost of funds.

This problem is specific to financial systems where firms have a main bank. If fact, if firms have many lenders as happens, for instance, when bond markets are well developed, the soft budget constraint distortion that provokes the process of accumulation of losses does not arise. In this case, the possibility that banks are running a Ponzi game can be excluded and there is no increase in the cost of funds. Consequently, there are no banking crises. However, this does not imply that close bank–firm relationships are necessarily bad. In fact, the corporate finance literature shows that if asymmetric information problems are severe it may be optimal to have a single lender because this avoids the duplication of costs for information acquisition and the excessive liquidation of projects that experience temporary difficulties (Bolton and Scharfstein 1996).

Unfortunately, besides the increase of capital requirements, no easy solutions are available to improve the financial stability of bank-based financial systems. A lender of last resort, for instance, could not prevent the illiquid banks from becoming insolvent. In fact, their insolvency is not due to the premature liquidation of illiquid projects and bank runs, as in Diamond and Dybvig (1983). Instead, the increase in the interest rate on deposits turns illiquid banks insolvent and blurs the distinction between the two types of banks. In this context a lender of last resort, who can observe the quality of bank losses, should insure illiquid banks from an increase in the interest rate on deposits.

An improvement in the regulatory and legal system that encourages transparency, before the liberalization of capital inflows, seems warranted to increase the stability of bank-based financial systems and to avoid banking crises and contagion. To

guarantee that capital inflows are indeed channeled to productive firms, the regulator should be able to observe promptly bank losses and intervene before crises and contagion occur. Instead, if the level of transparency is still low it may be optimal to limit capital inflows in order to prevent the soft budget constraint distortion to arise.

NOTES

1. See Nam (1996) and Rajan and Zingales (1998) for empirical evidence on bank–firm relationships in East Asian economies, Velasco (1991) for Chile, and Drees and Pazarbaşioğlu (1995) and Gup (1998) for Nordic countries and in particular Sweden.

2. In Diamond and Dybvig (1983) and Chang and Velasco (1998) illiquid banks may default, because withdrawing the deposits is a best response if the other investors are withdrawing as well. These strategic complementarities are not considered in this paper.

3. Here, by contagion I mean the tendency of a financial crisis which begins as a country-specific event to affect other countries and regions around the globe.

4. See Pritsker (2001) and Kaufman (1999) for detailed surveys.

5. The experience of Malaysia in 1997 is a remarkably good example of the channel of contagion illustrated in this paper. Very likely, international investors considered Malaysia as similar to the other lower-income East Asian economies (Indonesia and Thailand) before the unfolding of the 1997 Asian crisis (Radelet and Sachs 1998). In fact, its banking system was relatively stronger in 1997 (IMF 1998), since following the banking crisis of 1985–1988 the asset quality of Malaysian banks had improved substantially and the ratio of nonperforming loans to total lending had fallen steadily, even if the economy was still highly leveraged. However, when the cost of external funds increased, banks and finance companies experienced a significant deterioration in asset quality, and the financial crisis unfolded in Malaysia as it did in Indonesia and Thailand. Another example is Argentina during the Tequila crisis. See Edwards (1998) for a detailed description.

6. See, for instance, Akerlof and Romer (1993), McKinnon and Pill (1996), Krugman (1998), and Corsetti, Pesenti, and Roubini (1999a and 1999b).

7. This assumption reflects very well the situation of the East Asian economies, since as noted by Hunter, Kaufman, and Krueger (1999, ch. 5), the level of accounting transparency was very low and did not allow a distinction between the insolvent and the solvent banks.

8. Results are unchanged if one assumes that also domestic banks do not know ex ante the country type. In fact, in the model only the relation between the bank and the project it funds is relevant, and it is possible to show that aggregate uncertainty would not affect banks' optimal decision.

9. I abstract from the possibility of internal financing. However, the assumption that managers cannot use retained profits to refinance the project is not restrictive because the opportunity cost of reinvesting profits must be taken into account.

