Bank Fragility in Developing Economies*

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Abstract

Banks supply liquidity to insure individuals against possible short-term consumption needs. 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 tradeoff liquidity insurance for portfolio risk. High growth expectations, typical of emerging economies, increases the optimal liquidity supply even when this increases the risk of 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 not exposed to the risk of a real shock-induced bank run. Policies of providing bail-outs or deposit insurance are ex-ante Pareto efficient even if they always increase the risk of crisis. Some empirical evidence is provided.

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1 Introduction

Banking panics are frequent phenomena in the developing economies. Several studies, using various definitions for a banking crisis, find that at least 70% of them in the last quarter century occurred in developing countries.[1] Table 1 seems to support this idea: banking crises are more frequent in economies on a pattern of high growth. In this paper we aim to show why a developing country might be more vulnerable to a banking crisis.

Table 1: Frequencies of Crisis in countries with different past growth, years 1982-99[2]

Years of previous Growth > 3%	$\frac{\#Crisis}{\#Obs.}$	*# Observations*
less than 5	.031	1680
5 or more	.097	82
all observations	.034	1762

For concreteness, we build on the celebrated 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.

If individuals are sufficiently risk averse competitive banks tradeoff liquidity supply -to cover individuals' illiquidity shocks- for portfolio risk. Therefore, a lower level of future expected volatil-

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

[2] Data on crisis elaborated from Caprio and Kligebiel (1999) and Lindgren, Garcia and Saal (1996). Growth rates are from World Bank, WDI database. The years while the crisis is ongoing are excluded. In the empirical section we provide a more accurate description of our Dataset.

ity and (or) higher expected returns, by increasing the optimal illiquidity insurance, increase the risk of crisis. In other words, banks optimally expose their customers to the risk of bank run in an environment where the economy is on a path of high growth. This happens since risk averse individuals prefer to transform into more liquidity insurance part of the utility deriving from the higher expected return on investments, even if individuals know that more illiquidity insurance increases the risk of a banking crisis. On the other hand, when investments and growth are very uncertain, like in less developed economies, individuals perefer only a limited amount of illiquidity insurance in order to reduce the protfolio risk and not to be exposed to a possible bank run. Moreover, mild output fluctuations- like the business cycles in developed economies- are not strong enough to trigger a bank run and, therefore, the deposit contracts offered by the banks are bank run proof, like in the less developed economies.

The empirical evidence provided at the end are consistent with this result. In particular, we show that high deposit interest rates fully explain the higher frequency of crisis of the countries that experienced high growth in the past five and more years (as showed in table 1).

Our finding emphasizes how a higher level of vulnerability to banking crises is welfare maximizing in fast developing countries. This implies that external interventions lowering the cost of the crisis may be desirable even if they further increase the vulnerability of the banks. In our model indeed, deposit-insurance policy or a bail-out policy ensure a benefit in terms of better insurance which outweighs the costs deriving from the subsequent higher level of fragility.

Furthermore, our model highlights an important difference between the bail-out and deposit insurance. As a bail-out does not avoid the run to the counter, individuals still face an uninsurable cost of arriving late and being able to withdraw less than early withdrawers. This risk is absent under an effective deposit insurance scheme, which avoids the run.[3]

[3]This may explain why most banking crises never resulted in actual runs in our fairly extensive banking-crisis

Most papers based on the DD model deal with differentiating between real shock-driven and sunspot-driven bank runs.[4] Here, we focus on real-shock-driven bank run and determine the external conditions that increase the exposure of banking systems to financial crisis.[5] The modeling features of the paper are to some extent similar to Allen and Gale (1998), who consider an optimal deposit contract in the situation where a real signal can trigger a generalized run. The Allen-Gale model (AG model) finds that a bank run produces an efficient allocation when a bank's portfolio is perfectly illiquid. Whereas, we determine the optimal contract as a function of the economic fundamentals, assuming that porfolio liquidation is possible but costly. Moreover, the AG model assumes all agents are treated equally in case of a run, while in our model we specifically account for the first-come first-served constraint, whereby the first customers making it to the counter are able to withdraw more money. This adds an element of inefficiency to the bank run, because individuals face a non-insurable risk of arriving late at the counter.

Chang and Velasco (2001) utilize a DD-based model to explain the financial crises of the mid-1990s. They focus on the role of short-term international capital flows in increasing the fragility of a banking system with respect to a sunspot-driven bank run. While the Chang-Velasco model represents a powerful tool in explaining currency crises and their connection to banking crises, it lacks general empirical support in considering purely banking crises.[6] Moreover, it does not seem to provide a clear link between past growth and financial crises.

