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Bank Fragility and Growth Expectations*

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Abstract

Banks supply liquidity to insure individuals against possible short-term consumption shocks. The higher this level of illiquidity insurance the lower the investments in long run assets, and the higher the risk of a bank run generated by a real negative shock. If individuals are sufficiently risk averse, competitive banks trade off liquidity insurance for portfolio risk. High growth expectations, typical of emerging economies, increase the optimal liquidity supply even when this increases the risk of a bank run. On the contrary, deposit contracts offered when economic performances are very uncertain (like in less developed economies), and where output fluctuations are milder (like in developed economies), are less exposed to the risk of a bank run. In this setting, a bail-out in case of crisis is ex-ante Pareto efficient even if it always increases the risk of crisis.

KEYWORDS: illiquidity insurance, portfolio risk, bank run, growth expectations

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1 Introduction

Banking crises are familiar occurrences in developing economies. Indeed, by some measures, over 70% of banking crises in the last quarter century took place in developing countries.[1] Table 1 shows the frequency of crisis in countries with differing growth patterns and it seems to support this regularity–banking crises are more frequent in economies during phases of sustained and continuous growth, suggesting that rapidly developing economies may be particularly susceptible to banking crises.[2]

Table 1: Frequencies of crisis and economic growth, 1982–1999[3]

Years of previous growth $> 3\%$	$\frac{\#Crisis}{\#Obs.}$	*# Observations*
less than 5	.031	1668
5 or more	.097[4]	82
Years of previous growth $> 5\%$		
less than 5	.032	1729
5 or more	.142[5]	21
all observations	.034	1750

Accordingly, this paper investigates the link between economic development and banking crisis, emphasizing a possible mechanism through which high growth expectations typical for a taking-off economy result in increased

[1] See Londgren, Garcia and Saal (1996), Kaminsky and Reinhart (1996), Caprio and Kilinger (1999), Demirguç-Kunt and Detragiache (1998, 2002).

[2] Since the business cycles typical of modern developed economies feature a peak and a low about every five years, we argue that a growth rate exceeding 3 percent for five or more years is compatible mostly with emerging economies. In the data used in Table 1, the subsample does not include even one of the top ten richest countries (in terms of 1998 per capita income) and Ireland is the only country in top 20 (see the last section for dataset details and the list of fast-growing countries selected by our criteria).

[3] Data on crisis elaborated from Caprio and Kligebiel (1999) and Lindgren, Garcia and Saal (1996). Growth rates are from World Bank, WDI database. The actual years of crisis are excluded. In the final section of this paper, we provide a more accurate description the dataset.

[4] An OLS regression of the probability of crisis on a binary dummy selecting countries with 5 or more years of growth greater than 3 percent per year gives a significant coefficient at the 99 percent level (coeff. 0.067; std err 0.020).

[5] An OLS regression of the probability of crisis on a binary dummy selecting countries with 5 or more years of growth greater than 5 percent per year gives a significant coefficient at the 99 percent level (coeff. 0.11; std err 0.039).

fragility of the banking system. We demonstrate that rational individuals in fast-growing economies tend to increase their demand for liquidity to smooth their consumption path, especially when consumption is initially low. Competitive banks respond by increasing the liquidity supply even if this implies higher exposure to financial crises. Individuals, in turn, accept the increased risk because of the consumption-smoothing utility.

We analyze a simple model based on the classic Diamond and Dybvig (1983) model (henceforth DD model), where banks supply demand deposit contracts to provide an insurance against illiquidity shocks, investing some of depositors' liquid capital in long-term assets. A high level of liquidity supply exposes the bank to a crisis in the case of a negative shock hitting banks' investment portfolios. Assuming individuals are sufficiently risk averse competitive banks trade off liquidity supply – to cover individuals' illiquidity shocks– for portfolio risk. Therefore, a lower level of future expected volatility and (or) higher expected returns, by increasing the optimal illiquidity insurance, increase the risk of crisis.

In other words, individuals prefer to transform into more illiquidity insurance (then into more liquidity supply) part of the utility deriving from the higher expected return on investments, even if they know that more liquidity supply increases the risk of a banking crisis. Interestingly, our setting emphasizes that the only necessary condition for high growth expectations that enhance financial fragility is a sufficiently *high* level of risk aversion. This happens because only sufficiently risk-averse individuals choose an high level of insurance for the illiquidity risk and, therefore, need to trade off illiquidity risk with long-term portfolio risk.

Our result underlines a non-monotonic relationship between bank fragility and degree of development. High growth expectations typical of emerging economies increase the risk of bank run. Conversely, the risk of bank runs are lower in underdeveloped and highly developed economies. For less developed economies, investments and growth are uncertain, so individuals need only limited illiquidity insurance to reduce portfolio risk and avoid the harms of a possible bank run. In developed economies, output fluctuations are typically insufficient to trigger a bank run, so the deposit contracts offered by the banks are essentially bank-run proof.

Perhaps less intuitively, we also note that the increased vulnerability to banking crises in fast-developing countries can be welfare-maximizing. In our setting, bank bail-outs can be ex-ante Pareto efficient even if they increase bank vulnerability. This is because bail-outs decrease the cost of a crisis for individuals and, therefore, give them an incentive to bear increased risk.

This is ex-ante Pareto efficient being the result of an increase in the set of consumption bundles available to all individuals.

Finally, when we explicitly introduce (as an extension of our main model) the liquidation costs for long-term assets, we show that the high liquidity of an asset itself can increase the fragility of the banking system. The obvious explanation here is that a higher level of asset liquidity decreases the cost of the crisis and induces the bank to supply a riskier deposit contract.

Our analysis reveals a link between the level of economic development and bank fragility arising from growth expectations; to the best of our knowledge, this result is new with respect to the existing literature.

Recent contributions addressing the issue of financial crisis in emerging countries fall broadly into two groups. One strand of the literature points focuses on the presence of excessive short-term foreign-denominated assets at the start of crises.[6] This literature deals extensively with currency crises and their connection to banking crises, and is particularly relevant to the financial distress of emerging markets in the mid-1990s.[7] Nevertheless, empirical evidence does not support general application of a link between currency and banking crises.[8] The second strand of literature on financial crisis in developing countries focuses on the role of bad loans in the banking system, a.k.a. *over-borrowing syndrome*, born out of crony relations between investors and governments through banks.[9] This explanation also does not generalize well. Krugman (1999), for example, points out how this interpretation implies that the economic fundamentals of the economy before crisis hits must be poor, which simply is not always true.[10]

Therefore, even granting that the mechanisms cited above may well have the played fundamental roles in certain financial crises, we argue that there may be additional explanations for the weakening or systemic collapse of banking systems in emerging countries. Here, we investigate the explanatory power of another channel, that, unlike in earlier literature, is not linked to a particular pathology present in the economy. Accordingly, our explanation

[6] Radelet and Sachs (1998), Chang and Velasco (2001), Neeman and Orosel (2002), among others.

[7] See e.g. Hardy and Pazarbasioglu (1998).

[8] Demirguç-Kunt and Detragiache (1998), and Eichengreen and Arteta (2000). See also the empirical observations presented at the end of this article.

[9] Mc Kinnon and Pill (1996), Krugman (1998), Corsetti, Pesenti, and Roubini (1999), Femminis and Ruggerone (2004), among others.

[10] The empirical evidence for this link is mixed at best. For example, Caprio and Kingebeil (1996b) find no evidence that a financial crisis is proceeded by a period of lending boom. See also the empirical observations presented at the end of this article.

is not linked to a particular wave of crisis and, in this sense, is related to the line of argument used by Allen and Gale (1998), who analyze the impact of an economic downturn on the bank run with the aim to determine the characteristics of optimality of a deposit contract allowing for a bank run equilibrium. Unlike the Allen-Gale article, however, we analyze the link between the likelihood of a crisis and growth expectations. In this case, an economic downturn only triggers a crisis when its ex-ante probability is sufficiently low.

In terms of economic policy, the literature is heavy with discussions of the potentially bad effects of external intervention insuring banks against the risk of premature asset liquidation (e.g. deposit insurance and bail-out). The contributions based on the over-borrowing syndrome as a cause of financial fragility emphasize how external insurance exacerbates moral hazard problems to increase banks' fragility. Our framework adds perspective for the regulator by discussing another channel through which a bail-out, even if it increases banking system fragility, may nevertheless be welfare-improving.

