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## The lender of last resort: a 21st century approach

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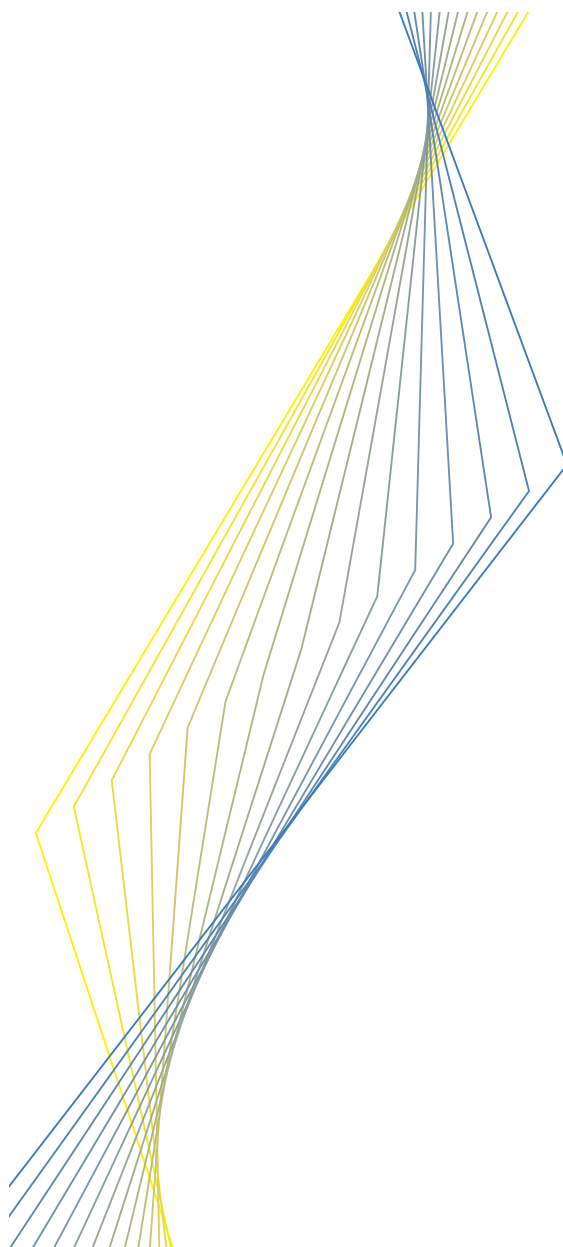
**WORKING PAPER NO. 298**

**THE LENDER OF LAST RESORT:  
A 21<sup>ST</sup> CENTURY APPROACH**

**BY XAVIER FREIXAS,  
BRUNO M. PARIGI AND  
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**DECEMBER 2003**

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## Abstract

The classical Bagehot's conception of a Lender of Last Resort (LOLR) that lends to illiquid banks has been criticized on two grounds: on the one hand, the distinction between insolvency and illiquidity is not clear cut; on the other a fully collateralized repo market allows Central Banks to provide the adequate aggregated amount of liquidity and leave the responsibility of lending uncollateralized to the banks. The object of this paper is to analyze rigorously these issues by providing a framework where liquidity shocks cannot be distinguished from solvency ones and ask whether there is a need for a LOLR and how should it operate. Determining the optimal LOLR policy requires a careful modeling of the structure of the interbank market and of the closure policy. In our set up, the results depend upon the existence of moral hazard. If the main source of moral hazard is the banks' lack of incentives to screen loans, then the LOLR may have to intervene to improve the efficiency of an unsecured interbank market; if instead, the main source of moral hazard is loans monitoring, then the interbank market should be secured and the LOLR should never intervene.