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data taken from Caprio and Kingebiel (1999) and Lingren, Gillian, and Saal (1996).

[4] 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 excellent surveys on the argument.

[5] The fact that bank run are triggered by real shock rather than by sunspot, like in the original DD model, seems supported by the empirical literature. Gorton and Winton (2002) in their recent survey on financial intermediaries mention a number of empirical papers and conclude (page 77): "The previous evidence about the organization of the banking system strongly suggest that, at least hystorically, there is not necessary a link between banks and panics".

[6] See the empirical evidence in the last section, Demirguç-Kunt and Detragiache (1998), and Eichengreen and Arteta (2000).

The paper is organized as follows: in the next section, we analyze the main model. In section 3 we consider the economic policy implications. In section 4, we provide some empirical evidence by using a simple econometric logit model. We draw our conclusions in section 5.

2 The model

We now present a model of banking along the lines of the DD model. Additionally (as in Allen and Gale), we assume that the asset revenue is random, and a bank run can be generated by a bad real signal on the economic performances. Individuals take into account the risk of a bank run ex ante and decide the level of insurance against the risk of illiquidity.

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 correlated with the aggregate production in the economy. A unit invested at time 0 yields, after two periods, R^l with probability $1 - q$ and (slightly abusing 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.

In order to simplify, we assume that a unit invested in the asset at time 0 can be disinvested and yields exactly one unit of the good at time 1. Under this assumption, it is optimal at $t = 0$ to invest the entire wealth in the illiquid asset. Moreover, in order to avoid the trivial result that a liquidation of the assets is always optimal whenever $R^i = R^l$, we assume $R^l > 1$.[7]

There are 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 gets her utility only from consuming at time 2. Then a typical consumers' utility function at $t = 0$ can be written as

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

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, and the Inada conditions: $\lim_{c \to 0} u'(c) = 0$ and $\lim_{c \to \infty} u'(c) = \infty$. 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 adequately 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 bank run.[8]

[7] This condition is made more stringent by our assumption about the liquidability of the initial investment and on the non perishability of the good. If the good was perishable a level of $R^l < 1$ could also yield non trivial results.

[8] For our purposes, it is also 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

Demand deposit contract and bank run

As already the DD model makes clear, a bank can optimally increase individuals' utility, by pulling all their investments and insuring individuals against idiosyncratic illiquidity shocks. Accordingly, we now determine the optimal contract, conditional on R^l, r and q, a bank offers to its customers in order to ensure them against the illiquidity shock, and analyze the risk of a information-based bank run. For expositional simplicity, we first determine the level of c_1 and c_2 which may trigger a banking crisis for some levels of R^l and r; we 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 function of R^l, r and q.

As in Allen and Gale, we assume, that the signal about the economy is not contractible, therefore c_1 cannot directly be made contingent on R^i. Accordingly, individuals surrend all their endowment to a 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 $c_2(R) = [c_2(R^h), c_2(R^l)]$.

The demand deposit contract cannot always be fulfilled: given that types are not observable, a bank run, where also some patient individuals decide to go to the bank and withdraw their savings at time $t = 1$ as well, can happen in some circumstances. To account for this possibility, we need to introduce some 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 a patient individuals who "lie" on their own type and 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:

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).

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

2. Then banks liquidates and distributes its remaining capital $(1 - \frac{1}{2}c_1)$ to all customers, weather 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 the 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 are unexpected and 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 a bank exhausts its cash, the counter closes and the bank spends the next few days liquidating its 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 $\frac{1}{2}$.[9]

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

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 the appendix ■

[9] Although such behavior is realistic, it is not the only possible behavior. For example, a pure sequential service constraint would bind the bank to serve all customers according to their position in the queue. This would leave those later in line without anything once the bank exhausts its cash. However, we assume this pattern only to simplify the algebra of the model. What is critical for some of our following results is that early and late withdrawers are not treated equally, so that there is a non-insurable risk of arriving late.

Condition (2) is only sufficient for a run. It is well known, as DD and following models extensively emphasized, that as far as $c_1 > 1$ there are multiple equilibria and, therefore, the possibility of a bank run generated only by sunspots. As we already said, in this paper we focus only on the bank run generated by economic fundamentals as determined by condition (2), which the literature usually refer as *information-based bank run.* Therefore, we assume away the possibility of pure panic-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 the appendix* ■

The Optimal Demand Deposit Contract

Using lemma 1 and lemma 2 we can 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.[10]

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 $\frac{1}{2}u(c_1) + \frac{1}{2}E\left[u(2(1 - \frac{1}{2}c_1)\tilde{R})\right]$.