The paper is organized as follows: in the next section, we analyze the main model, assuming that a long-term asset can be liquidated at no cost at time 1. In section 3, we consider the economic policy implications of the main model. In section 4, we relax the assumption of zero liquidation cost of long-term assets. In section 5, we conclude by showing some empirical observations.

2 The Theoretical Framework

The model of banking here follows the DD model, but assumes that asset revenue is random and that a bank run can be generated by a bad real signal on economic performance. Individuals take the risk of a bank run into account ex ante and decide the level of insurance against the risk of illiquidity. While most papers based on the DD model deal with differentiating between real-shock-driven and sunspot-driven bank runs,[11] we focus here solely on real-shock-driven bank runs to determine the external conditions that increase the exposure of banking systems to financial crisis.[12]

[11] Gorton (1987), Chiari and Jaganathan (1988), Jacklin and Battacharya (1988), Goldstain and Pauzner (1999), Gren and Li (2000), and Peck and Shell (2003) among others. See Freixas and Rochet (1999) and the more recent Gorton and Winton (2002) for an excellent survey on the argument.

[12] The empirical evidence suggests that bank runs are triggered by real shocks rather than sunspots as in the original DD model. See e.g. the survey of Gorton and Winton

Economy description

In our economy, there is a continuum of agents with mass 1 and a single good that can be consumed or invested. Every agent owns a unit of endowment at $t = 0$ and lives for three periods. The good can be costlessy stored or invested in an illiquid asset, which consists of a share of the market portfolio that we assume perfectly correlates with the aggregate production in the economy. In order to fully solve the model so that we will can perform comparative statics with growth expectations, we assume the simplest portfolio's return distribution: a unit invested at time 0 yields, after two periods, R^l with probability $1 - q$ and (slightly abusing the notation) $R^h = R^l + r$ with probability q, where $r > 0$. If agents perceive that the economy is on a path of high growth, q is close to 1. Conversely, q is close to 0 in a stagnating economy. We define $\tilde{R}$ as the random variable describing the returns on portfolio with $E(\tilde{R}) > 1$, R^i the realization of $\tilde{R}$ and R the asset return vector. The performance of the economy at time 2 is public knowledge at time 1, after the agent receives a perfect signal about the state of the economy, while at time 0, all agents have identical growth expectations described by R^l, r and q.

A unit invested in the asset at time 0 can be disinvested and yields p unit of the good at time 1. We first assume simply that $p = 1$. This assumption implies that it is optimal at $t = 0$ to invest the entire wealth in the illiquid asset. In section 4, we relax this assumption and solve the model for a general p. Finally, for expositional simplicity (to ensure that the asset is ex ante always demanded for any level of individuals' risk aversion and any probability q), we assume $R^l > 1$.[13]

We consider two types of individuals: "patient" and "impatient." Every individual knows their types only at time 1, while at time 0 each individual knows that she will be impatient with a probability of $\frac{1}{2}$. An impatient individual obtains no utility in consuming at $t = 2$, while a patient individual obtains her utility only from consuming at time 2. A typical consumers' utility function at $t = 0$ can thus be written as

$$U(c_1, c_2) = \begin{cases} u(c_1) & \text{With prob. } \frac{1}{2} \\ u(c_2) & \text{With prob. } \frac{1}{2}. \end{cases} ,$$

(2002, p.77).

[13] Otherwise, we should have fixed a minium R^l dependent on q and on the individuals' risk aversion such that investing in the assets is strictly preferred than holding liquidity at time 2.

where c_t denotes consumption at time $t = 1, 2$. We define the event of being impatient as the risk of *illiquidity shock*.

As usual, we assume function $u(\cdot)$ twice continuously differentiable, increasing, strictly concave, unbounded above, and with $\lim_{c \to 0} u'(c) = \infty$. Moreover, individuals are "sufficiently" risk averse, so that

$$-\frac{cu''(c)}{u'(c)} > 1. \tag{1}$$

This is a standard assumption in the DD model; it ensures that individuals are willing to insure themselves against an illiquidity shock choosing $c_1^* > 1$. Given assumption (1), we will see that individuals desire to translate part of the utility derived from a less risky outcome in the long run to more insurance against short-term illiquidity, even if this would imply higher risk of a bank run.[14]

Demand deposit contract and bank run

As the DD model shows, a bank can optimally increase individuals' utility by pooling all their investments and insuring individuals against idiosyncratic illiquidity shocks. Accordingly, we now determine the optimal contract, conditional on R^l, r and q, that a bank offers its customers to ensure them against the illiquidity shock and analyze the risk of a information-based bank run. For expositional simplicity, we determine the level of c_1 and c_2 that can trigger a banking crisis at levels of R^l and r; and then endogenize the optimal choice of c_1 and c_2 and determine the likelihood of a bank run triggered by the event $R^i = R^l$as a function of R^l, r and q.

As in the Allen-Gale case, we assume that the signal about the economy cannot be made into a contract condition. Therefore, c_1 cannot directly be made contingent on R^i. Accordingly, individuals surrender their entire endowment to the bank, which at time $t = 0$ offers a deposit contract defined by the type and state-dependent consumption bundle $(c_1, c_2(R))$, where

[14]For our purposes, it is instructive to think of (1) in terms of the inverse of elasticity of substitutions, i.e.

$$-\frac{u'(c)}{cu''(c)} < 1.$$

Put in this way, we see that assumption (1) implies a preference to translate part of the increase in expected returns at time 2 into time 1 consumption. Therefore, individuals prefer a smoother consumption path. Higher expected returns in the long run always translate into higher short-term consumption rather than into higher long-run investment (i.e. the income effect outweighs the substitution effect).

$c_2(R) = [c_2(R^h), c_2(R^l)]$.

As it is not apparent who is patient and who is impatient in the midst of a bank run, it is possible that some patient individuals decide to go to the bank and withdraw their savings at time $t = 1$ if circumstances warrant. To account for the possibility that a patient individual withdraw at $t = 1$, we introduce further notation. Let $c_{2,t}$ denote the consumption of patient individuals who withdraw at time $t = (1, 2)$. Hence, $c_{2,1}$ is the consumption of patient individuals who withdraw at time 1. Recalling that the good is perfectly storable and types are private information, patient individuals withdraw at time 1 if $c_{2,1} = c_1 > c_{2,2}$. Let ρ be the mass of early withdrawers − so that a bank run implies $\rho > \frac{1}{2}$− and assume the following timing and bank behavior in case of a run:

1. The bank respects sequential (first come, first served) service and gives c_1 to the first $\rho = \frac{1}{2}$ individuals.

2. The bank liquidates and distributes its remaining capital $(1 - \frac{1}{2}c_1)$ to all customers, whether or not they joined the queue.

We assume the bank does this after formally closing the counter, so that it is not bound to respect sequential service after point 2. Accordingly, all remaining individuals receive the same amount $(2 - c_1)$. This sequence of events appears to reflect actual bank behavior during a run. Bank runs typically arise unexpectedly; it often takes banks several days to fulfill the requests of an unexpectedly large number of withdrawers. Accordingly, banks normally serve the first customers arriving at the counter, but at some point, perhaps when the bank exhausts its cash on hand, the counter closes and the bank devotes time to liquidating assets. At this point, the bank distributes equally to all the remaining customers the liquidity realized from the asset sales. Alternatively, we may assume that the government decides to suspend convertibility once it is certain a run is taking place, i.e. if earlier withdrawers are more than $\frac{1}{2}$.[15]

We note that $c_{2,2}(R) = (2 - c_1)R$ in the equilibrium with no run (i.e. if $\rho = \frac{1}{2}$) and we state the following

[15] Although such behavior is realistic, it is not the only possible behavior, for example Allen and Gale consider an equal treatment for all customers. We will argue below how any other rule involving efficiency loss from the bank run would not change qualitatively our results.

Lemma 1 *Whenever*

$$c_1 > \frac{2R^i}{R^i + 1}. \tag{2}$$

the information-based bank run is the only Nash Equilibrium.

Proof. see Appendix. ■

Condition (2) is only sufficient for a run. As the DD model and its offspring extensively emphasize, as long as $c_1 > 1$, there are multiple equilibria and, therefore, the possibility of a bank run generated only by sunspots. However, here we rule out the possibility of pure panic-based bank runs to focus solely on bank runs generated by economic fundamentals as determined by condition (2). The literature usually refers to these as *information-based bank runs*.

