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# Financial Liberalization and Banking Crises: The Role of Capital Inflows and Lack of Transparency

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## Abstract

This paper shows that the liberalization of capital inflows may undermine bank stability in emerging markets. After financial liberalization, uninformed international investors rationally provide large amounts of funds at low cost. This enables insolvent banks to accumulate bad loans. In equilibrium, when a substantial amount of losses may have been accumulated, solvent banks do not find it any longer optimal to issue debt at the interest rate that would compensate investors for risk. Investors anticipate this and stop holding bank debt. When the market for bank liabilities breaks down, insolvent banks default. I show that, because of wasteful investment, the liberalization of capital inflows may decrease aggregate welfare.

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Keywords: Banking crises, Capital inflows, Transparency, Capital requirements

JEL Classifications: G21, G28, F34

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# Financial Liberalization and Banking Crises:
## The Role of Capital Inflows and Lack of Transparency

**Mariassunta Giannetti***

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## 1. Introduction

Financial liberalizations in emerging markets are often followed by reckless lending and severe banking crises.[1] The identification of the causes of banks' behavior is often difficult because financial liberalizations entail several contemporaneous changes. Competition in the banking sector increases, and, at the same time, the liberalization of the current account allows capital inflows.

The existing literature has mainly stressed the first of these changes: Among others, Hellmann, Murdock and Stiglitz (2000) and Allen and Gale (2000) have analyzed how competition affects banks' incentives to risk-taking. The argument goes as follows: Competition in the market for deposits increases banks' cost of funds and gives an incentive to select riskier projects (to shift risk on depositors).

While this argument can provide a good explanation for the Saving and Loan crisis in the U.S., and, in general, for banking crises in developed markets, it is unlikely to capture the effects of financial liberalizations in emerging economies. In these countries, the liberalization of the capital account, which is an essential part of the financial liberalization, implies that large amounts of funds become available to the banking system, thanks to capital inflows. Since emerging market economies are small with respect to the funds potentially available from international investors, the supply of funds becomes perfectly elastic. Hence, not only is competition unlikely to increase the cost of funds, but the cost of bank liabilities often decreases because banks are no longer constrained by low domestic saving (Henry, 2000). Competition in the loan market is also unlikely to become so fierce as to significantly decrease intermediation margins and increase incentives to risk-taking. In fact, information asymmetries remain strong after financial liberalizations and banks face little competition from financial markets (Demirguc-Kunt, Laeven, and Levine, 2004). Hence, the very mechanism on which the competition argument relies –lower profit margins– is unlikely to be at work.

Probably for this reason, the vast literature on banking crises in emerging markets considers bailout guarantees as the main cause of excessive lending to unprofitable projects.[2] Bailout guarantees would cause moral hazard because of the lack of punishment for investors and domestic banks in case of default. Knowing that banks will be bailed out, investors would

[1] See Kaminsky and Reinhart (1999) for a detailed description of the empirical evidence.

[2] There is a large literature relying on bailout guarantees. See, for instance, McKinnon and Pill (1996); Dooley (1997); Krugman (1998); Burnside, Eichenbaum and Rebelo (2001); Corsetti, Pesenti and Roubini, (1999); Chinn and Kletzer (2000); Dekle and Kletzer (2001); and Schneider and Tornell (2004). Bailout guarantees play an important role also in Akerlof and Romer (1993) where overlending arises because of looting.

provide funding even though they know that domestic banks are financing negative-net-present-value projects.

However, the empirical evidence on the bailout guarantees explanation is mixed (Eichengreen and Arteta, 2000). Martinez Peria and Schmukler (2001) find that depositors discipline banks by withdrawing deposits and requiring higher interest rates when bank fundamentals deteriorate, if the credibility of deposit insurance is weak. Additionally, Davenport and McDill (2005) find that deposit insurance does *not* diminish the extent of market discipline in the U.S., where the credibility of bailout guarantees should be far higher. Gorton and Winton (2002) also question the relevance of the bailout guarantees explanation.

This paper proposes a new explanation for boom-bust cycles in emerging markets. It shows that capital inflows may be at the origin of overlending problems. In the model, banks do not observe whether borrowers have access to positive-net-present-value projects when they begin to lend. As a result, banks may become insolvent. In this case, having limited liability, banks refinance negative-net-present-value projects, if they have access to funds. Thus, capital inflows may cause overlending because they increase the amount of funds domestic banks can intermediate.

In equilibrium, overlending arises if investors have incomplete information about the quality of bank assets. Incomplete information may originate from the fact that, within a country, some banks are sound, while others are insolvent. It may also depend on the fact that investors are unable to judge the determinants of lending booms. Consequently, they are uncertain whether capital inflows finance profitable investment opportunities or are used to roll over bad loans.[3]

Incomplete information may explain why, in equilibrium, investors initially provide short-term loans to domestic banks at a relatively low interest rate, and only later on require a risk premium: Investors require a risk premium for lending to domestic banks only if there is a positive probability of bank defaults. In the early phase of the lending boom, since the expected amount of bank losses is still low, the probability of having lent to an insolvent bank is small. The risk premium, which compensate for such an event, is thus relatively low. Both solvent and insolvent banks issue debt (and fund their borrowers) if investors ask to be compensated for risk. This implies that any investor can be reimbursed in full because there are other investors who want to hold bank debt at the equilibrium interest rate. Hence, investors

[3] In support of this, Caprio and Klingebiel (1996) do not find any stable relation between credit growth and credit problems in a sample that includes both emerging markets and industrialized economies. This suggests that lending booms may lead to banking crises, but also spur growth, especially in countries with developed financial systems.

*rationally* do not require any risk premium.

If some banks are expected to accumulate losses, however, the probability of not recovering the capital invested increases, and so does the risk premium that compensates investors for risk. When a substantial amount of losses has potentially been accumulated (the threshold is determined endogenously in the model), solvent banks do not find it any longer optimal to issue debt at the interest rate that would compensate investors for risk. Investors anticipate this. Hence they first ask for a risk premium, and then completely stop holding bank debt. Insolvent banks thus default.

Put differently, the insolvency of a few banks creates a lemon problem in the market for bank liabilities, like in Akerlof (1970). In the early stage, the lemon problem is not as severe as to disrupt solvent banks' demand for funds. The market for bank liabilities can thus thrive. As bank losses grow, the lemon problem becomes more severe. Solvent banks stop issuing debt when the risk premium becomes too high. Investors, aware of this, do not lend to domestic banks any longer. Only then, insolvent banks stop the process of evergreening of loans and declare default.

I show that in this context the liberalization of capital inflows may decrease aggregate welfare. After the financial liberalization, some capital is invested in negative-net-present-value projects. Depending on the country's investment opportunities and the availability of domestic funds, the increase in profitable projects that receive funding may not be sufficient to compensate for the wasteful investment. If the country has low growth opportunities or high domestic saving, financial liberalizations decrease the average productivity of investment and ultimately aggregate welfare.

The model suggests some policy implications for avoiding boom-bust cycles. The presence of bailout guarantees appears to be irrelevant for overlending to arise. Restrictions on capital inflows could limit (or even avoid) credit expansion to insolvent projects, but would also constrain the number of projects that are started in countries with good growth opportunities. Also attempts to lengthen the maturity of capital inflows do not help eliminate overlending problems, because long-term debt does not prevent banks from accumulating losses.

Other mechanisms, which act by improving market discipline, are preferable. Greater transparency about the effective conditions of emerging economies, higher capital requirements and diversification of bank assets could improve financial stability. If investors knew the quality of bank assets, they would not lend to banks that fund negative-net-present-value projects. Even if international financial institutions are making efforts in this direction

(Fischer, 1999; Basel Committee on Banking Supervision, 2003), it is difficult to completely overcome asymmetric information. Transparency by itself may not be sufficient to improve financial stability because even a small amount of incomplete information may lead to banking crises in the long-run, if the mechanisms highlighted in the model are at work.

Another, possibly easier, way of improving financial stability is by weakening banks' incentives to renew loans to negative-net-present-value projects. Solvent banks do not renew bad loans because this would not maximize their net wealth. Hence, financial stability could be improved by increasing bank capital in countries with severe asymmetric information. Alternatively, financial stability could be improved by creating the conditions for better diversification of bank assets.[4] If banks are well-diversified, their solvency is less likely to depend on the outcome of a handful of loans. Banks are thus less likely to become insolvent. Incentives to renew loans to insolvent projects therefore become weaker. Banks have weaker incentives to specialize and diversify their assets in environments where asymmetric information is lower (Winton, 2003). Transparency could thus improve financial stability thanks to the *indirect* effects on the structure of bank-firm relationships.

The remaining of the paper is organized as follows. Section 2 describes the related literature. Section 3 describes the model. Section 4 and 5 describe the equilibrium with and without capital inflows. Section 6 presents the welfare analysis. Section 7 examines some extensions of the model. Section 8 describes the institutional arrangements that can improve financial stability. Section 9 concludes.

## 2. Related literature

The model is related to several other papers in the literature. First, it builds on Dewatripont and Maskin (1995), by analyzing how the availability of funds to expand credit may lead not only to the financing of negative net-present value projects, as they show, but also to boom-bust cycles.

Second, the paper is related to first generation models of currency crises because it explains why fundamentals may not affect the interest rate on bank liabilities for a long time in the same way as the exchange rate appears not to incorporate fundamentals in the early phase of a speculative attack (Flood and Garber, 1984).

[4] In emerging markets, bank assets are often concentrated in a handful of borrowers (Drees and Pazarbaşioğlu, 1995; Nam, 1996; Velasco, 1991). Bank stability may thus depend on a single borrower.

Third, the model is related to Giannetti (2003), who also studies the effect of transparency (incomplete information on the quality of bank assets) on the stability of the banking system in a model that borrows from first generation models of currency crises.

Giannetti (2003) and this paper have different focus and different implications on the dynamics of banking crises. Giannetti (2003) studies sequential banking crises and contagion, while this paper shows that asymmetric information can cause a sudden and complete collapse of the credit market. This paper abstracts from problems deriving from banks' illiquid assets and contagion. This paper also analyzes why the collapse of the market for bank liabilities can happen after the financial liberalization, but not when the economy is closed to capital inflows; and several possible policy responses, not considered in Giannetti (2003), which can help to reduce financial instability.

The dynamics of the banking crisis is different in the two models because of different assumptions on banks' objectives. In Giannetti (2003), insolvent banks' managers face a trade-off because, on the one hand, they enjoy continuing lending to insolvent projects and, on the other hand, they derive disutility from accumulating further losses. At some point, when the equilibrium interest rate implies a large enough increment in the losses, insolvent banks' managers *voluntarily* declare default. In this paper, the payoff of the managers of insolvent banks does not depend on the level of bank losses, because banks are more realistically assumed to have limited liability. This assumption generates important differences in the dynamics of the crisis. The model in this paper implies that solvent banks at some point drop out of the market. For this reason, consistently with the empirical evidence, international investors completely stop lending when the crisis happens. The market for bank credit collapses because of a lemon problem that was initially latent. In Giannetti (2003), instead, there is no lemon problem. International investors require a finite risk premium that drives only *insolvent* banks out of the market. Illiquid banks continue to lend, but, as she shows, the temporary increase in the interest rate burden may have made them insolvent. Illiquid banks may thus fail after a few periods. Not only there is no collapse in the market for bank liabilities in her model, but, given the different assumptions on banks' objectives, solvent liquid banks (which are not explicitly considered) would not be affected.