[10] 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:

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

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

$$\text{s.t. } c_1 \leq \frac{2R^l}{R^l+1}, \tag{6}$$

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

$$\text{s.t. } c_1 > \frac{2R^l}{R^l+1}.$$

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.

To simplify the exposition, before stating the more general proposition 1, we initially illustrate the solution of problem (4) by adopting a numerical example: we assume a CRRA utility function with $\sigma = 2$, and $R^l = 1.01$, $R^h = R^l + r = 1.05$. We present the solution of this example in Figure 1, where we can 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 there is only one available contract that solves problem (4), which is determined by subproblem 5 and it is bank-run proof. When $\underline{q} < q \leq \bar{q}$, 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.

INSERT FIGURE 1 HERE

Now, if we define

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

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

we can more generally state:

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

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

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. ■

In order to illustrate the implications of proposition 1, it is useful to refer again to our example, considering now r as a variable (and keeping $R^l = 1.01$ and $\sigma = 2$), so that we can determine functions $\bar{q}(r)$ and $\underline{q}(r)$ that we show in Figure 2. In that way we can represent the optimal contract with respect to growth expectations and analyze the risk of bank run in three different economic 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 very uncertain, hence demanding a high level of liquidity insurance would be too risky and, therefore, banks face no risk of bank run. On 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.

INSERT FIGURE 2 HERE

3 Economic policy

In the past section we saw that a bank offers a safe contract and supply a lower level of illiquidity insurance when the uncertainty about the future is high, in order to avoid the costs of early asset liquidation caused by a bank-run. Therefore policy of bail-out or deposit insurance, aimed to decrease or avoid the costs of early liquidation, induce the banks to offer risky contract, even in an economic environment with higher level of uncertainty in the long run. However, in this section we will see that these policies, in spite of increasing the financial fragility and provided that they do not have other costs for the economy, are ex-ante Pareto improving. In other words, all individuals are strictly better off at time 0, when a central agency is committed to one of the two policy.

The bail-out policy

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 cotsts) 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 weather 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.[11]

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. This can be illustrated by using 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

[11]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.

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 agent expect a bail-out in the sense that the risky region is bigger in Figure 3 than in Figure 2.

Deposit Insurance

A government (or central bank) can always change c_1 ex-post by levying a tax on consumptions (or printing money), when it observes the realization of $\tilde{R}$. Accordingly, we assume that at time $t = 1$ the government observes R^i and the level of early consumptions fixed by the banks, say $\hat{c}_1$, and, if conditions (3) are true, the government sets a tax t on $\hat{c}_1$ to avoid the bank run.[12]

Therefore, the level of early consumptions are defined by the following expression:

$$c_1(R^l) = \begin{cases} \hat{c}_1(1-t) = \frac{2R^l}{R^l+1} & \text{if } \hat{c}_1 > \frac{2R^l}{R^l+1} \\ c_1 = \hat{c}_1 & \text{if } \hat{c}_1 \leq \frac{2R^l}{R^l+1}, \end{cases} \tag{14}$$

$$c_1(R^h) = \hat{c}_1 \tag{15}$$

Moreover, if the policy is implemented by taxing early consumption, it is assumed that their revenues are given back to banks, so that

$$c_2(R^i) = (2 - c_1(R^i))R^i$$

is always true.

[12] The government could actually do better than that by maximizing individuals' utility ex-post. Here, we assume it limits itself to this "minimal" intervention, to straighten our result that this policy is more efficient than a the bail-out.

Ex-ante the bank, knowing the policy rule (14), chooses $(\hat{c}_1, \hat{c}_2(R))$ to maximize

$$\frac{1}{2}E(u(c_1(\tilde{R}))) + \frac{1}{2}E(u\left((2 - c_1(R))\tilde{R}\right)) \quad (16)$$

$$s.t.\ (14).$$

If $\hat{c}_1 < \frac{2R^l}{R^l+1}$ problem is an unconstrained maximization, whose solution is implicitly determined by condition (8), hence $\hat{c}_1 = c_1^{di} = c_1^1$. However for $c_1^1 \geq \hat{c}_1$ (that in the appendix we show it happens if and only if $q >\underline{q}$) the government intervenes setting $c_1^{di}(R^l) = c_2^{di}(R^l) = \frac{2R^l}{R^l+1}$. Comparing it with the case without insurance the bundle $(c_1^{di}(R), c_2^{di}(R))$ dominates $(c_1^*, c_2^*(R))$.[13]

As before, this intervention increases the fragility of the system, in the sense that banks incur financial distress for a larger interval of q.[14] Without deposit insurance, the reason to prefer the bank run-proof contract when $\underline{q} \leq q \leq \bar{q}$ are the liquidation costs in case of ban run. With the deposit insurance there is not early liquidation of more assets since the impatient are guaranteed the same consumptions as the early withdrawers, $c_{1,2} = c_{2,2}$. Exactly like with the bail-out policy, using Figure 3 we note that banks choose a risky contract whenever $q >\underline{q}(r)$, hence banks are more likely to set a contract with an higher risk of banking crisis.