Finally, before determining the optimal deposit contract, it is useful to demonstrate a second lemma:

Lemma 2 *If $R = R^h$ there is never an information-based bank run.*

Proof. *See Appendix.* ■

The Optimal Demand Deposit Contract

Using lemma 1 and lemma 2, we argue that a bank run takes place only if:

$$R = R^l \text{ and } c_1 > \frac{2R^l}{R^l + 1} \tag{3}$$

Since everybody observes the signal at the same time and runs to the counter when conditions (3) are true, $\frac{1}{2}$ is the probability of being in the first $\frac{1}{2}$ to arrive at the counter with other early withdrawers.[16]

Moreover, recalling that the bank cannot discriminate between patient and impatient types, $c_{2,1} = c_1$. Accordingly, the agents' utility at time 0, conditional that the run happens, is $\frac{1}{2}u(c_1) + \frac{1}{2}u(2(1 - \frac{1}{2}c_1))$. While, the ex-ante utility with no run is $\frac{1}{2}u(c_1) + \frac{1}{2}E\left[u(2(1 - \frac{1}{2}c_1)\tilde{R})\right]$.

[16] The simplifying assumption that everybody observes the signal does not affect the final result. We can more realistically assume that only a share s of individuals receive the signal. Thus, if s is the probability of receiving the signal, $\frac{1}{2}/\frac{s+1}{2} = \frac{1}{(1+s)}$ is the probability of being in the first $\frac{1}{2}$ to arrive at the counter. Since the probability of being an early runner is $\frac{1}{2}(1+s)$, the ex-ante probability of being among the first $\frac{1}{2}$ is simply $\frac{1}{2}$.

Since banks are in competition, they maximize individuals' utility. As a result, given conditions (3), we write the problem for the bank as follows:

$$\max_{c_1(R^l,r,q)} \{V^{br}(R^l,r,q); V^{rp}(R^l,r,q)\} \tag{4}$$

$$V^{rp}(R^l,r,q) = \max_{c_1} \ \frac{1}{2}u(c_1) + \frac{1}{2}\left(qu\left((2-c_1)(R^l+r)\right) + (1-q)u(2-c_1)R^l\right) \tag{5}$$

$$\text{subject to } c_1 \leq \frac{2R^l}{R^l+1}, \tag{6}$$

$$V^{br}(R^l,r,q) = \max_{c_1} \ \frac{1}{2}u(c_1) + \frac{1}{2}\left(qu\left((2-c_1)(R^l+r)\right) + (1-q)u(2-c_1)\right) \tag{7}$$

$$\text{subject to } c_1 > \frac{2R^l}{R^l+1}.$$

Hence, if the contract is *bank-run proof*, the expected utility from the contract is $V^{rp}(R^l,r,q)$. Otherwise, the expected utility is $V^{br}(R^l,r,q)$ and a bank run is possible.

Now, if we define c_1^1 :

$$u'(c_1^1) = q(R^l+r)u'\left(2(1-\frac{1}{2}c_1^1)(R^l+r)\right) + (1-q)R^l u'\left(2(1-\frac{1}{2}c_1^1)R^l\right) \tag{8}$$

and c_1^2 :

$$u'(c_1^2) = q(R^l+r)u'\left(2(1-\frac{1}{2}c_1^2)(R^l+r)\right) + (1-q)u'\left(2(1-\frac{1}{2}c_1^2)\right) \tag{9}$$

we can more generally state

Proposition 1 *If individuals are sufficiently risk averse, so that condition (1) is true. There exists a $\underline{r} > 0$ such that for any given $r > \underline{r}$ and R^l, the solution of (4) can be expressed as:*

$$c_1^* = \begin{cases} c_1^1(q) & \text{if } q \leq \underline{q} \\ \frac{2R^l}{R^l+1} & \text{if } \underline{q} < q \leq \bar{q} \\ c_1^2(q) & q > \bar{q} \end{cases}, \tag{10}$$

with $c_1^1(q) \leq \frac{2R^l}{R^l+1} < c_1^2(q)$. Therefore, the risky contract (strictly) dominates *the bank-run-proof contract if, and only if,* $q \geqslant \bar{q}$ $(q > \bar{q})$, *with* $\frac{\partial \bar{q}}{\partial r} < 0$ *and* $\frac{\partial \underline{q}}{\partial r} < 0$.

Proof. See Appendix. ■

To better illustrate proposition 1, we numerically solve problem (4). We assume a CRRA utility function with $\sigma = 2$, and $R^l = 1.01$, $R^h = R^l + r = 1.05$. A sample solution is provided in Figure 1, where we analyze the optimal contractual choice with respect to different levels of q. When the $q \leq \underline{q}$ constraint (6) is not binding, it implies that there is only one available contract that solves problem (4). This is determined by subproblem 5 and is bank-run proof. When the $\underline{q} < q \leq \bar{q}$, constraint (6) is binding and $V^{rp} > V^{br}$, agents prefer a safe contract and choose $c_1 = \frac{2R^l}{R^l+1}$. Finally, when $q > \bar{q}$ then $V^{br} > V^{rp}$: the expected utility for a risky contract is so high that agents choose it despite the risk of a bank run.

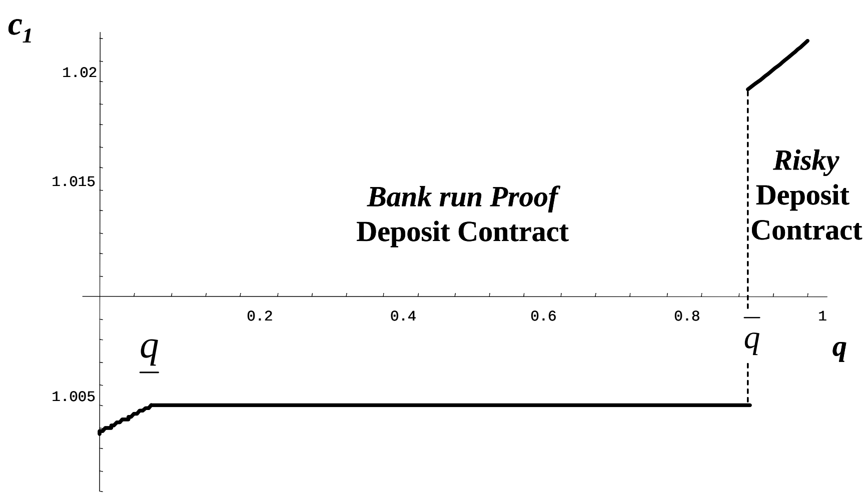

Figure 1: Deposit contract and risk.

To illustrate the implications of proposition 1, it is useful to refer again to our example. Now, however, we consider r as a variable (and keep $R^l = 1.01$ and $\sigma = 2$), so that we can determine functions $\bar{q}(r)$ and $\underline{q}(r)$. As shown in Figure 2, we represent the optimal contract with respect to growth expectations and analyze the risk of bank run under three scenarios:

1. Less-developed economies, where r can be large but q is small: there is at the best an high level of uncertainty, given the production structure is not diversified.

2. Developing economies with a large r and a relatively small q given to the good perspectives of future growth.

3. Developed economy, where growth expectations are lower than in developing countries, so that r is relatively small.

In less-developed economies, economic performances are at the best uncertain, hence demanding a high level of liquidity insurance would be too risky and, therefore, banks face no risk of bank run. At the other extreme, the developed economies scenario, given that r is relatively small, an efficient illiquidity insurance does not trigger a run even in the event of a bad shock. Finally in Scenario 2, the developing economy environment, agents prefer more short-term insurance, given that r is big and the probability of a bad shock, $1 - q$, is sufficiently low, at the cost of risking a bank run.