Additionally, even though in both papers the interest rate on bank liabilities initially does not incorporate the risk premium, the similarities on the equilibrium path of the interest rate stop here. In this paper, the interest rate is equal to the risk free interest rate and then rises abruptly to infinite, after incorporating a finite risk premium for one period. In Giannetti (2003), the interest rate rises to incorporate a finite risk premium for two periods (when

insolvent banks default). It then decreases for a few periods before rising again (when illiquid banks defaults occur). While Giannetti (2003) can provide a good explanation for sequential banking crises across countries, this paper has more realistic implications for the dynamics of banking crises within a country and describes how a lemon problem in the market for bank liabilities can originate a bubble-like equilibrium.

The two papers have also different welfare implications. While Giannetti (2003) does not explicitly consider welfare implications, under her assumptions, insolvent banks accumulate losses only if renewing the loan after the first period is efficient (the return from continuing the project is higher than the risk free interest rate after the first period loan is sunk). As will be clearer later, the results of this paper hold under more general assumptions (insolvent banks having limited liability renew loans to any project in order to postpone default) and, more importantly, imply that financial liberalization can decrease aggregate welfare because it decreases aggregate return to investment in a country.[5]

Finally, this paper contributes to the literature on banking crises in emerging markets by clarifying to what extent bailout guarantees and the currency of denomination and the maturity of bank liabilities contribute to bank instability. In particular, it shows that bailout guarantees are irrelevant and, under certain circumstances, may even help to decrease the accumulation of bank losses. If bank liabilities are denominated in domestic currency, the only effect of bailout guarantees is to transform the risk that investors bear from default risk in exchange rate risk because the government can at most guarantee the nominal value of bank liabilities.

## 3. The model

In emerging markets, the process of financial liberalization entails both the deregulation of the financial sector, which increases competition in the banking system, and the liberalization of the capital account, which enables domestic financial institutions to borrow abroad (Kaminsky and Schmukler, 2002). Financial liberalizations are often followed by large capital inflows, mostly consisting of short-term debt intermediated by the banking system.[6] Capital inflows in turn foster lending booms, which often lead to banking crises (Kaminsky and Reinhart, 1999; Caprio, Honohan and Stiglitz, 2001).

[5]If loans are renewed only when continuing the project is efficient, the negative welfare effects of the financial liberalization are clearly much smaller.

[6]For instance, the World Bank (1998) reports that, before the 1997 crisis, East Asian banks intermediated large amounts of foreign debt with maturity under one year.

In what follows, I build a model that studies the effects of short-term capital inflows on a small open economy with a competitive banking system. The structure of the model is as follows. There are three types of agents: project managers, domestic banks, and investors. Investors may be either domestic or foreign. Domestic and foreign investors are identical. Investors buy short-term debt issued by domestic banks. The domestic banks decide whether to finance managers, who have the option to start a project and need external financing.

The results of the model derive from the assumptions on the information structure. There are three types of asymmetric information. First, the quality of a project is initially private information of the project manager. After one period, the financing bank can determine the project quality because it observes whether the project manager pays back the initial loan. Second, investors do not know which type of project has been financed by their bank, but have information on the average quality of bank assets. Third, investors have incomplete information on the average quality of bank assets in a country.

As will be clear later, the third type of incomplete information is not crucial for any of the main results of the paper. It is assumed mostly for realism and generality and it is necessary only for the generalization in Subsection 7.3, where I consider conditions under which twin banking and currency crises arise. Additionally, incomplete information on the quality of bank assets allows explaining why banking crises may affect several countries at the same time.

The assumptions on the information set imply that investors cannot observe the output of the projects funded by the banking system. This can be justified on two grounds. First, developing countries' statistics are often imprecise and unreliable. Firm financial statements and growth of the aggregate output, even if observed, may not be easy to interpret, because the liberalization of capital inflows, which 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 price of non-traded 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. If observed, aggregate output and macroeconomic data, such as capital inflows, could at most be a noisy signal of country types. Even if investors observe such a noisy signal and update their beliefs on the country type, all the results of the paper go through, as all agents are risk neutral. The only relevant difference is that the date of the crisis to be determined below is stochastic (i.e., a crisis is delayed by a sequence of positive shocks to the output). I address this extension in Subsection 7.4.

Not only incomplete information is plausible in emerging markets, but is also relevant. Recent empirical evidence (Tadesse, 2004) shows that banking crises are more likely in less transparent countries. Lack of transparency on the positions built up by borrowers and lenders has also been stressed as an important determinant of the intensity of recent crises in the policy debate (Fischer, 1999; Basel Committee on Banking Supervision, 2003). In marked contrast, incomplete information plays no role in most of the explanations of banking crises, which rely either on bailout guarantees or on multiple equilibria and liquidity problems (Chang and Velasco, 2000 and 2001).

A more detailed description of the model follows.

### *3.1. Projects*

I first describe investment opportunities at *t=0*. At *t=0*, a country has a continuum of managers of mass one who can start a project. The project managers are risk neutral. 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. The project managers have no initial wealth and need loans from domestic banks to invest in their projects. The projects have fixed scale and can be either solvent (S) or insolvent (I). Ex ante no agent in the economy with the exception of the project manager can distinguish the project type.

Solvent projects generate $y_S$ units of output after one period, if $L$ units of the good have been invested. If the project is refinanced in each period, production lasts forever.[7] The return on solvent projects is higher than return on the risk free asset, $i^*$: $y_S > (1+i^*)L$. The private benefits of a project manager running a solvent project (good manager), $E_S$, are positive. Hence, a solvent project is always started if it receives a loan.

An insolvent project does not generate any output at date *t=1*, even if $L$ has been invested at *t=0*. From $t \geq 2$, it generates output $y_I$, if $L$ is invested at *t-1* and, like a solvent project, it can be continued forever. The net present value of an insolvent project is negative at *t=0*. This implies that the following condition holds:

$$y_I < (1+i^*)^2 L. \qquad (1)$$

[7] I abstract from the possibility of internal financing. However, the assumption that managers cannot use retained profits to refinance the project is not restrictive if the opportunity cost of reinvesting profits is taken into account.

Condition (1) requires that the insolvent project (even if continued forever) provides a lower return to investment than the risk free asset.

A project manager running an insolvent project (bad manager) has positive private benefits only if the project is refinanced at *t=1* and has a chance to produce positive output. In this case, the manager's private benefits are $E_{I/R} > 0$. If the project defaults after the first period, the manager's private benefits are negative ($E_{I/D} < 0$). This makes sense if running a firm without producing any output has a stigma effect on the project manager. Alternatively, the manager might extract more from a project if it produces positive output. The manager can always achieve a payoff of zero by not starting the project.

The assumptions on project outputs and managerial private benefits are similar to Dewatripont and Maskin (1995). They ensure that managers with insolvent projects undertake the project if they anticipate to be refinanced. This problem is generally referred to as "soft-budget-constraint distortion." The problem I model is however not identical to Dewatripont and Maskin (1995), who assume that the first period investment is written off and that, afterwards, continuing the project is profitable (i.e., $y_I - L(1+i^*) > 0$). In my model, the first period investment is never written off. Nevertheless, as will be clear later, insolvent banks have an incentive to renew loans even if this implies accumulation of further losses because they have limited liability. Hence, projects such that $y_I - L(1+i^*) < 0$ are refinanced.

### *3.2 Country types*

Countries can be of two different types. Country types differ in projects' average return and cannot be distinguished by investors. Differences in the average return result from a different mix of heterogeneous projects.

A country may be crisis prone (type I) or not (type II). A country is type I if it is endowed both with solvent and insolvent projects, in proportions $\theta$ and 1-$\theta$, respectively, while it is type II if it has only solvent projects. Besides being more productive, a type II country also has growing investment opportunities: New solvent projects become available each period so that total lending grows at the same rate of a type I country. Capital inflows are thus not informative about the country type. Total lending may be increasing for very different reasons and investors cannot distinguish whether current account imbalances are due to capital flowing to the most advantageous investment opportunities or to overlending problems. This is in marked contrast with the existing literature which assumes either that current account

imbalances are bad because they are driven by accumulation of bank losses (Krugman, 1998), or that capital inflows are good because they finance high-yield investment opportunities in low-saving countries (Obstfeld and Rogoff, 1995).

The prior of investors is that a country is type I (i.e., it has a fraction $1-\theta$ of insolvent projects) with probability $\varphi_I$. It is important to note that the main results of the paper hold if $\varphi_I = 1$. Incomplete information on the country type is needed only for the generalization in Subsection 7.3, where I consider conditions under which twin banking and currency crises arise.

For simplicity, I assume that banks do not observe the country type and share investors' prior beliefs. None of the results however depends on this assumption as bank lending policies depend only on the interest rate on bank liabilities. Finally, I assume that at $t=0$ the expected return on investment is higher than the risk free interest rate: $\left(\varphi_I\theta+\left(1-\varphi_I\right)\right)y_S > (1+i^*)L$. This ensures that banks have incentives to lend.

### *3.3. Domestic banks*

Risk neutral managers run domestic banks[8] and maximize bank net wealth, which is equal to the expected discounted profits. At $t=\tau$, a bank's net wealth is:

$$V_{\tau-1} = \sum_{t=\tau}^{\infty} \frac{E\left(\left(1+i^l_{t,j}\right)l_{t-1} - \left(1+i^d_t\right)d_{t-1}\right)}{\left(1+i^*\right)^t}, \qquad (2)$$

where $E$ is the expectation operator, and $l_t$ and $d_t$ are respectively loans and liabilities at time $t$.[9]

Each period bank managers decide whether to lend at the interest rate $i^l_{t,j}$ (which varies according to the project type, $j$, and is optimally chosen taking into account bank competition as is described below) and how much debt to issue at the interest rate $i^d_t$. For the time being, I assume that bank assets and liabilities are denominated in real terms and have maturity of one period. Hence, banks, like project managers, refinance their liabilities every period. At any date $t$, before taking any lending and borrowing decisions, insolvent banks have outstanding loans

[8] Here I abstract from the micromotives for banking and focus on banks' and investors' incentives under different institutional arrangements.

[9] Equation (2) presumes that banks do not write off bad loans and keep them on the books.

and liabilities equal to their previous losses, $x_t$. Hence, the manager of an insolvent bank can choose $d_t$ and $l_t$ under the constraints $d_t \geq x_t$ and $l_t \geq x_t$.

A bank that has accumulated losses $x_t$ defaults at *t* if it cannot issue debt $d_t \geq x_t + L$, in order to refinance the bad managers funded at *t=0*. In contrast, a bank that has funded a good manager has no losses and can always choose $d_t = 0$ and reimburse investors.

The value of the bank for the manager is equal to the net wealth if non-negative, and to zero otherwise, because banks are assumed to have limited liability. If the net wealth becomes negative, bank managers avoid default in order to postpone a reputation penalty that accrues with it as long as possible. For notational simplicity, I assume that banks have no initial capital. I discuss the implications of relaxing this assumption in Section 7.