**Key words:** Lender of Last Resort, Interbank Market, Liquidity.

**JEL Classifications:** E58, G28.

## Non-technical summary

This paper offers a new perspective on the role of emergency liquidity assistance (ELA) by the Central Bank (CB) often referred to as the Lender of Last Resort (LOLR). We take into account two well acknowledged facts of the banking industry: first that it is difficult to disentangle liquidity shocks from solvency shocks; second that moral hazard and “gambling for resurrection” are typical behaviors for banks experiencing financial distress. In today’s world, the “classical” Bagehot’s conception of a Lender of Last Resort has been under attack from two different fronts. First, the distinction between solvency and illiquidity is less than clear-cut. As Goodhart (1987), (1995) points out the banks that require the assistance of the LOLR are already under suspicion of being insolvent. Second it has been argued (for example by Goodfriend and King 1988) that the existence of a fully collateralized repo market allows Central Banks to provide the adequate aggregate amount of liquidity and leave the responsibility of lending uncollateralized to the banks thus giving them a role as peer monitors, and introducing market discipline. Furthermore if indeed the LOLR policy is to lend against good collateral, it is not clear why, except for the case where money markets do not operate correctly (e.g. because of coordination failures) an open market policy would not be enough to guarantee the efficiency of the program. The object of this paper is to analyze rigorously these issues, ask whether there is a need for a Lender of Last Resort and how should it operate in a framework where liquidity shocks cannot be distinguished from solvency ones.

The model set-up is as follows: banks collect deposits and equity and invest these in a risky project. Banks have to exert effort at two stages: at date 0, to screen projects (i.e. to ex-ante detect projects that are worthwhile financing), and at date 1, to monitor projects (i.e. to ensure that the selected project has a high probability of success). Both sources of moral hazard imply certain restrictions on the payoffs to the banks. Banks can be hit by a liquidity shock or a solvency shock, both of which induce the bank to demand more liquidity. An illiquid bank would use it to satisfy the additional liquidity demand, while the insolvent bank would “gamble for resurrection” i.e. invest in an additional project with negative net present value.

Since the opacity of banks’ balance sheets makes it impossible to distinguish among insolvent, illiquid and normal banks (which suffer neither type of shock) both for the market and for the regulators, the Central Bank cannot simply close down insolvent banks. We argue that in order to avoid “gambling for resurrection”, the Central Bank should give monetary incentives to the solvent banks to close down rather than “gamble for resurrection”. This implies that insolvent banks might obtain a positive profit (even though a first best solution would require zero profits). At the same time, profits to the solvent banks might have to be increased to avoid moral hazard (i.e. to maintain a high level of effort).

The efficiency of the interbank market depends on which form of moral hazard is more severe. It is shown that when the monitoring moral hazard is the most severe problem, then a fully collateralized interbank market is able to implement the efficient allocation. Instead, if the screening moral hazard is the most severe problem, then the efficient solution in general is not obtainable and the interbank market should be unsecured.

Emergency Liquidity Assistance can improve the allocation because it can change the seniority of the claims upon the bank, by overriding claims from the Deposit Insurance Fund (DIF). By changing the seniority of these claims, the Central Bank is in fact able to lend at lower rates than the market. This has beneficial effects especially in times of crisis when spreads are high. In normal periods, instead, the interbank market provides sufficient liquidity to banks.

Our analysis allows us to make a number of policy recommendations. Briefly, the design of an efficient market for liquidity has to be based on the interaction between the following five regulatory instruments: interbank lending (secured or unsecured), closure policy, capital requirement, DIF premium, ELA lending terms. These instruments, although controlled by potentially different and independent institutions, should be designed in an integrated fashion. In the end, unlike its "classical" predecessor, the LOLR of the 21st Century lies at the intersection of monetary policy, supervision and regulation of the banking industry, and design of the interbank market. The issue is not "what are the rules the LOLR should follow?" but rather "what architecture for the liquidity markets?"



# 1 Introduction

This paper offers a new perspective on the role of emergency liquidity assistance (ELA) by the Central Bank (CB) often referred to as the Lender of Last Resort (LOLR). We take into account two well acknowledged facts of the banking industry: first that it is difficult to disentangle liquidity shocks from solvency shocks; second that moral hazard and gambling for resurrection are typical behaviors for banks experiencing financial distress.