10. This is a direct consequence of the inability to estimate total factor productivity.

11. Under the assumption of Bertrand competition in the banking system, the stability of manager–bank relationships can be achieved as an equilibrium outcome. Competition among banks ensures that after the first period the nominal interest rate on loans for managers running solvent projects is equal to the interest rate on deposits. Therefore, they have no incentive to switch financing bank. On the other hand, if the project is insolvent and the previous-period loan must be paid back before switching the financing bank, internal funds are not sufficient to pay back the loan. If an outside bank were asked for a loan, the amount of funds required would signal the quality of the project and no bank would accept to lend. Alternatively, even if firms do not need to repay the previous-period loan to switch financing bank, there is still a lack of incentive to change financier. In fact, the project manager who switches has a perfectly solvent project from the point of view of the new bank. Therefore, the assumptions on bank competition imply that $i^l_{t,S} = i^d_t$. In equilibrium, the profits from running the project must be transferred to the old financing bank to avoid default, and the payoff of the manager is not increased by the change of financing bank.

12. To determine the interest rate on loans at $t = 0$, it is necessary to consider that there is a positive probability that banks will be unable to recover the loans at the end of the first period, because they financed a slow project, but also that at least part of the initial period loss may be recovered in the future. Note that i^{li}_1 is equal for all the project managers, because at $t = 0$ banks do not observe their type.

13. If the liberalization of capital flows happened in a situation of weak competition in the banking sector, however, the banks could extract rents from good projects. This could, of course, limit their losses in the case where they fund both good and bad projects, and the conclusion of the model would be less clear-cut. Not casually, banking crises usually follow both the deregulation of the banking system and the liberalization of capital flows.

14. One may think that bank managers aim to minimize losses because the punishment (or the loss of reputation) is inversely related to losses.

15. I use $1/(1 + i_t^d)$ as the intertemporal discount rate, because I implicitly assume that domestic banks' liabilities and assets must be domestic deposits. Of course, their net supply in equilibrium is equal to the deposits held by the international investors.

16. This is a sufficient condition for having loan renewals by banks funding illiquid projects. The necessary and sufficient conditions for the renewal of loans at $t - 1$ is that losses are still decreasing after t. This implies $\tilde{x}_{tS2} < \tilde{x}_{S2}$, where $\tilde{x}_{tS2}$ is the value of losses at t if loans are renewed at the interest rate on deposits $\tilde{i}_t^d$.

17. If $y_{S2} - (1 + \tilde{i}_{t+1}^d)L < 0$, but $y_{S2} - (1 + \tilde{i}_{t+1}^d)L > 0$, there are two possible equilibria. If $i_t^d = \tilde{i}_t^d$ then only insolvent banks default and this is ex post rational for international investors. However, if $i_t^d = \tilde{i}_t^d$, both insolvent and illiquid banks default and this can also be supported as an equilibrium of the model.

18. This can be clarified through a numerical example. Let's assume $\theta_{S1}^I = 0.063$, $\theta_{S2}^I = 0.054$, $L = 1$, $i^* = 0.1$, $y_{S1} = 1.18$. If $y_{S2} = 1.45$, the difference in productivity between the illiquid and the insolvent project is relatively high: the interest rate on deposits increases and insolvent banks fail at $t = 5$, but there is no contagion as $x_{5S2} < \tilde{x}_{S2}$. However, if the productivity of the illiquid project is lower, for instance, $y_{S2} = 1.37$, the failure of insolvent banks at $t = 5$, is followed at $t = 6$ by the failure of illiquid banks, because $x_{5S2} > \tilde{x}_{S2}$. Finally, if $y_{S2} = 1.21$, both insolvent and illiquid banks fail at $t = 2$.

19. In financial systems based on arm's length relationships, in which firms have many financiers, loans to projects in temporary difficulties are often not renewed. See, for instance, Hart (1995).

20. See Corsetti, Pesenti, and Roubini (1999a), McKinnon and Pill (1996), and Krugman (1998) for similar assumptions.

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