Furthermore, we note that the two above mentioned policies are not equivalent. Accordingly, comparing the deposit insurance policy to the bail-out policy, we state

Proposition 2 *For any given $r > \underline{r}$, a deposit insurance policy is preferred to a bail-out whenever $q > \underline{q}(r)$ while for $q \leq \underline{q}(r)$ the two are equivalent.*

Proof. *See the appendix.* ■

[13] Similiarly as in note 11, boundle $(c_1^*, c_2^*(R))$ is always available when the bank choose $(c_1^{di}(R^i), c_2^{di}(R^i))$. Whenever $q \leq \bar{q}$ and when $q > \bar{q}$ and $R = R^h$, the intertemporal budget constraints are always equal and determined by $(2 - c_1(R))R$ in both cases, for $q > \bar{q}$ and $R = R^l$ the budget contraints with deposit insurance is stricly larger, $(2 - c_1)R^l > (2 - c_1)$.

[14] Since we cannot talk about a run in this case, we define "financial distress" as a situation where external intervention is required.

Intuitively, if $q > \underline{q}$ and the government commits to bailing out a bank in a crisis, and then there is a bank run when $R = R^l$, late withdrawers are always treated worse than early withdrawers, since $c_1^{bo} > 2(1 - \frac{1}{2}c_1^{bo})R^l$. In other words, agents are not insured against the risk of arriving late to the counter in case of a bank run. The same problem does not arise under a deposit insurance scheme, since c_1 can be changed ex-post such that $c_1^{di} = c_2^{di}$, for this reason the deposit insurance dominates the bail-out.

4 Empirical evidence

In this section, we show that, consistent with our findings, high deposit interest rates fully explain the higher probability of crisis for countries who experienced high growth in the past five years, as table 1 shows, even after controlling for the other factors that could otherwise explain this relationship.

Data and variables

The difficulty of building a reliable dataset for banking crises reflects the fact that only a minority of crises actually result in bank runs. In most cases, governments or external institutions intervene to avoid the run. Therefore, several criteria need be fixed to distinguish a systemic banking crisis from an isolated episode of financial distress for banks. We follow Demirguç-Kunt and Detragiache (1998a and 1998b and 2002, henceforth DKD) in our definition of banking crises, including in our Dataset all episodes listed in Caprio and Kingebiel (1999) and Lingren, Gillian, and Saal (1996) where at least one of the following conditions holds (a complete list of crises appears in the appendix):

1. An extensive bank run took place or emergency measures were enacted by the government in response to a crisis.

2. The cost of rescuing the financial system was at least 2 percent of GDP.

3. The banks involved collectively controlled over 50% of the credit market.

4. A deep restructuring, such as wide-scale nationalization, took place in the sector.

5. The ratio of non-performing assets over the total assets in the banking system exceeds 30 percent.

From these conditions, 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. Following DKD, the years of crisis following 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, apart from the growth rate.

To distinguish the past growing countries that according to table 1 were more vulnerable to crisis, we determine the dummy variable

$$RH_{i,t-1} = \begin{cases} 1 & \text{if } GR_{i,t-1} > 3\%, \ \ldots \ , GR_{i,t-1-5} > 3\% \\ 0 & \text{otherwise} \end{cases} .$$

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 108 countries and 48 crisis episodes, and a total of 1,308 observations for the regressions in the largest sample (the list of countries in our Dataset are reported in the appendix).

The other explanatory variables are: 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) and the yearly growth rate of per capita GDP, GR_t (World Bank).

The control variables are: the Log per capita GDP_{t-1}, (WDI), as a proxy for the quality of bank regulation and the legal environment, the Domestic credit provided by the banking sector (in percentage of GDP), DC_{t-1}, to control for the possibility of an "overborrowing syndrome" by banks in a growing environment (IMF-IFS dataset); the currency devaluation, DEV_{t-1} (IMF-IFS dataset) to test whether the crises are driven by excessive foreign exchange risk exposure.

Results

We follow the literature in banking difficulties and 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.