The LOLR policy has a long history. Bagehot's (1873) "classical" view maintained that the LOLR policy should satisfy at least three conditions: (i) lending should be open only to solvent institutions and against good collateral, (ii) these loans must be at a penalty rate, so that banks cannot use them to fund their current operations, (iii) the CB should make clear in advance its readiness to lend without limits to a bank that fulfils the conditions on solvency and collateral.

In today's world, the "classical" Bagehot's conception of a Lender of Last Resort has been under attack from two different fronts. First, the distinction between solvency and illiquidity is less than clear-cut. As Goodhart (1987), (1995) points out the banks that require the assistance of the LOLR are already under suspicion of being insolvent.<sup>1</sup> Second it has been argued (for example by Goodfriend and King (1988) that the existence of a fully collateralized repo market allows Central Banks to provide the adequate aggregated amount of liquidity and leave the responsibility of lending uncollateralized to the banks thus giving them a role as peer monitors, and introducing market discipline. Furthermore if indeed the LOLR policy is to lend against good collateral, it is not clear why, except for the case where money markets do not operate correctly (e.g. because of coordination failures, a case analyzed in Freixas, Parigi and Rochet 2000) an open market policy would not be enough to guarantee the efficiency of the program.

These arguments are so convincing that the Bagehot view of the LOLR is seen as obsolete in a well developed financial system. Yet, it should be emphasized that although it is appropriate to dismiss the Bagehot's view, there is no existent set of rules to replace it. From an institutional perspective, the discount window provides liquidity support to banks in a way that leaves some discretion to Central Banks (e.g. the Marginal Lending Facility in the Eurosystem) . On the theory side, things may look better but only at first glance. The Goodfriend-King's argument sounds attractive only if we assume perfect interbank markets (both repo and unsecured). But this contrasts with the asymmetric information assumption that is regarded as the main justification for the existence of banks.<sup>2</sup> Goodfriend-King's argument sounds even less attractive if we take into account Goodhart's criticism: when liquidity and solvency shocks cannot be distinguished, the interbank market is far from being perfect. So, to summarize, if we agree with both

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<sup>1</sup>Furfine (2001) provides empirical evidence of banks' reluctance to borrow from the FED discount window for fear of the stigma associated with it.

<sup>2</sup>In the UK, the announcement of BCCI's closure on 5 July 1991 rapidly accelerated the withdrawal of wholesale funds from small and medium-sized UK banks. In a perfect interbank market, this would have led to loans from large to small banks, as the withdrawals of funds from small banks was deposited in large banks. But the interbank market did not recycle back the funds and within three years, a quarter of the banks in this sector had, in some sense, failed.

Goodfriend-King, and Goodhart's criticisms we are simply left with no theory of the LOLR interventions.

The object of this paper is to analyze rigorously these issues, ask whether there is a need for a Lender of Last Resort and how should it operate by providing a framework where liquidity shocks cannot be distinguished from solvency ones. As we shall see in the sequel determining the optimal Lender of Last Resort policy requires the correct modeling of the structure of the interbank market and of the bank closure policy.

By building a model that takes into account both criticisms, we find a new role for the LOLR. This new role stems from the unique possibility that the CB has to change the priority of claims on bank's assets. In periods of crisis, borrowing in the interbank market may impose a high penalty on banks because of the high spread demanded on loans. As noticed by Goodfriend and Lacker (1999), the CB has the power to change the priority of claims and thus it can lend at lower rates than the market.

We construct a model in which banks are confronted with interim shocks that may come from uncertain withdrawals by impatient consumers (liquidity shocks) or from losses on the long term projects they have financed (solvency shocks). Banks are of three types: illiquid (if they have a large fraction of impatient consumers; i.e. they suffer a liquidity shock), insolvent (if their investment is worth little; i.e. they suffer a solvency shock), or normal if they do not suffer from any shock. We take for granted that the opacity of banks' balance sheets makes it difficult to distinguish among insolvent, illiquid and normal banks both for the market and for the regulators. Thus, in acting as the LOLR, the CB faces the possibility that an insolvent bank may pose as an illiquid bank. In particular we envision a situation where the insolvent bank is able to borrow either from the interbank market or from the CB and "gambles for resurrection", that is, it invests the loan in the continuation of a project with a negative expected net present value.