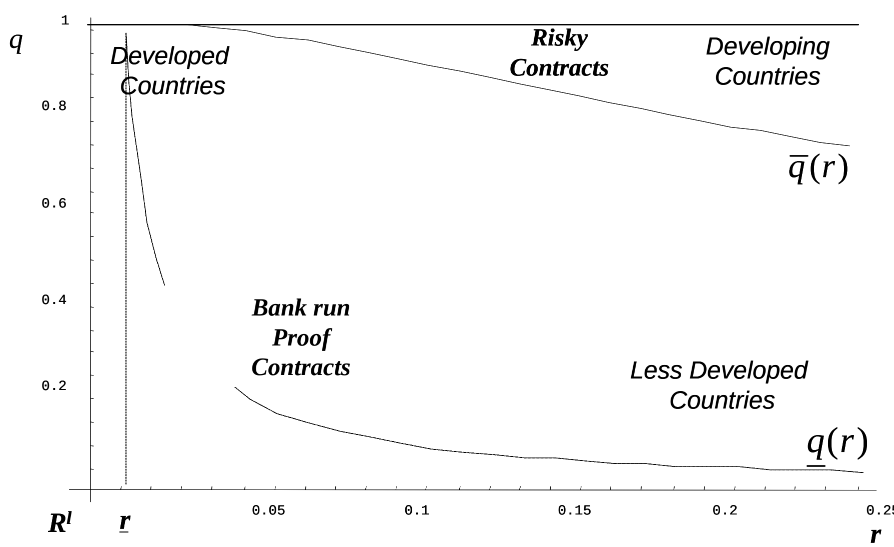

Figure 2: Optimal contract as a function of q, r, R^l.

Repayment rules adopted by banks in the event of a run

We now argue how our results only depend on the existence of some efficiency loss following the bank run. It is robust to the introduction of another rule of payment in case of a run. In a hypothetical benchmark case, Allen and Gale show that when long-term assets cannot be liquidated early (i.e. there is not a secondary financial market) and where banks treat all individuals in the same way in case of a run, the usual deposit contract achieve a first best efficient level of intertemporal insurance, even if an early bad signal can potentially cause a bank run. In this case, no contract can do better than a deposit contract even if there is a positive probability of bank run in case of a low R (defined above as a "risky contract").[17] As in Allen and Gale's benchmark case, the option defined above as a "bank-run-proof contract" is never chosen.

Allen and Gale also note, however, that if we introduce the possibility of an early asset liquidation, the risky contract ceases to be efficient as the assets liquidation cost rises. This creates the possibility that a contract specifically set to avoid the bank run is the optimal solution. Specifically, consider our setting under the alternative assumption of *equal treatment for all withdrawers* in case of a run. Here, all individuals obtain a utility equal to $u(1)$ (strictly less than $u(c_1)$) with an aggregate liquidation cost equal $R^l - 1$. Under this alternative assumption, our model results do not change qualitatively as competitive banks will trade off this liquidation cost with the benefit of an higher level of intertemporal insurance, so a bank-run-proof contract will sometime result the welfare-optimizing choice.[18]

Obviously, this reasoning holds if we consider a pure *first-come-first-served rule*, where banks give c_1 to every eager arrivals at the counter and nothing to late-comers. In this case, there is also an efficiency loss (generated by the early asset liquidation plus the non insurable risk of arriving late in case of bank run), so banks will trade off this cost with the benefit of a higher illiquidity insurance and sometimes choose a bank-run-proof contract as in our model.

Therefore, as far as there is a loss in efficiency following the bank run (i.e. we are not in the AG benchmark case of equal treatment rule *plus* asset illiquidity), competitive banks may decide to supply a bank run proof contract if the probability a negative shock is high. Thus, our main results still hold.

3 Economic policy

In the previous section, we saw a bank offer a safe contract and supply a lower level of illiquidity insurance when the uncertainty about the future is high to

[17] The proof is in the main section of Allen and Gale's paper.

[18] Note that our first-come-first-serve rule of payment, if compared with the equal treatment rule, involves higher bank run costs since the former rule implies a non-insurable risk of arriving late to the counter.

avoid the costs of early asset liquidation caused by a bank run. Therefore, a policy of bail-out aimed at decreasing or avoiding the costs of early liquidation induces banks to offer risky contracts, even in economic environments with high long-term uncertainty. However, even if a bail-out policy increases financial fragility, it is ex-ante Pareto-improving provided that it does not have other costs for the economy either in terms of opportunity costs or in terms of inefficient distortions of investment choices. In other words, all individuals are strictly better off at time 0, when a central agency is committed to intervene in case of crisis.

In a bail-out policy, a central agency, in the event of a run, is committed to acquiring bank's assets, or equivalently, to lending money to banks using their illiquid assets as a collateral. Thus, this policy is zero-cost (if we abstract from the opportunity costs) in the sense that the agency lends at time 1 an amount $2(1-\frac{1}{2}c_1)R^l$ to the bank, which then completely repays the loan at time 2 when it liquidates assets and realizes R^l.

Such lending avoids the loss $2(1-\frac{1}{2}c_1)(R^l-1)$ for the bank when it liquidates assets. As a result, $c_2(R^l)=2(1-\frac{1}{2}c_1)R^l$, no matter whether there is a bank run or not. The new problem then becomes

$$\max_{c_1}\ \frac{1}{2}u(c_1)+\frac{1}{2}E(u((2-c_1)\tilde{R}), \tag{11}$$

and the optimal consumption bundle, say $(c_1^{bo}, c_2^{bo}(R))$ is determined as

$$u'(c_1^{bo})=q(R^l+r)u'(2(1-\frac{1}{2}c_1^{bo})(R^l+r))+(1-q)R^lu'(2(1-\frac{1}{2}c_1^{bo})R^l), \tag{12}$$

$$c_2(R)=2(1-\frac{1}{2}c_1^{bo})R \tag{13}$$

We note that the optimal consumption bundle $(c_1^{bo}, c_2^{bo}(R))$ generated by problem (11) dominates $(c_1^*, c_2^*(R))$ from problem (4) since it avoids the cost of early asset liquidations.[19]

Furthermore, comparing (8) and (9) with (12) we can see that $c_1^{bo}=c_1^*$ if $q\leq \underline{q}$ while $c_1^{bo}>c_1^*$ for $q>\underline{q}$. The presence of a bail-out increases the interval of q when a run takes place.

[19]More formally, when $q\leq\bar{q}$ or when $R^i=R^h$ both $(c_1^*, c_2^*(R))$ and $(c_1^{bo}, c_2^{bo}(R))$ belong to the feasible sets $\{S(i): c_2\leq(2-c_1)R^i\}$.On the contrary, when $q>\bar{q}$ and $R=R^l$, $(c_1^{bo}, c_2^{bo}(R^l))\in\{S(l): c_2\leq(2-c_1)R^l\}$ while $(c_1^*, c_2^*(R^l))\in\{S^{‘}: c_2\leq(2-c_1))$ with $S^{‘}\subset S(l)$. Therefore $(c_1^*, c_2^*(R))$ is always avaiable when $(c_1^{bo}, c_2^{bo}(R))$ is chosen.

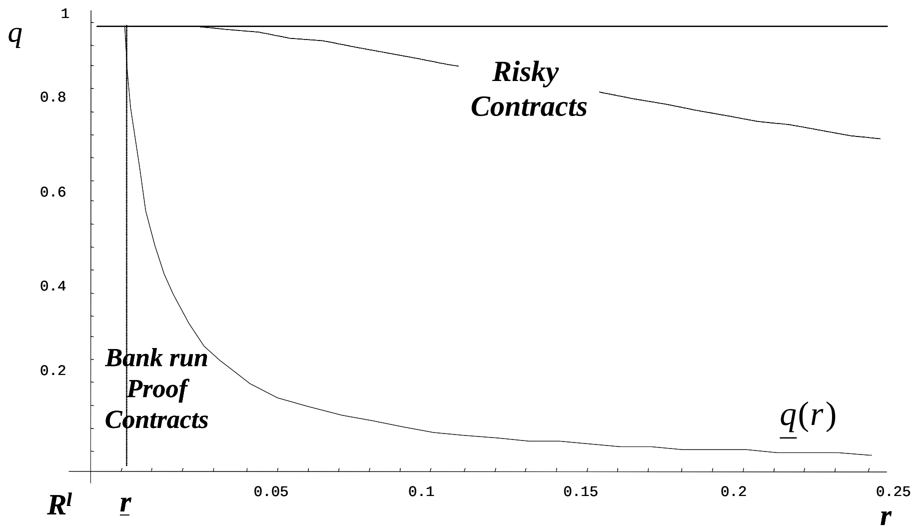

Figure 3: Optimal contract with external intervention

This is illustrated in Figure 3, where we present the deposit contract when individuals expect a bail-out. Whenever $q > \underline{q}$, a run will take place in the bad state, R^l. While, in the same state of nature and without bail-out, a run will only take place if $q > \bar{q}$ as shown in Figure 2. Therefore, a bank run is more likely to happen in when agents expect a bail-out in the sense that the risky region is bigger in Figure 3 than in Figure 2.