In regression 1, 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. *Therefore, regressions 1 and 2 together suggest that the higher vulnerability of developing countries is entirely related to the high real deposit interest rate.*

Furthermore, we note that growth rate GR is negative and highly significant, confirming the notion that a real shock is needed to trigger a crisis.[15] The bank domestic credit, DC, is not

[15] Problems of endogeneity might arise in this case, but they may not be very strong since financial crises seriously hit the economy in subsequent years.

significant, which seems to rule out the possible alternative explanation that high growth induced credit institutions to overlend, weakening in that way the banking system.

To verify whether the result is driven solely by the east Asian crisis, we run regression 3, which excludes 1997 and subsequent years. The significance of the coefficient of $RH^{*}RDIR$ is substantially unchanged. Finally in regression 4, we introduced the currency devaluation, DEV, which is not significant. This seems to rule out the external capital channel as a general determinant of banking crises. 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. 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.[16]

[16] Both DKD (1998) and Eichengreen and Arteta (2000) obtain a similar result. However, the depreciation appears positively related to the crisis in DKD (2002).

Table 2. Deposit interest rates and banking crises

	1	2	3	4
years	$1982-99$	$1982-99$	$1982-96$	$1982-99$
Log (GDP/CAP)$_{t-1}$	-.279	-.341	-.266	-.275
	(.119)*	(.116)**	(.124)*	(.119)*
Banking Credit$_{t-1}$	-.0003	.0010	-.0028	-.0003
	(.004)	(.003)	(.005)	(.0041)
Depreciation$_{t-1}$				.0006
				(.0014)
Growth$_t$	-8.79	-8.60	-7.47	-8.858
	(2.839)**	(2.803)**	(2.841)**	(2.851)**
$RDIR_{t-1}$	.001	.003	.002	.002
	(.011)	(.012)	(.011)	(.011)
$RH^{*}RDIR_{t-1}$	.379		.533	.377
	(.155)*		(.254)*	(.156)*
RH	-.152	1.74	-2.00	-.139
	(1.05)	(.438)**	(1.91)	(1.055)
No. of obs.	1308	1308	1104	1308
No. of crises	48	48	43	48
No. of countries	108	108	104	108
$\sum_{i=0}^{N} RH$	80	80	66	80

Dependent variable $Crisis_{i,t}$. Absolute value of z statistics in parentheses.

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

5 Conclusions

This paper shows how a higher level of vulnerability to banking crises may be optimal in fast developing countries. Moreover, the model emphasizes that both a bail-out policy (when a banking crisis is already under way) and a deposit insurance scheme (to prevent bank runs altogether) could be desirable even if they increase the fragility of the banking system.

In particular we show that both policies are Pareto efficient since they lead to an increase in the level of bank liquidity supply and, in that way, to an optimal increase of the illiquidity insurance. This is true in spite of the fact that they increase the fragility of the banking system. Therefore in our model, the benefit of these policies outweighs the costs deriving from the subsequent higher level of fragility, provided that a deposit-insurance policy or a bail-out policy can be put in place at no cost.

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,[17] and $\rho \in [\frac{1}{2}, 1)$: when $\rho - \frac{1}{2}$ impatient 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, on the contrary, 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 of problem (4):

[17] 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.

$$\max_{c_1} \frac{1}{2} u(c_1) + \frac{1}{2} \left(E \left(u(2 - c_1)\hat{R} \right) \right) \tag{17}$$

$$st.\ c_1 \leq \frac{2R^l}{R^l + 1}, \tag{18}$$

and

$$\max_{c_1} \ \frac{1}{2} u(c_1) + \frac{1}{2} \left(qu \left(2 - c_1)R^h \right) + (1-q) u \left(2 - c_1 \right) \right) \right) \tag{19}$$

$$st. c_1 > \frac{2R^l}{R^l + 1}. \tag{20}$$

Condition (8) determines c_1^1, the internal solution of problem (17) and condition (9) determine c_1^2, the internal solution of problem (19), given the Inada conditions $c_1^j < 2$, 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 envelop theorem we will argue that

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

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

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

the numerator is negative given (1) (which implies $x'u'(x)$ decreasing) and the denominator is always negative, given $u'' < 0$. The same reasoning applies for c_1^2 using (9).

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 choose R^l small enough and r large enough such that $c(R^h,1) > \frac{2R^l}{R^l+1}$.