Notice that banks find it optimal to choose $d_t = l_t$ as investors can invest directly in the risk free asset, while only banks can lend to domestic project managers.

There is a continuum of banks of mass one that compete *à la* Bertrand in the loan market by bidding the interest rate to attract borrowers.[10] For simplicity, I assume that at *t=0* each bank finances a project. In a type II country, new projects that become available at $t \geq 1$ are financed by the existing banks. Project managers and banks are randomly matched and no manager changes financing bank.[11]

At *t=0*, banks have the same information as investors. At *t=1*, after observing whether the project manager repays the first period loan, banks learn the type of project they have funded.[12]

The assumptions on bank competition imply that for solvent projects: $i^l_{t,S} = i^d_t$ as long as solvent banks find it optimal to lend. It will be clear in Section 3 that this implies the following feasibility condition: $\frac{y_s}{L} - 1 \geq 1 + i^d_t$. In contrast, banks can appropriate profits if previous loans

[10] This assumption is common in models of bank-firm relations (see Von Thadden, 2004; Rajan, 1992; Sharpe, 1990) and captures a situation of strong competition. It is consistent with the fact that the liberalization of capital inflows is often accompanied by the deregulation of the banking sector, which makes the environment highly competitive.

[11] Under the assumption of Bertrand competition, the stability of manager-bank relationships can be achieved as an equilibrium outcome if project managers cannot switch banks without previously repaying the loan. In this case, only managers with solvent projects can switch bank because the amount of funds required by a bad manager would signal the quality of the project and no bank would accept to lend. Competition among banks ensures that after the first period the nominal interest rate on loans for solvent projects is equal to the interest rate on deposits. Therefore, good managers have no incentive to switch financing bank.

[12] This implies that banks can update their beliefs on the country type. In particular, banks that have funded an insolvent project learn to be in a type I country.

have not been repaid.[13] Note that the assumption of incomplete information on the quality of bank assets implies that investors do not observe the lending rate. This is consistent with the previous literature on bank-firm relations (Sharpe, 1990; Rajan, 1992; Von Thadden, 2004). Additionally, since banks do not provision for losses, loan income does not reveal the actual bank status.

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 assumption of competition à la Bertrand, the interest rate must be such that banks' expected profits are equal to zero. With probability $\varphi_I(1-\theta)$ banks are unable to recover the loans at the end of the first period, because they financed an insolvent project. In this case, the expected discounted profits become negative and the value of the bank to its shareholders is zero. Hence, the interest rate, at which banks break even (and lend) at *t=0*, is: $i_1^l = \frac{1+i_1^d}{\varphi_I\theta+(1-\varphi_I)}-1$. The assumptions on project availability in Subsection 2.1 ensure that banks break-even if $i_1^d = i^*$.

### *3.4. Investors*

Before financial liberalization, only domestic investors can hold bank liabilities. After financial liberalization, international investors can lend to domestic banks and, in countries with low domestic saving, they hold most of the bank liabilities. Both domestic and international investors have incomplete information on the quality of bank assets. In the context of the model, this implies that they observe only the aggregate capital inflows to a country, which are not informative on the available investment opportunities, as explained in Subsection 3.2.

All lenders are risk neutral. Hence, they invest in the economy only if the expected return is larger or equal to the risk free interest rate, $i^*$. Each investor lends *L* units of capital. The mass of international investors is large with respect to the investment opportunities of a country, while domestic investors alone can lend at most *S* in the aggregate.

Investors simultaneously announce the lowest interest rate at which they would lend to banks. Since they behave competitively, after financial liberalization, investors' expected return is equal to the risk free interest rate in equilibrium. If this condition is satisfied and there

[13] Note that insolvent banks, not caring about the level of their losses, could also charge a lower interest rate in

are no restrictions on capital movements, any amount of foreign capital can flow into the economy.

### *3.5. Timing*

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

- The output of projects financed in *t-1* is realized. The project manager appropriates profits, $\pi_{tj} = y_j - (1 + i^l_{t,j})L$, if previous loans have been repaid. Otherwise, the financing bank appropriates profits.
- Based on their beliefs on the losses of domestic banks and the probability of bank defaults, investors announce the minimum interest rate, $i^d_{t+1}$, at which they are willing to lend to domestic banks.
- After observing $i^d_{t+1}$, banks decide whether to issue debt in order to renew loans. Only solvent banks are able to reimburse investors, if they do not renew loans. Banks that funded insolvent projects default if they cannot renew loans.
- If banks renew loans, production continues until the following period. If there is a default, the investors of an insolvent bank share its assets. The game ends when banks stop renewing loans.

The economy is in equilibrium if all agents maximize their objective functions, their beliefs are confirmed, and markets for loan and bank liabilities clear. In what follows, I focus on a symmetric competitive equilibrium in which all banks take the borrowing rate as given.

## 4. Lending policies with capital inflows

This Section illustrates the effect of capital inflows on bank lending policies, bank losses, and the equilibrium interest rate on bank liabilities. It shows that lack of restrictions on the growth of bank liabilities can undermine the stability of the banking system.

### *4.1. Bank lending decisions and losses*

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equilibrium. They would accumulate losses faster, but none of the results of the model would change.

I first analyze banks' lending decisions. The assumptions on project payoffs and bank competition in Subsections 3.1 and 3.3 imply that losses cannot be recovered. Hence bank managers treat the continuation value of the expected discounted profits as a lump-sum constant in deciding the current period lending and borrowing policies. Solvent banks maximize the expected discounted profits and consequently fund projects if and only if, in the current period, the expected repayment is large enough to compensate for the cost of funds. In other words, at *t*, solvent banks renew loans if and only if the following condition is satisfied: $y_S - (1+i_t^d)L > 0$.

Banks that have funded insolvent borrowers at *t=0*, however, have different incentives: Their expected discounted profits are negative. For instance, at *t=1,* they can obtain a repayment of $y_I$ against a loan (and liabilities) of $\left(L+\left(1+i_1^d\right)L\right)\left(1+i_2^d\right)$. Inequality (1) clearly implies that at any date *t* the expected repayment of a bad manager is less than the liabilities that the bank has to issue to fund the project, even if $i_1^d = i_2^d = i^*$. Hence, because of limited liability, once a loss is realized, the bank manager's payoff no longer depends on the cost of debt and the lending rate. The bank manager chooses to roll over bad loans and defaulting in the future to avoid the reputation penalty. Insolvent banks thus continue to lend as long as investors are willing to provide funds even if this involves accumulation of losses. These considerations can be summarized in Lemma 1.

**Lemma 1. Banks' lending decisions.** *Solvent banks issue short-term debt and renew loans if and only if* $y_S - (1+i_t^d)L > 0$. *Insolvent banks always issue short-term debt and renew loans if investors are willing to hold bank liabilities.*

In a small open economy open to capital inflows, bank can issue any amount of liabilities as long as investors are promised the risk free interest rate in expected value. In equilibrium, banks that fund insolvent projects at *t=0* can renew loans. Anticipating this, at *t=0* bad managers start their projects and some banks actually become insolvent. The equilibrium is similar to the equilibrium with centralization of Dewatripont and Maskin (1995): Bad managers ask for funds at *t=0*, if they expect banks to have large availability of funds at *t=1*. In Dewatripont and Maskin, large banks have a soft budget constraint because they have a large amount of internal funds. Here, the budget constraint becomes soft, if capital inflows are allowed and the aggregate supply of funds is large. Additionally, while in Dewatripont and Maskin (1995) the renewal decision is always efficient, I assume that some banks, being

insolvent, have an incentive to renew loans even if this increases their losses. This generates novel results on the dynamics of the banking crisis.

By renewing loans to insolvent projects, banks that happen to fund bad managers at *t=0* accumulate losses. The losses of a bank that financed an insolvent project are a state variable. Their dynamics evolve according to the following difference equation:

$$x_t^I = (1+i_t^d)x_{t-1}^I + \left[(1+i_t^d)L - y_I\right], \tag{3}$$

with initial condition $x_0^I = L(1+i_1^d)$. Equation (3) shows that the level of losses of any bank financing an insolvent project at time *t*, $x_t^I$, depends positively on the previous period losses, $x_{t\text{-}1}^I$, and on the interest rate that must be paid on debt, $i_t^d$, and negatively on the current period profits, $\left[y_I - (1+i_t^d)L\right]$. The losses of a bank that funded a solvent project are equal to zero.

It is important to note that losses grow over time (i.e., $\tilde{x}_{t+1}^I > \tilde{x}_t^I$), even if banks renew loans to insolvent projects with positive current profits because insolvent projects' current profits do not cover the interest rate payments on the initial loss even if $i_t^d = i^*$.

The dynamics of the model depends on the banking system aggregate losses. These in turn mimic the losses of individual banks, $x_t^I$. Taking into account that there is a continuum of insolvent projects of mass $1-\theta$, the dynamics of the aggregate losses, $X_t$, are described by:

$$X_t = (1+i_t^d)X_{t-1} + [(1+i_t^d)L - y_I](1-\theta) \quad \text{if } X_t > 0, \tag{4}$$

with initial condition $X_0 = (1+i_1^d)L(1-\theta)$. Losses remain equal to zero, otherwise. They are always equal to zero in type II countries.

**Lemma 2. The dynamics of aggregate losses.** *The aggregate losses of the banking system increase over time in a type I country, even if the interest rate on bank liabilities is equal to the risk free interest rate,* $i^*$.

**Proof**. The assumptions on project outputs imply that the initial condition of equation (4) is at the right of the steady state, $\bar{X}^{SS} = \dfrac{[y_I - (1+i^*)L](1-\theta)}{i^*}$ and, consequently, the path of the aggregate losses is explosive. ■

Aggregate losses grow over time in type I countries because the current period profits are not sufficient to cover the interest rate on the first period loss. Figure 2 represents the law

of motion of aggregate losses in a type I country, if the interest rate on bank liabilities is equal to the risk free interest rate.

[Insert Figure 1 here]

*4.2. The cost of funds and the unfolding of the crisis*

Lemma 1 establishes that insolvent banks stop renewing loans and default only if investors no longer want to hold bank short-term debt. This is possible in an economy with capital inflows if investors expect to lose their investment with probability one. These beliefs are confirmed if solvent banks do not find it optimal to issue debt at the interest rate that compensates investors for the risk of bank defaults. A crisis may thus happen only if the interest rate on bank liabilities increases.

For characterizing the equilibrium, it is necessary to determine the equilibrium interest rate on bank liabilities. In equilibrium, the expected return on bank liabilities must be equal to the risk free interest rate. Hence the interest rate on bank liabilities is determined by investors' beliefs about the probability of bank defaults, which must be equal to the actual probability of bank defaults in equilibrium. The probability of bank defaults in turn is conditional on the interest rate on bank liabilities at time *t* because insolvent banks default only if the cost of funds becomes infinite (investors no longer want to hold bank debt).