It is important to emphasize, however, that the above result hold only in this simplified setting. For the more complex real world, regulators need to consider two caveats:

i) The extent to which the cost of the higher risk of bank run outweighs the benefit is subject to our assumption that a bail-out can be implemented at no cost. If we assume some opportunity cost of the funds necessary for the bail-out (i.e. there are diverted from more profitable investments) and not internalized by depositors, the ultimate impact of the external intervention becomes ambiguous.

ii) Inefficiency also arises from the fact that expectations of a bail-out generate moral hazard problems. For example, we can assume in case of bad aggregate shock, good investments yield $R^l = R^l_g > 1$. Bad investments, in turn, yield $R^l = R^l_b < 1$, so banks must bear a selection cost $c > 0$ to identify their good investments. If banks expect a bail-out where all investments will be bailed out for an amount $p^{bo} \geq R^l_b$, they may not want to spend c to select the right investments, and there will be a positive share of bad investments that are not liquidated at time 1 even if would be efficient to do so.[20]

Accordingly, this section emphasizes a possible benefit from an bail-out and the fact that the usually invoked increased fragility of the banking system is not necessarily a reason to avoid such intervention. Clearly, the cost implied by caveats i) and ii) have to be carefully weighted before an automatic bail-out mechanism is put in place.

4 Costly liquidation

In this section, we consider the more general case where the asset can be liquidated in the asset market at a price $p < 1$.[21] In particular, we show that a higher liquidation price that reduces the cost of early liquidation can induce the bank to supply risky contracts that increase the probability of a bank run. At the same time, however, the higher liquidation price represents an improvement in the aggregate utility for the economy.

Assume for the sake of simplicity that individuals know ex-ante the liquidation price p if $R^i = R^l$ and there is a bank run. In this case, the bank at time 0, besides having to decide on the level of c_1, must decide on the allocation of its money (level L of liquidity and $1 - L$ in illiquid assets).

Since $p < 1$, a bank will liquidate the asset only if there is bank run. Otherwise, it prefers to invest in L. Accordingly, the bank run condition becomes

$$c_1 > L + R(1 - L), \tag{14}$$

and the banks' problem becomes

$$\max_{c_1(R^l,r,q,p)} \{V_L^{br}(R^l, r, q, p); V_L^{rp}(R^l, r, q)\} \tag{15}$$

$$V_L^{rp}(R^l, r, q) = \max_{c_1,c_2(R),L} \; u(c_1) + \frac{1}{2}E(u(2((1-L)\tilde{R} + L - \frac{1}{2}c_1)\;)$$

$$\text{if } c_1 \leq L + R(1 - L)$$

[20] This cost could be lowered or avoided if the bailing-out agency commits ex-ante to rescue only good investments effectively yielding R^l_g.

[21] If $p \geq 1$, this case is not qualitatively different from the previous section, since there is no incentive for the bank to retain liquidity.

$$V_L^{rp}(R^l, r, q, p) = \max_{c_1, c_2(R), L} \; u(c_1) +$$
$$\frac{1}{2}\left(qu\left(2((1-L)R^h + L - \frac{1}{2}c_1\right) + (1-q)u\left(2((1-L)p + L - \frac{1}{2}c_1\right)\right)$$
$$\text{if } c_1 > L + R(1-L).$$

As in the previous section, we split problem (15) in two sub-problems. First, considering a bank-run-proof contract, we notice that $c_1 = 2L$, so there is no need here to retain extra liquidity and banks will be reluctant to liquidate at time $t = 1$, since $p < 1$. Hence, the run-proof optimal contract can be described as

$$\max_{L} \; \frac{1}{2}u(2L) + \frac{1}{2}\left(Eu\left(2((1-L)R)\right)\right), \tag{16}$$

subject to

$$L \leq \frac{R^l}{1+R^l}. \tag{17}$$

The last constraint applies since a run can only occur when $R^i = R^l$.As stated above in lemma 2, it can never be an optimal contract if a crisis takes place anywhere in the world).

If the contract allows a bank run to happen in the event $R = R^l$, the problem becomes

$$\begin{aligned} \max_{c_1, L} \; & \frac{1}{2}u(c_1) + \frac{1}{2}(qu\left(2((1-L)R^h + L - \frac{1}{2}c_1)\right) \\ & + (1-q)u\left(2((1-L)p + L - \frac{1}{2}c_1)\right)), \end{aligned} \tag{18}$$

subject to

$$c_1 > L + R(1-L). \tag{19}$$

Considering problem (15), we show that

Proposition 2 *When individuals are sufficiently risk averse, so that condition (1) is true. There exists an $\underline{r}$, such that for for any given R^l, $r > \underline{r}$ and $p \geq 0$ there is a $\hat{q} < 1$ such that the risky contract (strictly) dominates the bank-run-proof contract if, and only if, $q \geqslant \hat{q}$ ($q > \hat{q}$), with $\frac{\partial \hat{q}}{\partial p} < 0$.*

Proof. *See Appendix.* ■

For a given q, a higher level of p may induce individuals to choose a risky contract. Thus, the higher liquidity of investments can generate a higher probability of crisis. This is true since a high liquidation price p lowers the cost of a bank run and thus individuals may prefer contracts that are not bank-run proof. One can argue therefore that a higher level of p, i.e. an higher level of asset liquidity, may be the result of an efficient, well-functioning financial market. Proposition 2 implies that an efficient secondary market for financial assets may actually increase the risk of a banking crisis.

Note finally that proposition 2 shows the existence a threshold $\hat{q}$ such that below this threshold a bank prefer a safe contract. In that sense, proposition 2 obtains qualitatively the same results as proposition 1 (related to the simple case where liquidation cost $p = 1$).

5 Conclusions and Empirical Observations

In this final section, we present some empirical observations consistent with the finding that high growth expectation increases the risk of crisis through high interest rate.

From table 1 in the introduction, we observed that the frequency of crisis for country with more than 5 years of growth larger than 3 percent a year is substantially and systematically higher than in the other countries (we henceforth define countries meeting these criteria as *fast growing economies*). The high-growth economies selected in our sample can be considered as emerging economies, and, more to the point of our model, economies where in those specific years individuals saw themselves as "pre-rich." A stagnating economy presents, by definition, a pattern of low or negative growth; on the other side, developed economies usually present business cycle behavior with a peak and a low about every five years. Therefore, considering five years of sustained growth should exclude both stagnating and rich economies, and select economies where individuals expect, with an high probability, to become rich in the future.[22]

[22] The countries and the observation periods in the sub-sample: Bahamas, 1981- Botswana,1981-92- Cameroon, 1986-87- Congo, Rep.,1983- Cyprus, 1981- Dominica, 1985- Egypt, 1984-86- Guyana,1996-98- Iceland, 1981- Indonesia, 1991-97- Ireland, 1999- Korea, Rep. 1986-97- Malaysia, 1981-97- Malta, 1981-82- Malta, 1992-98- Mauritius 1990-99- Oman, 1986- Portugal, 1991-92- Singapore, 1981-82- Singapore,1992-98- Sri Lanka, 1982- Thailand 1989- 97.

Accordingly, an empirical support for our model would be that high deposit interest rates explain the higher frequency of crisis in the fast growing economies as shown in Table 1. Obviously, evidence of this sort is at best indicative (since it does not imply a direct causality between growth expectation and interest rates), but it does accord broadly with the basic predictions of our model.

Several papers find a positive correlation between domestic interest rates and probability of crisis (e.g. Demirguç-Kunt and Detragiache, 1998 and 2002; and Hardy and Pazarbasioglu, 1998). Our data suggest this correlation is true only in high-growth economies. In the following econometric exercise, we broadly follow Demirguç-Kunt and Detragiache, 1998 and 2002, (henceforth DKD) with one important difference: we interact the real interest rates with past growth rates.

We follow DKD in the definition of banking crises, who include in the Dataset the "most serious" episodes among all the crisis listed in Caprio and Kingebiel (1999) and Lingren, Gillian, and Saal (1996).[23] Accordingly, we determine a dummy variable $Crisis_{i,t}$, which takes the value one when a banking crisis occurs in country i and time t, and 0 otherwise. The years of crisis after the first have been excluded from the sample to avoid problems of endogeneity. For the same reason, we will lag all the independent variables of one period.