Therefore, there exits a $r > \underline{r}$ and a $R^l <$ R̲ such that there is a $\underline{q}$=$\underline{q}(R^h, R^l)$:

$$u'(\bar{c}) = \underline{q}(R^l+r)u'\left((2-\bar{c})(R^l+r)\right) + (1-\underline{q})R^l u'\left((2-\bar{c})R^l\right) \tag{21}$$

so that $c_1^1(\underline{q}) = \frac{2R^l}{R^l+1}$. Accordingly, constraint (18) is binding for $q \geqslant \underline{q} > 0$.

Let us prove that there exists a $\bar{q} = \bar{q}(r, R^l) > \underline{q} : V^{br} \geq V^{rp}$ if and only if $q \geq \bar{q}$. Consider problem (7) for $q > \underline{q}$. Given (21) and that $R^l u'\left((2-\bar{c})R^l\right) < u'\left((2-\bar{c})\right)$, in the interval [$\underline{q}$,1] we can define a $\hat{q} = \hat{q}(R^h, R^l)$

$$u'(\bar{c}) = \hat{q}(R^l+r)u'\left(2(1-\frac{1}{2}\bar{c})(R^l+r)\right) + (1-\hat{q})u'\left(2(1-\frac{1}{2}\bar{c})\right), \tag{22}$$

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

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

$$DV =$$

$$(1-q)\left(\frac{1}{2}u(c_1^2) + \frac{1}{2}u\left(2(1-\frac{1}{2}c_1^2)\right) - u(\bar{c})\right) +$$
$$q\left(\frac{1}{2}u(c_1^2) + \frac{1}{2}u\left(2(1-\frac{1}{2}c_1^2)(R^l+r)\right) - \frac{1}{2}u(\bar{c}) - \frac{1}{2}u\left(2(1-\frac{1}{2}\bar{c})(R^l+r)\right)\right).$$

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

$$\frac{\partial DV}{\partial q} > 0. \tag{23}$$

Moreover:

- DV is continuous for $q \geqslant \hat{q}$.
- $DV(\hat{q}, r) = (1 - \hat{q})\ \left(-\frac{1}{2}\, u(\bar{c}) + \frac{1}{2}\ u\left(2(1 - \frac{1}{2}\, \bar{c})\right)\right) < 0$
- $DV(1, r) = (\frac{1}{2}\, u(c_1^2) + \frac{1}{2}\, u\left(2(\, 1 - \frac{1}{2}\, c_1^2)R^h\right) - \frac{1}{2}u(\bar{c}) - \frac{1}{2}u\left(2(\, 1 - \frac{1}{2}\, \bar{c})R^h\right)) > 0$ (as shown above)

Therefore for a given $r > \underline{r}$ there exist a $\bar{q} = \bar{q}(r) : \bar{q} > \hat{q} > \underline{q}$ 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.

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

$$\frac{\partial DV}{\partial r} = (\, 1 - \frac{1}{2}\, c_1^2)\, u'\left(2(\, 1 - \frac{1}{2}\, c_1^2)(R^l + r)\right) - (\, 1 - \frac{1}{2}\, \bar{c})u'\left(2(\, 1 - \frac{1}{2}\, \bar{c})(R^l + r)\right) > 0 \tag{24}$$

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 (21).

A.4 Proof for proposition 2

Ex-ante the bank, knowing the policy rule choose $(\hat{c}_1, \hat{c}_2(R))$ to maximize (16) subject to (14). We can split this problem in two subproblems

$$V1 = \max_{\hat{c}_1} \frac{1}{2}u(\hat{c}_1) + \frac{1}{2}\left(E\left(u(2-\hat{c}_1)\hat{R}\right)\right) \tag{25}$$

$$st.\ \hat{c}_1 \leq \frac{2R^l}{R^l+1}, \tag{26}$$

and

$$V2 = \max_{\hat{c}_1}\ q(\frac{1}{2}u(c_1) + \frac{1}{2}u(\left(2-c_1)R^h\right)) + (1-q)u\left(\frac{2R^l}{R^l+1}\right) \tag{27}$$

$$st.\hat{c}_1 > \frac{2R^l}{R^l+1}. \tag{28}$$

If $\hat{c}_1 \leq \frac{2R^l}{R^l+1}$ problem is an unconstrained maximization, whose solution is implicitly determined by condition (8), hence $\hat{c}_1 = c_1^{bo} = c_1^{di}$. However, for $\hat{c}_1 > \frac{2R^l}{R^l+1}$ the government intervenes and determines $(c_1^{di}(R), c_2^{di}(R))$:

$$\begin{aligned} c_1^{di}(R^l) &= \frac{2R^l}{R^l+1} \\ u'(c_1^{di}(R^h)) &= R^h u'(\left(2-c_1^{di}(R^h))R^h\right) \\ c_2^{di}(R) &= (2-c_1^{di}(R))R \end{aligned}$$

We already saw that for any $q \geq \underline{q}$ problem 25 has a corner solution. Compare for $q > \underline{q}$ the two utilities we notice that

$$V2 - V1 = \frac{1}{2}q(u(c_1^{di}(R^h)) + u((2-c_1^{di}(R^h))R^h)) - (u(\frac{2R^l}{R^l+1}) - u((2-\frac{2R^l}{R^l+1})R^h))) > 0$$

since $c_1^{di}(R^h)$ maximize $u(c_1) + u((2 - c_1)R^h)$.