To determine the equilibrium interest rate on bank liabilities, I evaluate the probability that an investor holds debt of an insolvent bank at any date *t*. Note that this probability is equal to the probability of not recovering the investment only if insolvent banks actually default at *t*. To capture this, I follow the methodology of Flood and Garber (1984) and define a shadow interest rate on bank liabilities.[14] The shadow interest rate on bank liabilities is the interest rate at which investors are willing to lend, if they expect insolvent banks to default.

The shadow interest on bank debt issued at time *t*, $\tilde{i}_{t+1}^{d}$, is:

$$\left(1-\varphi_I\right)\left(1+\tilde{i}_{t+1}^{d}\right)+\varphi_I\left(\frac{\left(X_t+(1-\theta)L\right)}{D_t}\frac{y_I}{x_t+L}+\left(\frac{D_t-X_t-(1-\theta)L}{D_t}\right)\left(1+\tilde{i}_{t+1}^{d}\right)\right)=\left(1+i^*\right), \qquad (5)$$

where $D_t$ is the aggregate level of bank liabilities.

Equation (5) requires that the return on investing one unit of capital in a country where banks might be accumulating losses is equal to the return of the risk free asset in expected

value. The left hand side implies that an investor receives $1+\tilde{i}_{t+1}^{d}$ with probability $(1-\varphi_I)+\varphi_I\left(\frac{D_t - X_{t-1} - (1-\theta)L}{D_t}\right)$ (that is, if the investor is lucky enough to invest in a non-crisis-prone country or in a solvent bank in the type I country) in return of one unit of capital. The investor buys liabilities of an insolvent bank with probability $\varphi_I \frac{\left(X_{t-1}+(1-\theta)L\right)}{D_t}$. In this case, she shares the only assets of the bank, $y_I$, with all the other claimants; the return is $\frac{y_I}{x_{t-1}+L}$.

Equation (5) can be rewritten as:

$$(1-\varphi_I)\left(1+\tilde{i}_{t+1}^{d}\right)+\varphi_I\left(\frac{(1-\theta)y_I}{D_t}+\left(\frac{D_t - X_t - (1-\theta)L}{D_t}\right)\left(1+\tilde{i}_{t+1}^{d}\right)\right)=\left(1+i^*\right). \qquad (6)$$

Equation (6) implies that there is a positive relation between the shadow interest rate on bank liabilities, $\tilde{i}_{t+1}^{d}$, and $X_t$, whose dynamics, described by equation (4), are taken as given by investors. Since the aggregate losses in a type I country are expected to increase over time, the shadow interest rate increases over time.

As $X_t$ grows $\tilde{i}_{t+1}^{d}$ becomes so high that, at that interest rate, it is no longer optimal for solvent banks to renew their loans. If investors demand such a high risk premium, solvent banks do not refinance the solvent projects and reimburse all investors. Hence, only insolvent banks, which do not care about the magnitude of their losses because of limited liability, would issue debt. Investors however expect to make losses with probability one. Therefore, they ask for an infinite interest rate on bank liabilities. In other words, they suddenly stop lending, as we often observe in emerging markets (Kaminsky and Reinhart, 1999). Insolvent banks, not being able to renew their loans, default.

These considerations allow me to solve for the timing of the crisis, and, then, by backward induction, for the equilibrium before the crisis.

**Proposition 1. The timing of the banking crisis.** *If* $y_S-(1+\tilde{i}_2^{d})L>0$, *a banking crisis happens in a type I country at* $\hat{t}\geq 2$, *where* $\hat{t}$ *is the first date at which solvent banks find it optimal not to renew loans if investors ask to be compensated for default risk. Formally, the*

[14]Giannetti (2003) applies a similar methodology to study contagion. The collapse of the market for bank debt, however, does not arise in her model because investment opportunities and bank objectives are different. The

*date* $\hat{t}$ *is the earliest date at which:* $y_S - (1+\tilde{i}_{t+1}^d)L < 0$. *Investors stop holding bank liabilities at* $\hat{t}$.

**Proof.** If the condition on parameters stated in Proposition 1 is satisfied, at *t=0* all managers with insolvent projects ask for funds because they expect to be refinanced at *t=1*. Consequently, if the country is type I, banks accumulate losses, as described by equations (3) and (4).

At any date $t<\hat{t}$, all banks issue debt and there are no defaults if investors demand a return $\tilde{i}_{t+1}^d$. In equilibrium, it is optimal for all investors to hold bank debt. Hence no bank defaults are expected. At $\hat{t}$, however, if investors demand $\tilde{i}_{t+1}^d$, solvent banks do not issue debt. Investors thus expect that the probability of holding debt of an insolvent bank is one and stop holding bank debt. No investor has an incentive to deviate. In fact, any investors who held bank debt would expect to make losses with probability one. This proves that asking for an infinite interest rate on bank debt at $\hat{t}$ is an equilibrium. ■

The condition on parameters in Proposition 1 requires that at *t=1* insolvent banks are able to renew loans. For this to happen, solvent banks must find it optimal to issue debt. From Lemma 1, I know that this is the case if $y_S - (1+\tilde{i}_2^d)L > 0$. From the inspection of equation (5), defining the shadow interest rate $\tilde{i}_2^d$, it follows that this condition is less likely to be satisfied in countries that are perceived as risky ($\varphi_I$ large) and/or with poor quality projects ($\theta$ small). In other words, this condition requires that investors expect a sufficiently large amount of profitable projects to be available and/or that solvent projects have relatively high return (high $y_S$).

**Remark.** If the condition in Proposition 2 is not satisfied, the model has no equilibrium in pure strategies. In fact, at *t=1* all insolvent projects are expected to be discontinued because investors do not want to hold bank debt. Expecting this, managers with insolvent projects should not ask for funding at *t=0*. However, if this is the case, at *t=1*, the interest rate on bank debt is equal to the risk free interest rate and all banks have incentives to issue debt and renew loans to their borrowers. This is clearly a contradiction and proves that no equilibrium in pure strategy exists.

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dynamics of the crisis are therefore different as explained in Section 2.

There exists a mixed strategy equilibrium, in which a subset of insolvent projects is not refinanced at *t=1*. In the mixed strategy equilibrium, bad entrepreneurs are renewed loans with a probability *1-p* strictly less than one that makes them indifferent between starting a project or not: $pE_{I/D} + (1-p)E_{I/R} = 0$. The subset of bad managers actually asking for funds at *t=0* makes the fraction of insolvent projects such that: $y_S - (1+\tilde{i}_2^d)L = 0$. The actual cost of funds for (all) banks is infinite with probability *p* and $\tilde{i}_2^d$ with probability *1-p*.[15] No investor has an incentive to deviate and lend when other investors do not because lending at $\tilde{i}_2^d$ guarantees the same payoff of the risk free asset. In the mixed strategy equilibrium investors stop lending to domestic banks with probability *p* at *t=1* and with probability *1-p* at *t=2*. When the crisis happens at *t=2*, investors that at *t=1* lent to insolvent banks lose part of their investment. In equilibrium, $i_2^d = \tilde{i}_2^d$ adequately compensates investors for this risk.

Importantly, none of the results of the model changes if a subset of insolvent projects is discontinued after the first period. Some banks renew loans to insolvent project and accumulate losses. In what follows, for expositional simplicity, I assume that the shadow interest rate always satisfies the condition on parameters, stated in Proposition 2.

Going backward, I analyze how the banking crisis unfolds by characterizing the equilibrium value of the interest rate on bank liabilities at $\hat{t}$ *-1*.

**Proposition 2. The unfolding of the banking crisis.** *The interest rate on bank liabilities rises above the risk free rate at* $\hat{t}$ *-1. Moreover,* $i_t^d$ *satisfies equation (5).*

**Proof**. A banking crisis happens at $\hat{t}$ in a type I country because investors do not want to hold bank liabilities any longer. This implies that insolvent banks default on debt issued at $\hat{t}$ *-1*. In equilibrium, at $\hat{t}$ *-1*, the interest rate on bank liabilities must be such to compensate investors for the probability of having lent to an insolvent bank. Hence, the interest rate on bank liabilities will have to be equal to the shadow interest rate defined in equation (5). This represents a fair compensation for risk because $y_S - (1+\tilde{i}_t^d)L > 0$ and both solvent and insolvent banks issue debt at $\hat{t}$ *-1*. ■

Proposition 1 and 2 prove that there exists an equilibrium in which a crisis happens as soon as the risk premium that compensates investors for the risk of having lent to an insolvent

[15] Note that this equilibrium involves that investors observe a sunspot, which acts as a coordinating device.

bank is so large that solvent banks do not issue debt any longer. Investors ask for a risk premium one period before the banking crisis can happen with positive probability. Proposition 4 proves that no risk premium is demanded before that.

**Proposition 3. The early phase of the financial liberalization.** *In equilibrium, the actual interest rate,* $i_t^d$ *, increases above the risk free interest rate,* $i^*$ *, only if there is positive probability of observing banks' defaults at t. Otherwise,* $i_t^d$ *remains equal to* $i^*$*.*

**Proof**. If bank defaults are expected with zero probability, bank debt is completely safe and has the same return of the risk free asset. In fact, if no bank defaults are expected at *t*, investors can call back their loans because there are other investors who want to hold bank liabilities at the equilibrium interest rate. Hence, bank debt has the same risk profile of the risk free asset at *t*. Competition among investors for providing bank debt ensures that bank liabilities have the same return of the risk free asset. ■

Proposition 3 implies that even if the banking system is expected to have bad loans with positive probability, bank liabilities are risk free in the short-run. This happens because bank liabilities have short maturity and can be redeemed before the date at which bank defaults are expected. If investors did ask to be compensated for the probability of having lent to an insolvent bank, all banks would issue debt as usual when the probability of lending to an insolvent bank is still small. No default would happen before $\hat{t}$ even if a risk premium were charged. Hence bank debt is rationally perceived as completely safe: Any international investor is able to redeem her loan in full because there are other investors who want to hold bank debt at the equilibrium interest rate. Consequently, competition among investors drives the risk premium to zero.

This explains why it is rational for investors to hold bank debt without requiring a risk premium until when a substantial amount of losses has been accumulated. Investors still hold bank debt at $\hat{t}$*-1* because they have incomplete information on the quality of bank assets and do not expect to make losses with probability one. It is crucial, however, that investors expect to recover their investment with probability larger than zero.

In equilibrium, the interest rate on bank liabilities increases one period before the crisis. The increase in the interest rate is followed by the collapse of the market for bank debt: Insolvent banks create a potential lemon problem in the market for bank debt. Stopping the process of accumulation of losses by a few insolvent banks requires that expected bank losses

increase and the lemon problem becomes so severe that solvent banks no longer issue debt. The market for bank debt thus collapses.

Insolvent banks default at $\hat{t}$. The temporary increase in the interest rate affects also solvent banks. Since solvent banks are assumed to be liquid, they do not default, but simply reimburse investors in full and do not refinance good managers. In this respect the banking crisis is not contagious because only insolvent banks fail. Nevertheless the credit crunch is costly for the economy as some positive net-present-value projects have to be interrupted.

Since $\varphi_I < 1$, some countries may experience an increase in the cost of funds and bank runs even if they have no insolvent banks. These countries experience a disruption of the market for credit as banks stop granting loans, but no banks actually defaults. Hence countries that are equally rated by investors but are actually different exhibit comovements in the business cycles (as project interruption causes a drop in the output in crisis-prone and non-crisis-prone countries), but banking crises are not contagious.