To distinguish the fast growing economies, we determine the dummy variable

$$RH_{i,t-1} = \begin{cases} 1 & \text{if growth}_{i,t-1} > 3\%, \ \dots \ , \text{growth}_{i,t-6} > 3\% \\ 0 & \text{otherwise} \end{cases} .$$

[23] The crisis considered in our sample are: 1990-96, Bangladesh- 1988-93, Burkina Faso- 1987-92, Cameroon-1987-92, Cameroon-1995-98, Cape Verde- 1988-99, Central African Republic- 1979-92, Chad- 1992-99, Congo, Rep.- 1987-98, Costa Rica- 1988-91, Cote d'Ivoire- 1996-1999, Ecuador- 1989, El Salvador- 1991-94, Finland- 1982-99, Ghana- 1993, Guinea- 1995-97, Guinea-Bissau- 1992-94, Indonesia- 1998-99, Indonesia- 1990-93, Italy- 1994-99, Jamaica- 1992-99, Japan-1985-91, Kenya- 1997-99, Korea, Rep.-1985-88, Malaysia- 1997-99, Malaysia-1987-88, Mali- 1984-91, Mauritania- 1994-99, Mexico- 1988-91, Nepal- 1983-90, Niger- 1990-95, Nigeria- 1987-93, Norway- 1988-89, Panama- 1989-99, Papua New Guinea- 1995-99, Paraguay- 1998-99, Philippines- 1981-91, Philippines- 1983-91, Senegal- 1990-99, Sierra Leone- 1988-93 Sri Lanka- 1995, Swaziland- 1991-94, Sweden- 1984-87, Thailand- 1997-99, Thailand- 1993, Togo- 1982-93 Trinidad and Tobago- 1990-98, Uganda- 1981-83, Uruguay- 1993-99, Venezuela- 1996, Zambia-1995-99 Zimbabwe.

for country i at time $t-1$. In other words, $RH_{i,t-1} = 1$ when a country has experienced at least 5 years of uninterrupted growth at 3 percent at least.

We consider all countries in the World Bank development indicators 2004 (WDI) database from 1976 to 1999. Since each observation contains a variable lagged up to six years, our sample is restricted to the period 1982–1999 with gaps from missing data and data for subsequent crisis years deliberately omitted. We also exclude centrally planned economies and economies in transition. In this way, we are left with 107 countries and 46 crisis episodes, for a total of 1,274 observations in the regressions with the largest sample.[24]

The other explanatory variable is the Real Deposit Interest Rate $RDIR_{t-1}$, which is determined by subtracting from the deposit interest rate paid by commercial or similar banks (IMF's International Financial Statistics dataset) the contemporaneous rate of inflation, measured by the GNP deflator (World Bank).

Following this literature (e.g. DKD 2001) the control variables are: the Log per capita GDP, Log $(\text{GDP/CAP})_{t-1}$ (from WDI), as a proxy for the quality of bank regulation and the legal and institutional environment, the growth rate of the domestic credit provided by the banking sector (in percentage of the GDP) between time $t-1$ and $t-2$, $\text{Creditgrowth}_{t-1}$, to control for the possibility of an over-borrowing syndrome by banks (IMF-IFS dataset); the real currency devaluation with respect to the USD exchange rate, $\text{Depreciation}_{t-1}$, which is obtained by subtracting from the nominal depreciation rate with respect to the USD the differential between internal and US inflation rate (IMF-IFS dataset); to test whether the crises are driven by excessive foreign exchange risk exposure; the inflation rate, Inflation_{t-1},

[24]The countries in our sample are: Algeria, Australia, Bahamas, Bahrain, Bangladesh, Barbados, Belgium, Belize, Benin, Bhutan, Botswana, Burkina Faso, Burundi, Cameroon, Canada, Cape Verde, Central African Republic, Chad, Chile, Colombia, Comoros, Congo, Rep., Costa Rica, Cote d'Ivoire, Cyprus, Denmark, Dominica, Dominican Republic, Ecuador, Egypt, Arab Rep., El Salvador, Equatorial Guinea, Ethiopia, Fiji, Finland, France, Gabon, Gambia, Germany, Ghana, Greece, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Honduras, Iceland, Indonesia, Ireland, Italy, Jamaica, Japan, Jordan, Kenya, Korea, Rep., Kuwait, Lebanon, Lesotho, Luxembourg, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritania, Mauritius, Mexico, Morocco, Monzambique, Namibia, Nepal, Netherlands, New Zealand, Niger, Nigeria, Norway, Oman, Panama, Papua New Guinea, Paraguay, Philippines, Portugal, Rwanda, Samoa, Senegal, Seychelles, Sierra Leone, Singapore, South Africa, Spain, Sri Lanka, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Tanzania, Thailand, Togo, Tonga, Trinidad and Tobago, Tunisia, Uganda, United Arab Emirates, United Kingdom, Uruguay, Vanuatu, Venezuela, Zambia, Zimbabwe

in terms of GDP deflator, to account for central bank monetary policy and macroeconomic mismanagement; and the bank reserve in percentage of the total bank assets, Reserves_{t-1}.

Again following the literature, we use a Logit model to estimate the regressions; moreover we introduce a random effect to control for countries' heterogeneity. These results are reported in Table 2.

We run regression 1 and 2, without control variables: the effect of the real deposit interest rate $RDIR$ interacted with the dummy RH is positive and highly significant, while it is not significant on its own. The dummy RH is not significant and becomes significant when introduced without RH^*RDIR, as it is shown in regression 2 (and consistently with table 1 in the introduction). This implies that real interest rate entirely explain in our model the higher probability of crisis in fast growing countries .

In the following regressions, we introduce the control variables, but this does not substantially change our main result: the coefficient of RH^*RDIR is still highly significant in all regressions. Consider regression 3, the variable Log $(\text{GDP/CAP})_{t-1}$ is negative and significant at five percent level. The currency real devaluation, $\text{Depreciation}_{t-1}$, is not significant, this seems to exclude the external capital channel as a general determinant of banking crises.[25]

The bank domestic credit growth rate, $\text{Creditgrowth}_{t-1}$, is not significant.[26] Furthermore, in regression 4 we interacted $\text{Creditgrowth}_{t-1}$ with RH , the coefficient of this interacted term, $RH^*\text{Creditgrowth}_{t-1}$, is not significant nor does it change the coefficient of RH^*RDIR. This last finding does not seem to support the explanation that high interest rates could be generated by the supply of credit for excessively risky project when growth expectations are high. If this were the case, before the crisis we should have observed, a systematic growth of the credit supply in the growing economies.[27]

To verify whether the result is driven solely by the east Asian crisis, we run regression 5, which excludes 1996 and subsequent years. The significance

[25]If a crisis would have been generated by a sudden halt in the inflow of external capital, the crisis should have been preceded by a devaluation of the domestic currency (i.e. the sign should have been positive). This would have been generated by a massive sale of domestic currency either to buy dollars and repay loans denominated in domestic currency or to liquidate assets denominated in foreign currency. Both DKD (1998) and Eichengreen and Arteta (2000) obtain a similar result. However, the depreciation appears positively related to the crisis in DKD (2002).

[26]DKD (1998) obtain the same result, while in DKD (2002) this coefficient is weakly positive.

[27]Caprio and Kingebiel 1996b show evidence supporting a similar conclusion.

of the coefficient of $RH^{*}RDIR$ changes only marginally, while its magnitude actually increases.

We now summarize the main findings of this paper. The model emphasized how an higher level of vulnerability to banking crisis can be optimal in fast developing countries; to the best of our knowledge this result is new in the literature on financial crisis. It also pointed out how an external intervention is desirable and a bail-out to rescue banks can be welfare-improving even if it ex-ante increases the fragility of the financial system.[28] We then showed that individuals may prefer a riskier banking system to the extend that a more efficient financial market decreases the costs to liquidate long-term assets. In this final section of the paper, we saw how high interest rates are good predictor of crisis only for fast growing economies.