Therefore if $q > \underline{q}$ individuals prefer the "risky" contract, and banks set $\hat{c}_1 > \frac{2R^l}{R^l+1}$ This is also formal prof that the contract with deposit insurance is more risky (in the sense specified above) than the contract without insurance.

Therefore fixing a $r > 0$ and a $q <$$\underline{q}(r)$ such that $\hat{c}_1 \leq \frac{2R^l}{R^l+1}$, the two problems are equivalent, while for $q > \underline{q}$ such that $\hat{c}_1 > \frac{2R^l}{R^l+1}$ the $V2 > V1$ and the risky contract solution of $V2$ is chosen.

Let us compare the utility with a bail-out and the utility with deposit insurance, using the following functions $V^{di} - V^{bo}$:

$$V^{di} - V^{bo} = q(u(c_1^{di}) + u(2 - c_1^{di})R^h - u(c_1^{bo}) - u(\left(2 - c_1^{bo})R^h\right))) + (1-q)(u(\hat{c}_1) + u(2 - \hat{c}_1)R^l) - 2u\left(\frac{2R^l}{R^l+1}\right)).$$

The first term in parenthesis is positive since $c_1^{di} \in Arg\max u(c_1) + u((2 - c_1)R^h)$. The second term is also positive since $u(.)$ is concave and $\frac{c_1^{bo} + (2 - c_1^{bo})R^l}{2} < \frac{2R^l}{R^l+1}$ for $c_1^{bo} > \frac{2R^l}{R^l+1}$ which is true when $q >$$\underline{q}$. *Therefore*

$$\begin{aligned} V^{di} &= V^{bo} \text{ for } q \leq \underline{q} \\ V^{di} &> V^{bo} \text{for } q > \underline{q} \end{aligned}$$

the two policy are equivalent for $q \leq$$\underline{q}$ but the deposit insurance strictly dominates the bail-out for $q >$$\underline{q}$.

A.5 Data

Countries in the sample

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

List of Banking Crises

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.

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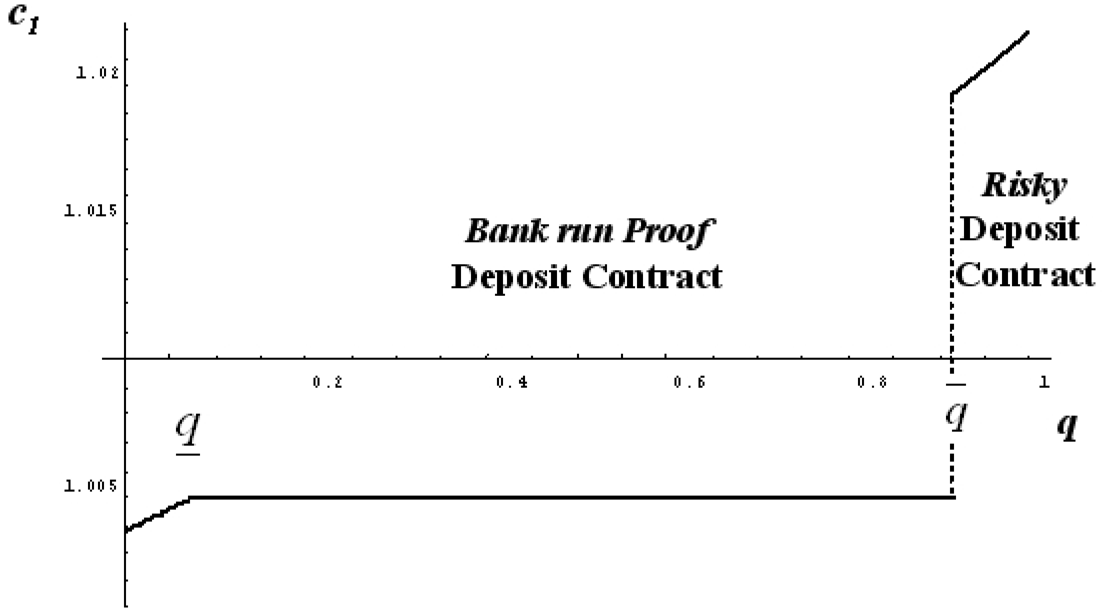

Figure 1: Deposit contract and risk.