Note that investors hold bank liabilities without requiring a risk premium even if they know that the country has some insolvent banks with probability one ($\varphi_I = 1$).[16] Also in this case, they have a positive probability of recovering the investment because some banks are solvent. The assumption of incomplete information about the country type ($\varphi_I < 1$) is crucial only for deriving the results in Subsection 7.2.

The equilibrium of the model is similar to Bhattacharya (2001) who models Ponzi games in finite economies. In his model, agents participate to the Ponzi game because they expect to be bailed out with some probability (similarly to the bailout guarantees theories of overlending, mentioned in the Introduction). I show that an equilibrium in which everybody expects a crisis at $\hat{t}$ can be sustained without expectations of bail out, if there is incomplete information on the quality of bank assets.

The way in which the crisis unfolds is similar to first-generation models of currency crises (Krugman, 1979; Flood and Garber, 1984), as the interest rate on bank debt (which parallels the exchange rate of Krugman's model) depends on economic fundamentals, the expected bank losses, which evolve continuously. However, the equilibrium does not have the major shortcoming of first-generation models of currency crises consisting in the counterfactual implication that all variables move continuously. Even though the underlying

[16]This implies that the equilibrium does not change if investors observe the aggregate quality of bank assets as long as they do not know which banks are insolvent.

economic fundamentals evolve continuously, the interest rate exhibits a jump at the time of the crisis due to the strategic interaction between investors and domestic banks.

Proposition 4 proves that there is a unique date when the banking crisis can occur.

**Proposition 4. Uniqueness of the date of the crisis.** *The date* $\hat{t}$ *when a banking crisis can occur is unique.*

**Proof.** By contradiction, assume that investors hold bank debt at the risk free interest rate until $\widehat{t}-1>\hat{t}$ and that they expect bank defaults to take place at $\widehat{t}$, if the country is type I. In this case, the interest rate they require on bank debt at $\widehat{t}-1$, $i_{\widehat{t}}^{d}$, must take into account that loans will not be recovered with probability $\varphi_I \dfrac{\left(X_{\widehat{t}-1}+(1-\theta)L\right)}{D_{\widehat{t}}}$. Moreover, since $\widehat{t}>\hat{t}$, $X_{\widehat{t}}^{I}>X_{\hat{t}}^{I}$. Hence the probability of having lent at an insolvent bank is larger than at $\hat{t}$. This implies that $i_{\widehat{t}}^{d}> i_{\hat{t}}^{d}$ and $y_S-(1+i_{\widehat{t}}^{d})L<0$. Banks' defaults should thus occur at $\widehat{t}-1$, rather than at $\widehat{t}$. Therefore, in equilibrium it should hold that $i_{\widehat{t}-1}^{d}>i^{*}$. Moreover either $\widehat{t}-1=\hat{t}$ and, hence, a crisis occurs at time $\hat{t}$, like in Proposition 2, or $\widehat{t}-1>\hat{t}$. In this case, $i_{\widehat{t}-1}^{d}> i_{\hat{t}}^{d}$ and therefore a crisis should occur at $\widehat{t}-2$. Going backward, I prove that the latest date a crisis can happen is $\hat{t}$.

Furthermore, a crisis cannot happen before $\hat{t}$, because , if $t<\hat{t}$, solvent banks would issue debt at the interest rate that compensate for the risk of lending to an insolvent bank. An investor would have an incentive to hold bank liabilities at a finite interest rate –because there is positive probability of recovering the investment— even if all other investors were not funding domestic banks: A deviating investor could offer to lend at the interest rate $\tilde{i}_t^{d}+\varepsilon$, where $\varepsilon$ is a constant larger than zero. This strategy would guarantee an expected payoff larger than $i^{*}$, because for any $\varepsilon$ such that $y_S-(1+\tilde{i}_t^{d}+\varepsilon)L>0$ solvent banks issue debt. Hence, the investor would receive $(1+\tilde{i}_t^{d}+\varepsilon)L$ if she happens to invest in a solvent bank. Otherwise she would share with any other investors the output from the previous period project. For $\varepsilon>0$, given that $\tilde{i}_{\hat{t}}^{d}$ is the interest rate that guarantees the same return of the risk free asset in expected value, this strategy gives an expected return larger than the risk free interest rate. Hence asking for an infinite interest rate before $\hat{t}$ is not an equilibrium strategy.■

The intuition behind Proposition 4 is the following: In contrast to models of bank runs, such as Diamond and Dybvig (1983) and Chang and Velasco (2000 and 2001), I do not assume that investors' claims are satisfied sequentially.[17] Hence there is no complementarity among investors' decisions whether to hold bank liabilities. Even if the lack of complementarity requires that at $t=0$ each investor can fund an entire bank, the result is more general. The date of the crisis is unique if a single investor is able to fund an entire project. This condition is likely to be satisfied in emerging markets as most of bank liabilities are held by international banks and other institutional investors. If the average investors of domestic banks were small depositors, the assumption would be more restrictive. It would still be true however that solvent banks can employ even small amounts of capital and obtain return larger than the risk free rate if projects can be run at variable scale. If projects cannot be run at variable scale and all investors are small depositors, the model has multiple equilibria because bank runs are possible at any date $t<\hat{t}$. However, the equilibrium that I describe above still exists.

The comparative static is more synthetically described in words. First, the date of the crisis depends on the parameters of the model as follows. A crisis is delayed by any factor that decreases the shadow interest rate in (5). For instance, the higher the productivity of insolvent projects is ($\frac{y_I}{L}$ is higher), the slower banks accumulate losses. Hence investors are willing to hold bank debt for a longer period of time. More interestingly, the greater is the reputation of a country (i.e., the lower is the probability, $\varphi_I$, that the country has insolvent projects), the later the crisis happens and the larger the losses accumulated by insolvent banks are. Any country expected to be endowed with insolvent projects, no matter how many (i.e., how large $\theta$ is), experiences a collapse in the market for bank debt. The larger is $\theta$, the later after the financial liberalization the banking crisis happens (the larger $\hat{t}$ is), but sooner or later it does.

Second, the jump in the interest rate at $\hat{t}-1$ is larger in countries with stronger growth opportunities (high productivity of solvent projects, $y_S$): If solvent projects are very profitable, the risk premium that induce solvent banks to stop issuing debt is larger ($i_t^d$ will have to compensate for a relatively higher $y_S$ in order for the condition in Lemma 1 to be satisfied). Hence, in countries with very productive solvent projects the banking crisis is delayed, but its severity, in terms of the increase in the cost of funds and the drop in the output, is stronger.

[17] In these models, bank runs happen because withdrawing the deposit is a best response if other investors are withdrawing as well.

*4.3. Supporting empirical evidence*

Recent financial crises in emerging markets share several features: (1) They occurred a few years after extensive financial liberalization, (2) they were preceded by large capital inflows that subsequently reverted abruptly (3) they were preceded by a substantial increase in the ratio of short-term debt to GDP (Glick, Moreno, and Spiegel, 2001) (4) they hit harshly economies that had previous registered strong growth (5) they involved several countries at the same time.

More specifically, most of East Asian countries had liberalized their banking systems by allowing market-oriented adjustment of the interest rates and allocation of credit already during the eighties. Measures to liberalize the capital account were taken in the early nineties and were followed by large short-term capital inflows, mostly intermediated by the banking system. As is well known, the first signs of financial instability emerged only in 1997. Also the 1982 Chilean crisis followed the financial liberalization of the late seventies and was preceded by large capital inflows, mainly under the form of short-term bank liabilities. The events surrounding the banking crises in Mexico in 1994 and the Nordic countries in 1992 are remarkably similar (Drees and Pazarbaşioğlu, 1995). In all these cases, the expansion of bank liabilities had as a counterpart an increase in bank credit. In none of these cases, output growth matched the growth in foreign liabilities: as a consequence, the ratio of foreign debt to GDP increased dramatically (see Velasco (1991) for evidence on Chile, and Tirole (2002) for evidence on East Asia).

Referring to the 1982 Chilean crisis, Velasco (1991) provides a description of the bank lending policies that it is remarkably similar to the one in the model:

"Perhaps, the single most important factor behind the growth of domestic indebtedness was the rolling over of credits and the capitalization of interest…Furthermore, the line between a performing and a nonperforming asset becomes fuzzy when rollovers and capitalization of interest are widely used to keep many problem loans on the books."

Before the crises, investors and professional economists seemed to share uncertainty about the origins of lending booms and the quality of bank assets: East Asia is again emblematic as even economists were debating on whether growth was led by strong investment opportunities (Young, 1998) or investment in low-productivity but capital-intensive projects (Hsieh, 2002). Even if investors observing the increasing leverage of the economies

should have inferred the country type ($\varphi_I$=1), the uncertainty on the quality of bank assets (within a country) can explain why the increase in leverage was not accompanied by signs of financial instability for long time. The latter interpretation is consistent with the empirical evidence showing that bank stock prices were low in anticipation of bank defaults well before the banking crises developed (Burnside, Eichenbaum, and Rebelo, 2001).

In many of these cases, the liberalization of the banking system was unlikely to have decreased bank charter values thus giving banks incentives to take on more risk as alternative explanations of banking crises assume. For instance, Cho (2001) reports that in Korea, after the financial liberalization, the interest rate on bank loans increased, while at the same time the interest rate on bank liabilities decreased.

Overlending episodes typically ended because foreign creditors outright refused to rollover loans (Caprio, Hanson, and Honohan, 2001). When the banking crisis materialized, investors typically made losses (Radelet and Sachs, 1998). This contrasts with theories explaining excessive lending with bailout guarantees, as these imply that investors lend exactly because they expect that the government will take the bill.

Many economists are also surprised by the fact that the crises hit so harshly the East Asian economies, which were considered star-performers only a few years before (Radelet and Sachs, 1998). My model suggests that the increase in interest rate and the drop in output can be more dramatic in countries where very profitable investment opportunities and insolvent projects coexist.

My model can also explain why recent crises involved several countries at the same time (Glick, Moreno, and Spiegel, 2001): Since the crisis originates from uncertainty on growth opportunities, investors suddenly stop holding bank debt of countries that they consider similar. The experience of Malaysia in 1997 is a remarkably good example. Very likely, international investors considered Malaysia similar to the other lower-income East Asian economies (Indonesia and Thailand) before the unfolding of the 1997 Asian crisis. 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 non-performing loans to total lending had fallen steadily. However, Malaysia experienced bank runs like Indonesia and Thailand.

In summary, the model gives a description of the dynamics of banking crises that is consistent with the empirical evidence from emerging markets (Kaminsky and Reinhart, 1999). In the period immediately following the financial liberalization, emerging economies enjoy

low interest rates and experience lending and investment booms. These booms end abruptly and capital inflows suddenly reverse.