[28] This last point is empirically supported by Demirguç-Kunt and Detragiache (2002), who find a strong positive effect of deposit insurance on the probability of crisis

Table 2. Deposit interest rates and banking crises

	1	2	3	4	5
$years$	$82-99$	$82-99$	$82-99$	$82-99$	$82-95$
Log (GDP/CAP)$_{t-1}$			-.44**	-.44**	-.401*
			(.231)	(.232)	(.237)
Creditgrowth$_{t-1}$			-.575	.906	.667
			(.805)	(.901)	(.928)
Depreciation$_{t-1}$			-.072	-.072	-.166
			(.093)	(.093)	(.117)
Reserves$_{t-1}$			-.010	-.010	-.008
			(.010)	(.010)	(.009)
Inflation$_{t-1}$			-.046	-.045	-.150
			(.093)	(.093)	(.117)
Cons.	-3.41***	-3.41***	-3.05***	-3.07***	-2.47***
	(.16)	(.16)	(.444)	(.446)	(0.533)
$RDIR_{t-1}$	-.004	-.0008	.019	.018	.005
	(-.011)	(.0013)	(.016)	.016	.018
$RH^{*}RDIR_{t-1}$	.440***		.411***	.406***	.618**
	(.158)		(.165)	(.166)	(.281)
RH	-.86	1.21***	-.89	-.683	-2.73
	(1.04)	(.408)	(1.08)	(1.09)	(1.97)
RH^{*}Creditgrowth$_{t-1}$				-1.93	
				(3.04)	
No. of obs.	1274	1274	1274	1274	1007
No. of crises	46	46	46	46	39
No. of countries	107	107	107	107	103
No. $RH = 1$	80	80	80	80	58
Wald χ^2	22.92***	8.93***	29.94***	30.20**	15.24**

*Significant at 10%; ** Significant at 5%; *** significant at 1%.

A Appendix

A.1 Proof of lemma 1

The following table shows the strategy payoffs for a patient individuals in the event $\rho = \frac{1}{2}$: when only impatient withdraw,[29] and $\rho \in [\frac{1}{2}, 1)$: when $\rho - \frac{1}{2}$ patient individuals decide to run to the bank as well.

Impatient Individual Payoffs

	$\rho = \frac{1}{2}$	$\rho > \frac{1}{2}$
W	c_1	$\frac{1}{2\rho}c_1 + (1 - \frac{1}{2\rho})(2 - c_1)$
N	$(2 - c_1)R$	$(2 - c_1)$

When (2) is true, $c_1 > (2 - c_1)R > (2 - c_1)$ (recalling that $R > 1$), so that withdrawing early (W) is the only dominant strategy of the game.

A.2 Proof of lemma 2

Suppose conversely that there is a bank run when $R = R^h$. From lemma 1, this happens only when $c_1 > \frac{2R^h}{R^h+1}$. In this case, there will be a bank run when $R = R^l$ as well, and all assets will be liquidated at time 1. This is not an optimal equilibrium since individuals can do strictly better in autarky by liquidating assets only if she is impatient.

A.3 Proof for proposition 1

To determine when a bank-run-proof contract is actually chosen, we consider separately the two sub-problems (5) and (7) of problem (4).

Condition (8) determines c_1^1, the internal solution of problem (5) and condition (9) determine c_1^2, the internal solution of problem (7). Given condition $u'(0) = \infty$, $c_1^j < 2$, with $j = 1, 2$. Using condition (1)– that is equivalent to assuming that $xu'(x)$ is decreasing– we show now that if $q > 0$ then $\frac{\partial c_1^j}{\partial r} > 0$ and $\frac{\partial c_1^j}{\partial q} > 0$. Let us consider 8. Using the implicit function theorem and the

[29] Note that if the strategy is W when $\rho = \frac{1}{2}$, the agent is the only impatient withrawing. Given that we are in the continuum case her payoff is c_1 since the probability of arriving among the first $\frac{1}{2}$ individuals is one.

envelop theorem we will argue that

$$\frac{\partial c_1^1}{\partial r} = \frac{q\left(u'((2-c_1^1)\left(r+R^l\right))+(2-c_1^1)\ (r+R)\ u''((2-c_1^1)\ (r+R))\right)}{u''(c_1^1)+(1-q)\ R^2 u''((2-c_1^1)\ R)+q\,(r+R)^2 u''((2-c_1^1)\ (r+R))} > 0.$$

Indeed, given (1) the numerator is positive, while the denominator is always negative. Using again the implicit function theorem:

$$\frac{\partial c_1^1}{\partial q} = \frac{-R\,u'((2-c_1^1)\ R)+(r+R)\ u'((2-c_1^1)\ (r+R))}{u''(c_1^1)+(1-q)\ R^2 u''((2-c_1^1)\ R)+q\,(r+R)^2 u''((2-c_1^1)\ (r+R))} > 0$$

the numerator is negative given (1) (which implies $x'u'(x)$ decreasing) and the denominator is always negative, given $u'' < 0$. Moreover notice that since we assumed u unbounded above we have $\lim_{r\to\infty} c_1^1 = \infty$ The same properties applies to c_1^2 using (9).(i.e. $\frac{\partial c_1^2}{\partial r} > 0$, $\frac{\partial c_1^2}{\partial q} > 0$ and $\lim_{r\to\infty} c_1^2 = \infty$)

Considering c_1^1,when $q = 0$, constraint (6) is never binding. This is true since (8) implies $c_1^1 < (2-c_1^1)R^l$ or $c_1^1 < \bar{c} \equiv \frac{2R^l}{R^l+1}$. Moreover, let $q = 1$ and define $c(R^h, 1)$:

$$u'(c(R^h,1)) = R^h u'\left((2-c(R^h,1)R^h\right)),$$

recalling that $R^h = R^l + r$, we can always find an r large enough such that $c(R^h, 1) > \frac{2R^l}{R^l+1}$.

Therefore, there always exits a $r > \underline{r}$ such that there is a $\underline{q}=\underline{q}(r)$*:*

$$u'(\bar{c}) = \underline{q}(R^l+r)u'\left((2-\bar{c})(R^l+r)\right)+(1-\underline{q})R^l u'\left((2-\bar{c})R^l\right) \qquad (20)$$

such that $c_1^1(\underline{q}) = \frac{2R^l}{R^l+1}$, hence constraint (6) is binding for $q \geqslant \underline{q} > 0$. Accordingly, we have shown that for any given $r > \underline{r}$, $c_1^* = c_1^1(q)$ iff $q < \underline{q}$ *and* $c_1^* = \frac{2R^l}{R^l+1}$ only if $q \geq \underline{q}$.

We now prove that there exists a $\bar{q}(r) > \underline{q}(r) = \underline{q} : c_1^* = c_1^2(q)$ if and only if $q \geq \bar{q}$. Consider problem (7) for $q > \underline{q}$. Given (20) and that $R^l u'\left((2-\bar{c})R^l\right) <$

$u'((2-\bar{c}))$, in the interval $[\underline{q},1]$ we can define a $\tilde{q}=\tilde{q}(r)$

$$u'(\bar{c})=\tilde{q}(R^l+r)u'\left(2(1-\frac{1}{2}\bar{c})(R^l+r)\right)+(1-\tilde{q})u'\left(2(1-\frac{1}{2}\bar{c})\right), \quad (21)$$

hence $c_1^2(\tilde{q})=\bar{c}$.

Therefore in the interval $q \geqslant \tilde{q}$,,we define function $DV \equiv V^{br}-V^{rp}$, i.e.

$$DV = \\ (1-q)\left(\frac{1}{2}u(c_1^2)+\frac{1}{2}\,u\left(2(1-\frac{1}{2}\,c_1^2)\right)-\,u(\bar{c})\right)+ \\ q\left(\begin{array}{c}\frac{1}{2}\,u(c_1^2)+\frac{1}{2}\,u\left(2(\,1-\frac{1}{2}\,c_1^2)(R^l+r)\right)-\frac{1}{2}u(\bar{c}) \\ -\frac{1}{2}u\left(2(\,1-\frac{1}{2}\,\bar{c})(R^l+r)\right)\end{array}\right).$$

The first term on the RHS is strictly negative. This is true since $u(\bar{c}) > u(\frac{1}{2}c_1^2+(1-\frac{1}{2}\,c_1^2)) > \frac{1}{2}u(c_1^2)+\frac{1}{2}u(2(1-\frac{1}{2}\,c_1^2))$, recalling that $\bar{c}>1$. The second term is positive: function $\frac{1}{2}\,u(c)+\frac{1}{2}\,u\left(2(\,1-\frac{1}{2}\,c)(R^l+r)\right)$ is increasing in $c \leq c_1^2$ because $u'(c_1^2) > (R^l+r)u'\left(2(1-\frac{1}{2}c_1^2)(R^l+r)\right)$. The last point is true given (9) and given that (1) implies that $Ru'\left(2(1-\frac{1}{2}c)R\right)$ is decreasing in R. Thus, $\frac{1}{2}\,u(c_1^2)+\frac{1}{2}\,u\left(2(\,1-\frac{1}{2}\,c_1^2)R^h\right) >.\frac{1}{2}u(\bar{c})+\frac{1}{2}u\left(2(\,1-\frac{1}{2}\,\bar{c})R^h\right)$ since $\bar{c}<c_1^2$.