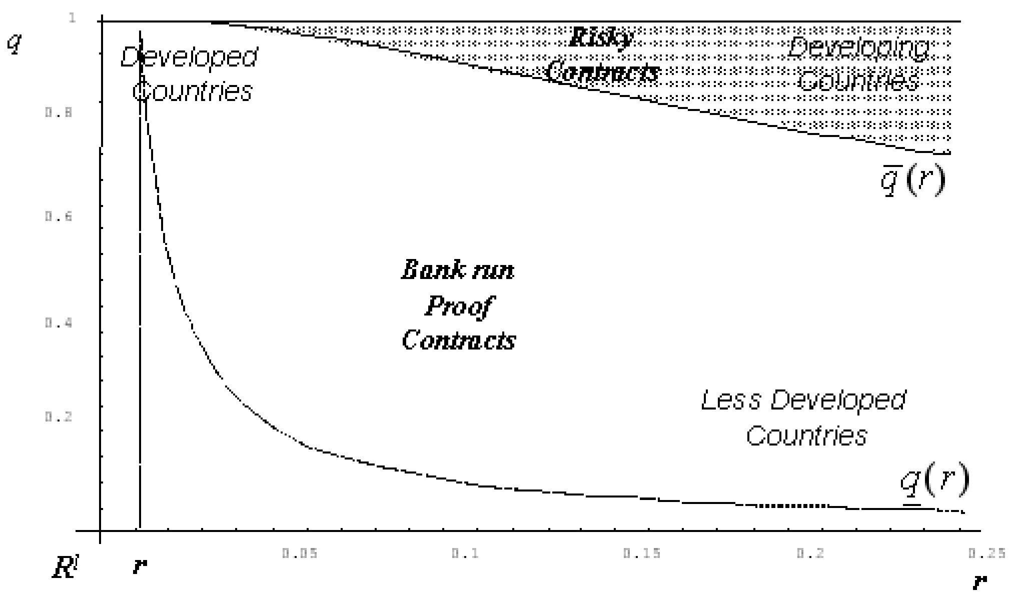

Figure 2: Optimal contract as a function of q, r, R^l.

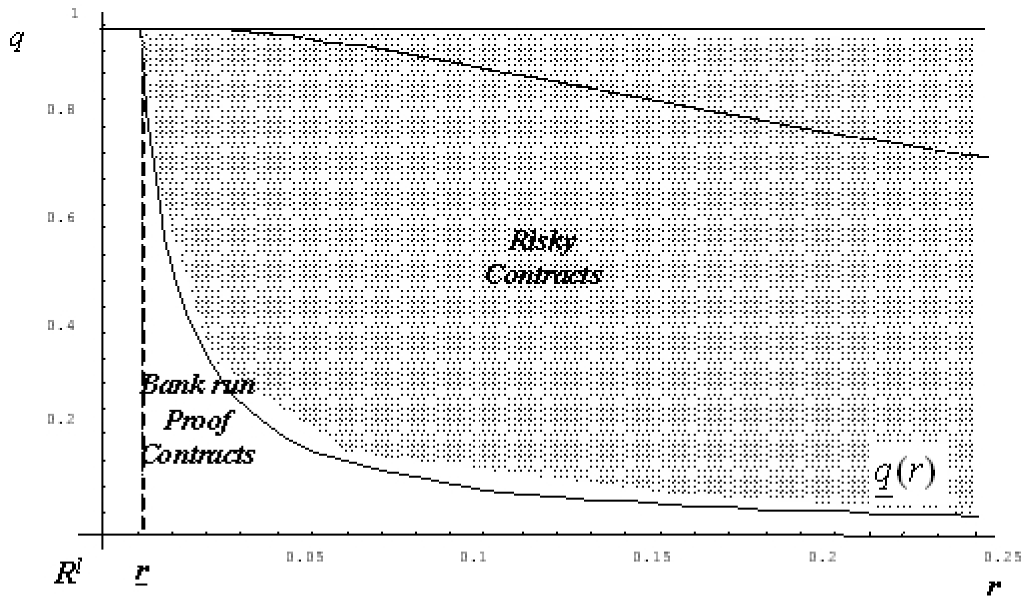

Figure 3: Optimal contract with external intervention