The applicability of the results of the model goes beyond the specific context described in Subsection 2.1. Any financial imperfection or exogenous shock causing insolvency of some banks may generate evergreening of loans. Some banks may become insolvent because after the financial liberalization they find it optimal to screen to a lesser extent, like Dell'Ariccia and Marquez (2005) suggest. Alternatively, bank solvency may be undermined by (unexpected) negative shocks affecting bank assets.[18] In all these cases, the model can explain banks' incentives not to recognize losses immediately and in particular investors' willingness to provide funds after a negative shock. In an economy close to capital inflows and low domestic saving, a negative shock to bank assets, which impairs the solvency of some borrowers, causes the immediate failure of some banks. The banking system would be stable thereafter. In an economy open to capital inflows, the banking system is apparently more resilient immediately after the shock because investors continue to hold bank liabilities until when banks accumulate a critical amount of losses. The delayed banking crisis is, however, more dramatic as banks accumulate more losses.

The latter interpretation of the model can help explaining bank behavior in Japan. After the collapse of the Japanese stock market and the dramatic decrease in real estate prices at the beginning of the nineties, Japanese banks' capital was significantly eroded, and Japanese banks engaged in processes of evergreening of loans (Peek and Rosengren, 2005). In particular, they appear to have kept insolvent borrowers alive, by supplying more loans, and concealed non-performing loans. The risk of default started to be reflected in all major Japanese banks' cost of funds only a few years later, in late 1995. Peek and Rosengren (2001) consider particularly striking that this risk premium was assessed by the markets only in 1995 because the precipitous declines in Japanese equity and commercial real estate prices, which had resulted in deterioration of bank financial health, had occurred much earlier. All major Japanese banks were required the same premium. This empirical evidence is consistent with both the time-series and the cross-sectional implications of the model: A risk premium starts to be required well after banks' financial health has been compromised and investors have not enough information for distinguishing across banks.[19]

[18] Note that if solvent banks expect a negative shock to their borrowers, they have no incentive to provide funds if expected profits are negative.

[19] The Japanese premium then decreased without a generalized banking crisis, which was probably avoided by the Japanese government decision of injecting funds into troubled banks.

## 5. Lending policies without capital inflows

This Section shows that a competitive banking system is stable in economies closed to capital inflows and with low domestic saving. Before the liberalization of capital inflows, bank lending decisions are still described by Lemma 1. However, contrary to the previous section, bank liabilities cannot grow above domestic saving if the economy is closed to capital inflows.

Let *S* be the total amount of funds that domestic investors can invest either in bank short-term debt or in the risk free asset (domestic saving). Proposition 5 gives conditions under which no insolvent projects are funded at *t=0*. Hence, all banks remain solvent and no banking crises occur in equilibrium.

**Proposition 5. Financial stability with low domestic saving.**

*If* $\frac{S}{(1-\theta)L(1+i^*)+L} < \frac{-E_{I/D}}{E_{I/R}-E_{I/D}}$, *then insolvent projects are not funded in equilibrium when the economy is closed to capital inflows.*

**Proof.** A manager with an insolvent project does not ask for a loan at *t=0* if the probability that the project is continued at *t=1* is $\nu < \frac{-E_{I/D}}{E_{I/R}-E_{I/D}}$. In fact, from the assumptions in Section 3.1, it follows that the expected payoff from starting a project is: $\nu E_{I/R} + (1-\nu)E_{I/D} < 0$ if $\nu < \frac{-E_{I/D}}{E_{I/R}-E_{I/D}}$, while the manager can achieve a reservation utility of zero by not starting the project.

The probability that a manager with an insolvent project is refinanced depends on fund availability and is determined as follows. If at *t=0* insolvent projects have been funded, at *t=1*, banks' demand for funds is: $(1-\theta)L(1+i_1^d)+L$ because the loans extended to insolvent projects in the first period ($(1-\theta)L$) cannot be recovered and banks must refinance also the interest matured on the short-term debt. Obviously, if $(1-\theta)L(1+i_1^d)+L > S$, not all projects can be refinanced. The fraction of projects that can actually be refinanced is: $\frac{S}{(1-\theta)L(1+i_t^d)+L}$. Clearly, $i_1^d = i^*$ (because no risk premium emerge in equilibrium), if only solvent projects are funded at *t=0*. Hence no bad manager actually asks for funding if $\frac{S}{(1-\theta)L(1+i^*)+L} < \frac{-E_{I/D}}{E_{I/R}-E_{I/D}}$, as stated in Proposition 5. ■

The condition on parameters stated in Proposition 5 requires that domestic saving is sufficiently low. If the previous condition is not satisfied, the equilibrium is very similar to the one described in Section 4. In particular, all or a subset of insolvent projects can be refinanced and some banks accumulate losses and default. Depending on the level of *S*, insolvent bank defaults when either the interest rate rises as described is Section 4 or, perhaps more realistically, banks' liabilities reach level S. In either case, the equilibrium of an economy with high domestic saving is identical to the equilibrium of the economy open to capital inflows: Insolvent banks can be forced to stop issuing liabilities only when solvent banks voluntarily stop doing so and the interest rate on bank liabilities becomes infinite.

Proposition 5 implies that economies with low domestic saving are less likely to experience banking crises even if the banking system is highly competitive. The intuition behind Proposition 1 is simple. Before the financial liberalization, due to low domestic saving, banks do not have access to an increasing amount of funds to refinance bad loans. They can thus credibly commit not to renew loans to insolvent projects. Managers with insolvent projects anticipate this and do not ask for funding at *t=0*.

This is similar to the equilibrium with credit decentralization of Dewatripont and Maskin (1995): If credit provision is decentralized among many banks with little access to funds, creditors can credibly commit not to refinance insolvent projects, thereby discouraging bad managers from undertaking them initially. Similarly in my model, low domestic saving constrains the expansion of domestic credit.

The implications of Proposition 5 are consistent with the empirical evidence showing that financial instability affects emerging economies only after the liberalization of capital inflows (Kaminsky and Reinhart, 1999). Additionally, bad managers are less likely to ask for funds if they expect a high penalty from default (low $E_{I/D}$) and low private benefits from running a project (low $E_{I/R}$). Hence strong investor protection may indirectly foster the stability of the banking system. This implication is consistent with recent empirical evidence showing that countries with stronger investor protection are less likely to experience financial crises (Kaminsky and Schmukler, 2002).

[Insert Figure 2 here]

Figure 2 represents the equilibrium in the market for bank liabilities at *t=1*. Banks' lending decisions depend on the supply of funds. If $S < \theta L$, as is represented in Figure 2, the equilibrium interest rate on bank liabilities is higher than the risk free interest rate because asking for an interest rate on bank short-term debt equal to solvent projects' expected return is

an investor's dominant strategy. Interestingly, even if at *t=0* no bad manager asks for funds and there is no risk, the interest rate on bank short-term liabilities, and consequently on bank loans is larger than the risk free rate.

Even though there are no banking crises, the equilibrium is inefficient. If the initial saving is less than $\theta L$, some profitable investment opportunities are foregone. Additionally, new profitable investment opportunities that become available cannot be undertaken. Hence financial liberalizations decrease the cost of capital and foster growth and investment as is consistent with the empirical evidence (Henry, 2000), but also provoke financial instability.

## 6. Welfare analysis

This Section discusses the conditions under which opening a country to capital inflows may be welfare-improving. In the welfare analysis, I take the perspective of a regulator whose objective is to maximize the economy-wide contractible net output, without considering managers' private benefits. While in the positive analysis of the crisis I did not consider what happens after the crisis, I now assume that solvent projects discontinued at $\hat{t}$ can be started again at $\hat{t}+1$. Insolvent projects on the other hand are interrupted forever. Proposition 6 gives conditions under which opening capital inflows is welfare improving.

**Proposition 6.** *The value of the banking system and the output are enhanced by the liberalization of capital inflows if the following inequality holds:*

$$\left(\varphi_I\theta+\left(1-\varphi_I\right)\right)\left(\sum_{t=1}^{\hat{t}}\frac{y_S-L(1+i^*)}{(1+i^*)^t}\right)+\varphi_I\left(1-\theta\right)\left(\sum_{t=2}^{\hat{t}}\frac{y_I-L(1+i^*)}{(1+i^*)^t}-L\right)>\frac{S}{\theta L}\sum_{t=1}^{\infty}\frac{y_S-L(1+i^*)}{(1+i^*)^t}. \quad (7)$$

The inequality in Proposition 6 compares the present value of the output with and without capital inflows. I assume that the economy has low domestic saving so that not all solvent projects can be funded without capital inflows (i.e., $S<\theta L$). The left hand side represents the net present value of the output if capital inflows are liberalized at *t=0*: In particular, the first term is the expected output from solvent projects and the second term is the expected output from insolvent projects. The right hand side represents the present value of the output if the economy remains closed to capital inflows and domestic saving is lower than the profitable investment opportunities.

The inequality in Proposition 6 is more likely to be satisfied in a country with low domestic saving (low *S*) and high growth opportunities (high $\theta L$): This follows immediately from the fact that the right hand side is increasing in *S* and decreasing in $\theta L$. The economic intuition is the following: In countries with low domestic saving, capital inflows allow undertaking relatively more new profitable investment opportunities. The lower *S* is, the larger the gain is. There is no benefit from liberalizing capital inflows if $S \geq \theta L$ (and no new solvent projects are available at *t>0*).

The term $-\varphi_I(1-\theta)\left(\sum_{t=2}^{\hat{t}} \frac{y_I - L(1+i^*)}{(1+i^*)^t} - L\right)$ represents the expected loss from the liberalization of capital inflows. The loss is negatively related to the productivity of insolvent projects, $y_I$, and depends on $\hat{t}$ in an interesting way. A delay of the crisis decreases the desirability of liberalizing capital inflows if $y_I - (1+i^*)L < 0$. In fact, in this case, refinancing an insolvent project is inefficient: It allows funds to be reallocated to projects with lower productivity than the risk free asset for a longer period of time. In this situation, a crisis is optimal because it is the only means to harden banks' budget constraints. Hence, the liberalization of capital inflows may be more harmful for a country that has high reputation and is believed to have low probability of being crisis prone (low $\varphi_I$) or has strong investment opportunities (high $\theta$). The effect of a decrease in $\varphi_I$ (increase in $\theta$) on welfare is ambiguous: On the one hand, a decrease in $\varphi_I$ (increase in $\theta$) increases the expected return on investment (i.e., the probability that banks are ever-greening loans), on the other hand it makes the distortions deriving from asymmetric information more severe, because the process of ever-greening of loans can continue for a longer time. An increase in $y_S$ has similar ambiguous effects on welfare. Interestingly, if $y_I - (1+i^*)L < 0$ and the country is actually crisis-prone (i.e., $\varphi_I = 1$ in (7) but $\hat{t}$ depends on $\varphi_I$ because investors believe that the country is type I with probability $\varphi_I$), an improvement in reputation (lower $\varphi_I$) is unambiguously harmful because it allows investment in negative-net-present-value projects for a longer period of time.

If $y_I - (1+i^*)L > 0$, however, once the first period investment is sunk, it would be efficient to continue these projects forever (because their return is higher than the risk free interest rate) and to recapitalize insolvent banks.[20] The banking crisis has a cost not only

[20] Alternatively, if investors are able to coordinate, they should renegotiate their claims with insolvent banks and allow them to continue to lend.

because solvent banks stop lending, but also because after the first period bad managers run projects with higher return than the risk free asset and are forced to discontinue them. Hence, in this case high reputation (low $\varphi_I$ or high $\theta$) increases output and the desirability of the financial liberalization.