Using these observations and the envelope theorem we have

$$\frac{\partial DV}{\partial q}>0. \quad (22)$$

Moreover:

- DV is continuous for $q \geqslant \tilde{q}$.
- $DV(\tilde{q},r)=(1-\tilde{q})\left(-\frac{1}{2}\,u(\bar{c})+\frac{1}{2}\,u\left(2(1-\frac{1}{2}\,\bar{c})\right)\right)<0$
- $DV(1,r)>0$ (as shown above)

Therefore for a given $r > \underline{\mathrm{r}}$ there exist a $\bar{q}=\bar{q}(r):\bar{q}>\tilde{q}>\underline{q}$ implicitly defined as $V^{br}(\bar{q},r)=V^{rp}(\bar{q},r)$, such that $V^{br}(q,r)\geq V^{rp}(q,r)$ if $q \geq \bar{q}$. While, for $q<\bar{q}$, the bank-run-proof contract is either preferred or the only feasible. Accordingly for a fixed $r>\underline{r}$, the optimal $c_1^*=c_1^2(q)$.in the interval $q \geq \bar{q}$.

The last point, $\frac{\partial \bar{q}}{\partial r} < 0$ can be proved noticing that

$$\frac{\partial DV}{\partial r} =$$
$$(1 - \frac{1}{2}c_1^2)\, u'\left(2(1 - \frac{1}{2}c_1^2)(R^l + r)\right) - (1 - \frac{1}{2}\bar{c})u'\left(2(1 - \frac{1}{2}\bar{c})(R^l + r)\right) > 0$$

given (1) and that $(1 - \frac{1}{2}c_1^2) < (1 - \frac{1}{2}\bar{c})$. While $\frac{\partial \underline{q}}{\partial r} < 0$ directly follows from (20).

A.4 Proof of proposition 2

Considering first problem 16. given constraint (17), we define the following Lagrangian:

$$\begin{aligned} La(L,\mu) &= \frac{1}{2}u(2L) + (\frac{1}{2})(qu\left(2((1-L)R^h)\right) + \\ & (1-q)u\left(2((1-L)R^l)\right)) + \mu(L - \frac{R^l}{1+R^l}) \end{aligned} \tag{23}$$

The KT condition implies:

$$u'(2L) = qR^h u'\left(2((1-L)R^h)\right) + (1-q)R^l u'\left(2((1-L)R^l)\right)) + \mu$$

two possible solutions

$$\begin{aligned} L &= \bar{L} = \frac{R^l}{1+R^l} \\ L &= L_{1a} \end{aligned}$$

where:

$$u'(2L_{1a}) = qR^h u'\left(2((1-L_{1a})R^h)\right) + (1-q)R^l u'\left(2((1-L_{1a})R^l)\right))$$

using the implicit function theorem we can see that L_{1a} is increasing in r and q (recall that we defined $R^h = R^l + r$) And for $q = 0$, $L_{1a} < \frac{R^l}{1+R^l}$; while for $q = 1$, there exist an $r > 0$ such that $L_{1a} > \frac{R^l}{1+R^l}$ (recall that we assumed $u(\cdot)$ unbounded above). Therefore, there exist a $\underline{r} > 0$ *such that* for any $r \geq \underline{r}$ there is a $\underline{q}(r) \leq 1$, such that the constraint of (23) is binding for $q > \underline{q}(r)$

where $\underline{q}(r)$ is defined as:

$$u`(2\bar{L}) = \underline{q}(R^l+r)u`\left(2((1-\bar{L})(R^l+r))\right)+(1-\underline{q})R^l u`\left(2((1-\bar{L})R^l)\right) \quad (24)$$

with $\frac{\partial q(r)}{\partial r} < 0$.

Clearly in this in this space ($q \geq \underline{q}(r)$ and $r \geq \underline{r}$) :

$$\bar{c} = 2\bar{L}$$

while for $q < \underline{q}(r)$, $L = L_{1a} < \frac{R^l}{1+R^l}$ and $c_1 = 2L$ and this is the best contract.

*Considering subproblem (*18*),* only defined in the space $q > \underline{q}(r)$ (hence, when $q \leq \underline{q}(r)$ the unconstrained subproblem (16) yields the optimal solution), there are only two solutions $\hat{c}_1$ and $\hat{L}$ satisfying the following conditions:

$$\begin{aligned} &u`(c_1) - qu`(2((1-L)R^h + L - \frac{1}{2}c_1) - \\ &(1-q)u`(2((1-L)p + L - \frac{1}{2}c_1)) = 0 \end{aligned} \quad (25)$$

$$\begin{aligned} &(1-q)(1-p)u`(2((1-L)p + L - \frac{1}{2}c_1)) - \\ &q(R^h-1)u`(2((1-L)R^h + L - \frac{1}{2}c_1)) = 0 \end{aligned} \quad (26)$$

they exist in $q > \underline{q}(r)$ since $\hat{c}_1$ increasing in r and in q and unbounded in r (given that $u(\cdot)$ is unbounded above), and $2L > c_1$ (given that banks will never liquidate assets before time 2, if there is not a bank run). Comparing now the two contracts when $q > \underline{q}(r)$:

$$\begin{aligned} DV_L &= V_L^{br} - V_L^{rp} \quad (27) \\ &= (1-q)\left(\frac{1}{2}u(\hat{c}_1) + \frac{1}{2}u\left(2((1-L)p + \hat{L} - \frac{1}{2}\hat{c}_1)\right) - u(\bar{c})\right) + \\ &\quad q\begin{pmatrix} \frac{1}{2}u(\hat{c}_1) + \frac{1}{2}u\left(2((1-\hat{L})R^h + \hat{L} - \frac{1}{2}\hat{c}_1)\right) \\ -\frac{1}{2}u(\bar{c}) - \frac{1}{2}u\left(2\left(1-\bar{L}\right)R^h\right) \end{pmatrix} \end{aligned}$$

the second is positive for the same argument seen in the previous section.

The first term is negative since given the concavity of u :

$$u(\frac{1}{2}\hat{c}_1+\frac{1}{2}\left(2((1-L)p+\hat{L}-\frac{1}{2}\hat{c}_1)\right) > \frac{1}{2}u(\hat{c}_1)+\frac{1}{2}u\left(2((1-L)p+\hat{L}-\frac{1}{2}\hat{c}_1)\right)$$

and

$$\bar{c} > \frac{1}{2}\hat{c}_1 + \frac{1}{2}\left(2((1-L)p+\hat{L}-\frac{1}{2}\hat{c}_1)\right) = (1-\hat{L})p+\hat{L}$$

(recall that $\bar{c} > 1$). Therefore, using the envelope theorem, we have that $\frac{dDV_L}{dq} > 0$ and fixing an $r > \underline{r}$, there exist a $\hat{q}$ such that $DV_L > 0$ iff $q > \hat{q}$. Moreover, if we notice that $\frac{dDV_L}{dp} > 0$ (since V_L^{br} is increasing in p and V_L^{rp} is independent), we can argue that, $\frac{d\hat{q}(r)}{dp} < 0$. For $p \to 1$ we are in the case analyzed in the previous section, where $c_1 = 2L$. We can therefore argue that there is a $r > \underline{\mathrm{r}}$ such that $\hat{q}(1) > \underline{q}(r)$, thus $\hat{q}(p) > \underline{q}(r)$ for all $p \in (0,1)$ (recall that $\underline{q}$ does not depend on p). Accordingly, we can state that for any p the is a $\hat{q}(p)$ such that the risky contract is preferred whenever $q > \hat{q}(p) > \underline{q}(r)$.

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