Even if the inequality in Proposition 6 is satisfied, and the liberalization of capital inflows is desirable, the equilibrium is inefficient because banks cannot commit not to refinance bad managers once they become insolvent. This gives bad managers an incentive to ask for funds at *t=0,* and decreases the return to investment in the economy.[21]

## 7. Extensions

### *7.1. Bailout guarantees*

The main conclusions of the model remain qualitatively unchanged if there are bailout guarantees. To show this, I assume that a central bank holds an amount *RX* of international reserves with zero return. International reserves consist of units of the same good produced by project managers. If the central bank provides bailout guarantees and any bank declares default, the central bank tries to reimburse all investors. If reserves are not sufficient to cover all losses of defaulting banks, reserves are distributed among insolvent banks' investors in proportion to their claims. Hence, the only difference from the case analyzed in Section 4 is that investors of insolvent banks can now receive some compensation from the central bank.

Differences about the timing of the banking crisis emerge: For investors, the probability of making a loss is smaller at any given date *t*. As before, solvent banks' investors will not be affected by a banking crisis. In contrast, insolvent banks' investors expect to get a share of the available international reserves that is proportional to their investment. Consequently, the shadow interest rate on bank liabilities, $\tilde{\tilde{i}}_t$, is now defined as follows:

$$\left((1-\varphi_I)\left(1+\tilde{\tilde{i}}_t^d\right)+\varphi_I\left(\frac{X_t+(1-\theta)L}{D_t}\frac{RX+(1-\theta)y_I}{X_t+(1-\theta)L}+\frac{D_t-X_t-(1-\theta)L}{D_t}\left(1+\tilde{\tilde{i}}_t^d\right)\right)\right)=\left(1+i^*\right), \quad (8)$$

[21] Even if the private benefits of the manager running the project are weighed in the welfare function, the equilibrium is clearly not Pareto optimal if: $\sum_{t=2}^{\infty}\frac{y_I}{(1+i^*)^t}+E_{I/R}-\sum_{t=1}^{\infty}\frac{L}{(1+i^*)^{t-1}}<0$.

where $\frac{D_t - X_t - (1-\theta)L}{D_t}$ and $\frac{X_t + (1-\theta)L}{D_t}$ are the fractions of liabilities of solvent and insolvent banks, respectively, in a type I country. Insolvent banks' investors now receive a partial compensation, $\frac{RX + (1-\theta)y_I}{X_t + (1-\theta)L} < 1$, from the central bank.

For any value of the expected losses of the banking system, the shadow interest rate is now lower than in equation (5). Proposition 1 to 4 can be easily extended to determine the date of the crisis. The interest rate on bank debt rises after the date determined in Proposition 1, because $\tilde{\tilde{i}}_t$ is smaller than $\tilde{i}_t$ for any value of the aggregate losses. Hence, if the country is actually insolvent, the banking crisis is delayed but a larger amount of losses is accumulated.

Overall, the implications of the model are robust to the introduction of bailout guarantees. In equilibrium, a risk premium emerges only if investors hold bank liabilities in excess of international reserves. Thus investors can make losses during a crisis as is consistent with the empirical evidence (Radelet and Sachs, 1998).

From a welfare point of view, bailout guarantees may be desirable or not. Bailout guarantees do not produce the main inefficiency of the model (i.e., the funding of bad managers). Their desirability depends on whether it is optimal to postpone the crisis.

### *7.2. Bank liabilities denominated in domestic currency and bailout guarantees*

The presence of bailout guarantees may also cause creditors of *solvent* banks to make losses if bank liabilities are not denominated in real terms. To show this, I assume that bank liabilities are denominated in domestic currency. Domestic currency is issued by the central bank, and assumed to be initially exchanged at par with one unit of the good. Before the crisis, banks can reimburse their nominal liabilities exchanging one unit of the good for one unit of domestic currency. When investors do not rollover their loans, the central bank can guarantee the nominal value of bank liabilities by creating domestic currency to reimburse investors of insolvent banks.

Since the central bank can guarantee their nominal value of domestic currency liabilities, investors are not subject to default risk. There is, however, exchange rate risk. When investors run to the central bank to convert domestic currency into foreign currency, a devaluation takes place if bank liabilities are larger than international reserves. I assume that international reserves are distributed pro-rata to all claimants.

The shadow exchange rate, $\tilde{i}_t^d$, takes into account that in case of devaluation all investors, including the ones of solvent banks, will be negatively affected:

$$\left( (1-\varphi_I)(1+\tilde{i}_{t+1}^d) + \varphi_I \frac{RX + (1-\theta) y_I + \theta L}{D_t} \right) = 1 + i^* . \tag{9}$$

With probability $\varphi_I$, the country experiences a banking crisis. The value of all bank debt is reduced by the devaluation and investors receive only $\frac{RX + (1-\theta) y_I + \theta L}{D_t (1+\tilde{i}_{t+1}^d)}$ units of the good for each unit of domestic currency.[22]

Clearly, the banking crisis unfolds in the same way as before. The only relevant difference is that now all investors make losses with probability $\varphi_I$. The uncertainty about the country type becomes crucial for the results. If $\varphi_I$ were equal to one, investors would demand at most *RX* bank liabilities. If they demanded more, they would expect to make losses with probability one. The results would be equivalent to models based on bailout guarantees, like Corsetti, Pesenti and Roubini (1999). In other words, if the nominal value of bank debt is guaranteed, bank specific risk becomes irrelevant because neither solvent nor insolvent banks default on their obligations. However, the real return on bank liabilities is still risky because of the possible devaluation. Incomplete information about the aggregate investment opportunities of the country is therefore crucial.

Interestingly, if the level of the international reserves is sufficiently low, the shadow exchange rate defined in equation (9) may be higher than the shadow interest rate defined in equation (5). Hence, the losses domestic banks accumulate before declaring default may be larger when there are *no* bailout guarantees. Contrary to the conventional wisdom, insolvent banks may accumulate smaller losses with bailout guarantees. In striking contrast with the bailout guarantees theory of overlending, not only bailout guarantees are not a necessary condition for excessive lending, but they can even limit it.

### *7.3. Maturity of bank liabilities*

So far, I have assumed that bank liabilities have short maturity. In this Section, I show that if banks issue long-term debt, capital inflows continue to cause overlending.

[22] This takes into account that before the devaluation, solvent banks exchange one unit of the output for one unit of domestic currency in order to reimburse investors.

To illustrate this, let's assume that in case of bank defaults all creditors share bank assets pro rata. In other words, all creditors are treated in the same way independently from the date at which their claims have been issued and mature. At $t < \hat{t}$, banks issue debt denominated in real terms to be reimbursed at date *s+1*. Banks issue short-term debt before and after.

The shadow interest rate that compensates for the risk of having a deposit in an insolvent bank, $i^d_{t,s+1}$, is determined as follows:

$$(1-\varphi_I)\left(1+\tilde{i}^d_{t,s+1}\right)+\varphi_I\left(\frac{X_t+(1-\theta)L}{D_t}\frac{y_I}{x_s+L}+\frac{D_t-X_t-(1-\theta)L}{D_t}\left(1+\tilde{i}^d_{t,s+1}\right)\right)=\left(1+i^*\right)^{s+1-t}. \quad (10)$$

Equation (10) requires that the return on long-term debt issued at time *t* and maturing at *s+1* is equal to the return on investing in the risk free asset for *s+1-t* periods in expected value.

Clearly, if $s \geq \hat{t}$ and $t < \hat{t}-1$, $i^d_{t,s+1} > i^d_t = i^*$. This implies that issuing long-term debt anticipates the banking crisis, because the risk premium is incorporated earlier in the cost of bank liabilities. Hence issuing long-term debt reduces the build-up of bank losses. However, at *t=1* overlending still arises (i.e., insolvent projects would be renewed funding).

To show that some bad managers are funded even if banks issue only long-term debt, let's assume that banks can issue only long-term debt with maturity $m \geq \hat{t}$. In particular, loan renewal to insolvent projects or funding of new profitable projects at *t=1* entails issuing long-term debt. I continue to assume that in case of default all claimants share bank assets pro rata. For reasons similar to the ones pointed out in the remark of Subsection 4.2, no equilibrium in pure strategy exists in which bad managers do not ask for funding. As explained in the remark, this depends on the fact that if bad managers are not expected to ask for funds, bank liabilities are riskless. This clearly cannot be an equilibrium because, expecting this, bad managers would find it optimal to ask for funding.

There exists an equilibrium in mixed strategies where at *t=1* bad managers are renewed loans with a probability *1-q* strictly less than one that makes them indifferent between starting a project or not: $qE_{I/D}+(1-q)E_{I/R}=0$. The subset of bad managers actually asking for funds at *t=0* makes the fraction of insolvent projects such that: $y_S-(1+\tilde{i}^d_{2,m})L=0$. The actual cost of funds for (all) banks is infinite (i.e., investors stop holding domestic banks' long-term debt) with probability $q$ and $\tilde{i}^d_{2,m}$ with probability *1-q*. No investor has an incentive to deviate and lend when other investors do not because lending at $\tilde{i}^d_{2,m}$ guarantees the same payoff of holding the risk free asset for *m* periods.

*7.4. Uncertainty about the timing of the crisis*

So far I have assumed that the timing of the crisis is deterministic because (1) bank losses evolve deterministically since project output is deterministic (2) investors do not observe any signals of the average quality of bank assets. Both assumptions are clearly restrictive and are done for tractability. Here I discuss to what extent the results of the model are robust.

Let's first consider stochastic project output. This could be introduced in different ways. On the one hand, all projects could be ex ante equal, but some could suffer a drop in output, which makes them (and their banks) insolvent.[23] Banking crises would ensue as in Section 4. On the other hand, the output of (ex ante) insolvent projects could be stochastic.[24] This would clearly make bank losses stochastic. If the distribution of insolvent projects' output is such that initial losses cannot be recovered, the results would be similar to the one I present. Additionally, if investors do not observe any signals of the actual level of bank losses, the timing of the crisis is still deterministic. The only difference from the analysis presented in Section 4 is that the shadow interest rate depends on the *expected* bank losses instead of their actual value. However, for more general distributions of insolvent projects' output, banks might be able to recover their initial losses. These banks would then become solvent and would discontinue the insolvent projects without defaulting. Hence, after a series of positive shocks to the output of insolvent projects, we might not observe banking crises.

Let's assume now that project output is deterministic. The timing of the crisis would nonetheless be stochastic if investors observed some signal of the average productivity of the projects in a country (i.e., increasing or decreasing exports, growth rate).[25] To see this, let's consider the following modification of the model. Investors observe a signal of the average project output. The signal can be either high ($Y_H$) or low ($Y_L$). Countries with strong investment opportunities (type II) have higher probability of generating a high signal then crisis-prone countries (type I): $p_I < p_{II}$. The rest of the economy continues to be specified as in Section 3.

[23] Clearly, the projects should be viable from an ex ante point of view. Otherwise, solvent banks would not lend.
[24] It is less interesting to make solvent projects' output stochastic because they are always able to reimburse the loan.
[25] In the case of East Asia doubts on debt sustainability were increasing due to poorer macroeconomic performance in the period immediately before the crisis.

The mechanism determining the timing of the crisis is the following. A low realization of the signal can be due to bad luck or to the fact that the banking system is funding insolvent projects. Investors update their beliefs on the country type depending on the realization of the signal and their prior on the country type. In particular, a sequence of low (high) signals increases (decreases) the posterior probability that the country is crisis prone. The shadow interest rate in (5) is computed using the posterior beliefs on the country type instead of the prior $\varphi_1$. Hence, the shadow interest rate now varies for two reasons. First, since with some positive probability the country is accumulating losses, the shadow interest rate grows over time. Second, the beliefs on the country type change: A sequence of low signal realizations increases the probability that the country is crisis prone. The shadow interest rate at which solvent banks stop issuing debt is therefore reached for a lower level of aggregate losses. By converse, after a sequence of positive realizations of the signal, the posterior probability that a country is crisis-prone is lower. For any given level of expected losses, the shadow interest rate is lower. Hence in equilibrium, investors are willing to lend for a longer period of time.

## 8. Institutional arrangements for financial stability

In the model, overlending and banking crises arise for two reasons. First, insolvent banks cannot commit to discontinue unprofitable projects if they have access to funds. Second, because of asymmetric information, the interest rate on bank liabilities does not reflect the quality of bank assets. This impairs market discipline.

Measures to enhance financial stability must affect either banks' incentives or investors' access to information. As discussed in Section 5, the most straightforward way of affecting banks' incentives would be not to allow credit booms. Capital controls that restrict the amount of funds the banking system can intermediate would provide a credible commitment not to renew bad loans. Capital controls are, however, a costly instrument to prevent banking crises because they also hamper the funding of new investment opportunities.

Lack of competition in the deposit market (and in general in the market for bank liabilities) –enforced for instance through a ceiling on the interest rate on bank debt—would stop capital from flowing into the economy because investors anticipate that banks will not be able to compensate them for risk. Hence, lack of competition in the market for bank debt is practically equivalent to restrictions to capital inflows and involves the same costs.

While in low-saving countries the crisis would not arise without the liberalization of capital inflows, competition in the loan market favors the crisis but is neither a necessary nor a

sufficient condition for it. In a competitive loan market, since profitability is lower, banks are more likely to become insolvent following negative shocks or wrong lending decisions. Hence, competition may favor banking crises. As long as some banks become insolvent, however, processes of evergreening of loans occur even without competition in the loan market.

There exist other instruments to improve banks' incentives, possibly less costly than capital controls. Banks have incentives to renew loans to unprofitable projects only if they become insolvent. If banks stayed solvent, they would maximize their expected profits and would have no incentive to accumulate losses by renewing bad loans. It follows that if banks were well capitalized no processes of accumulation of bank losses would ensue. To see this, suppose that at *t=0* a bank has own capital $k_0$ that can be invested in the risk free asset. Hence, its initial loss is: $x_0^I = (1+i^*)(L-k_0)$.[26] The larger is $k_0$, the smaller is the level of the losses at *t=0*; for high levels of $k_0$, unlucky banks (that have lent to insolvent projects) do not become insolvent because $x_0^I \leq 0$. Hence, they renew loans only if the project covers the cost of funds. The ex post lending decision thus becomes efficient and no process of accumulation of losses occurs.

The empirical evidence supports the assumption of my model that the level of capitalization of the banking system is such that bank solvency is easily impaired. Even though banks in emerging markets have the same capital requirements of developed countries, these seem insufficient for two reasons. First, lending in emerging markets is a far riskier business. Capital requirement that guarantee financial stability in developed economies may thus not provide a sufficient buffer to cover losses in emerging markets. Second, and perhaps most importantly, the discipline exercised by supervisors is generally much weaker because of the quality of data and the supervisory framework (Rojas-Suarez, 2002). Banks can thus hide losses from their balance sheets by rolling over bad loans and publishing figures that only in appearance meet the standards (Economist, 1997). Consistently, Bongini, Claessens, and Ferri (2002) document significant weaknesses in East Asian financial systems preceding the financial crisis.

Market discipline can also help to limit overlending problems. Greater transparency on the quality of bank assets implies that investors are able to distinguish good and bad banks.

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[26]The bank can finance the project by issuing debt $L$ and at the same time investing $k_0$ in the risk free asset. It is equivalent if the bank invests its own capital in the project and issues debt $L-k_0$. In particular, if the bank actually becomes insolvent (i.e., $L-k_0>0$) it has an incentive not to write off the capital in order not to signal its status to investors. The bank would thus refinance the whole loan and invest $k_0$ in the risk free asset.

Hence, they could charge a risk premium earlier on to low quality banks (banks that are believed to have higher probability of being insolvent). These banks would thus accumulate smaller (or no) losses. Most importantly, investors would not require a risk premium for debt issued by high quality banks if they were able to completely reveal their type.[27] In this respect, transparency helps preventing the disruption of the credit market.

Capital requirements and market discipline could then be used as complementary instruments to improve financial stability. In particular, capital requirements should be higher when asymmetric information problems are more severe. In this way, banks that are more likely to fund insolvent projects and are less subject to market discipline would be given stronger incentives to maximize their net wealth.

Greater transparency may also have *indirect* effects on financial stability. A common characteristic of underdeveloped financial systems is that most firms rely on a single financing bank. Thus bank assets are not well diversified and many financial institutions happen to have large exposures towards a few borrowers. (See Velasco (1991) for evidence on Chile before the 1982 crisis and Nam (1996) for evidence on Korea.) In this situation, bank solvency can be easily impaired by the inability of a single borrower to repay the loan. The nature of borrower-lender relationships is different in more advanced financial markets, where each project has many lenders and thus lenders have better diversified assets.

In the model, if $\varphi_I = 1$ and *all* banks funded *all* projects pro-rata, no bank would become insolvent. In fact, lending is ex ante profitable and the interest rate on loans at *t=0* is such that banks break even in expected value. In general, banks that fund two projects can use the ex post gains realized from funding a good manager to compensate for the ex post loss from funding a bad manager. The more diversified banks are, the lower the chances are that some banks become insolvent. To see this, let's assume for simplicity that $\varphi_I = 1$. At *t=1* a bank that funds one project has a loss of $L\left(1+i^*\right)$ with probability $\left(1-\theta\right)$. If the same bank funds half of two projects, it will have a loss of $L\left(1+i^*\right)$ only with probability $\left(1-\theta\right)^2$. With probability $2\left(1-\theta\right)\theta$, it will have a loss of $\frac{1}{2}\left[L\left(1+i^*\right)-L\left(1+i_1^l\right)+L\left(1+i^*\right)\right]$. This is definitively smaller than $L\left(1+i^*\right)$ and, depending on parameters' values, may be negative. This implies that if banks diversification improves, processes of evergreening of loans are less

[27] Note that if a small amount of incomplete information persists also for high quality banks, some insolvent banks (although fewer) would accumulate losses. The market for bank credit would therefore collapse also for high quality banks even though at a later date than for low quality banks.

likely to ensue. In fact, banks have higher probability to remain solvent and, consequently, have no incentive to renew loans to insolvent projects.

Hence increasing firm-transparency can play an important indirect role in fostering financial stability: Close bank-firm relationships in which firms rely mainly on a single lender are more common in environments where asymmetric information is more severe (Rajan and Zingales, 1998). In more transparent environments, banks choose to diversify their assets to a larger extent (Winton, 2003). Hence, they are less likely to become insolvent because of a few wrong lending decisions. This eliminates the soft-budget constraint distortion, and, ultimately, overlending problems.

## 9. Conclusions

This paper shows that the liberalization of capital inflows may generate boom-bust crises in emerging markets. After the liberalization of capital inflows, a few unlucky banks may become insolvent due to asymmetric information. If investors do not observe the quality of bank assets, banks accumulate losses even if investors expect a banking crisis. A few banks accumulating losses may thus disrupt the credit market and cause the interruption of solvent projects. This involves an output loss even if there are no illiquidity problems. I show that in this context a financial liberalization may reduce welfare.

The dynamics of the banking crisis is consistent with the empirical evidence from emerging markets (Kaminsky and Reinhart, 1999). Immediately after the financial liberalization, emerging economies enjoy low interest rates and experience lending and investment booms. These booms end abruptly and capital flows suddenly reverse. The implications of the model are also consistent with the empirical evidence showing that greater transparency reduces the probability of systemic banking crises (Tadesse, 2004). Additionally, the model can explain why banks that disclose more information on their assets are less likely to experience increases in the cost of funds (Nier, 2005).

Measures that improve transparency increase financial stability or at least help to limit accumulation of bad loans. Banks' incentives, however, matter as much as lack of market discipline. Insolvent banks, having limited liability, renew loans even if it entails accumulation of losses. No processes of ever-greening of loans would emerge if banks were not insolvent. This implies that measures improving bank resilience to errors in lending decisions –such as increased capital requirement or an improvement in diversification of bank assets– help to enhance financial stability.

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**Figure 1**

**Aggregate losses in an insolvent country (Type I)**

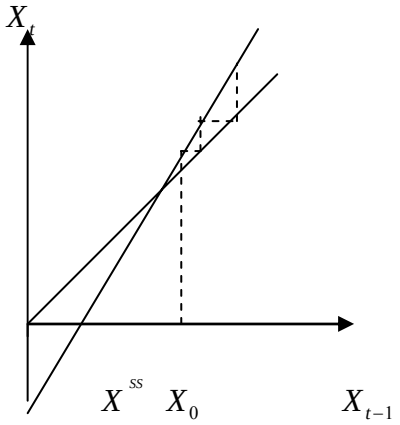
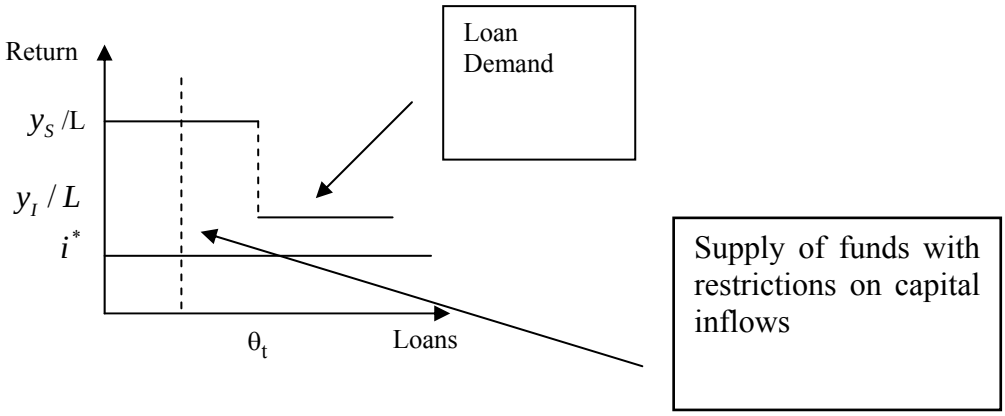



**Figure 2**

**Equilibrium in the loan market**



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