We distinguish two types of moral hazard, that we refer to as *ex ante* or screening moral hazard and interim or monitoring moral hazard. Because these two types of moral hazard play a key role in our analysis it is important to clarify their economic justification as well as to understand which of the two will be prevailing. In the screening moral hazard the cost of an effort depends on how difficult it is to identify the sound firms to lend to. It therefore depends on the heterogeneity of the population that is applying for a loan. For the banks, it is easier to screen firms in a stable than in a changing environment (Rajan and Zingales 2003); it is also easier at the beginning of an upturn, because the worst firms have gone bankrupt than at the end of an upturn when a larger proportion of lame ducks is to be expected. We thus expect screening moral hazard to be less stringent in these occasions. On the other hand, we also expect this constraint to be more stringent in some countries than in others. This will indeed be the case because of different roles of the banking industry, because of the difference in the costs of setting up a business, because of the different disclosure requirements, and because of the presence or not of credit bureaus and rating agencies (see Pagano and Jappelli 1993).

The interpretation of the monitoring moral hazard is different. In some countries, banks have easy access to information about the development of every firm they have financed and the cost of monitoring is low. This is the case in particular for bank-dominated countries where the bank's representative may seat in the board of directors. In

others countries, instead, it will be more difficult to obtain information on the development of the firms projects.

Our main findings are that when the main source of moral hazard is monitoring, a fully secured interbank market allows to implement the efficient allocation. When, instead, the main source of moral hazard is screening, if it is impossible to distinguish between illiquid and insolvent banks, the interbank market should be unsecured and there may be a role for Central Bank lending. When this occurs, the LOLR overrides the priority of the Deposit Insurance Fund (DIF) and thus lends against the assets of the bank and offers a better rate, at a cost to the DIF. This should take place when markets spreads demanded on interbank loans are excessively high, and should happen regardless of whether the deposit insurance company bails out insolvent banks or liquidates them, although it will be more frequent in the latter case. As a consequence, the efficient structure of the interbank market, (secured or unsecured) is related to the nature of the main type of moral hazard the banks are facing (monitoring or screening respectively). In the first case the Goodfriend-King argument applies, while in the second case there is a specific role for the LOLR policy.

Our result may clarify the debate on the role of the LOLR: when market discipline is the most important feature of an efficient banking system, because it gives the banks the incentives to screen their borrowers, the interbank market has to be unsecured and the LOLR may intervene in order to limit illiquid banks excessive liquidation of assets. On the other hand, if the basic role of the interbank market is to provide liquidity insurance, the interbank market claims can be made senior.

Of course information problems would be immaterial if banks had a sufficient amount of capital. That is why any model that deals with these issues has to consider that capital is scarce. As a consequence, there is a trade-off between the banks' safety and their funding costs. Our approach avoids the arbitrary resolution of this trade-off by considering the overall efficiency in terms of the total added value of the banking industry. Thus, not surprisingly, our framework provides as a by product a theory of optimal capital regulation. The amount of capital depends on how the interbank market works which in turn depends on the moral hazard constraints the banks are facing.

The rest of the paper is organized as follows. In Section 2 we set up the basic model of adverse selection of bank's types and moral hazard of bankers. In Section 3 we consider a perfect information setting and show how the interbank market can implement the efficient allocation. In Section 4 we bring in gambling for resurrection and consider the possibility of bailing out the insolvent banks and establish how the interbank market has to be structured. In Section 5 we show how and when Central Bank lending through a discount window will improve upon the market allocation. Finally in Section 6 we extend our results to an economy where it is impossible to prevent gambling for resurrection. Section 7 draws policy implications and concludes.

## 2 The Model

We consider an economy with three dates ( $t = 0, 1, 2$ ) where profit maximizing banks offer contracts to depositors while investing in a risky long term technology. At date  $t = 0$

deposits are collected and investment is made. At  $t = 1$ , a bank can be in 3 possible states, denoted  $k = S, L, N$ ; a bank may face a solvency shock ( $k = S$ ), a liquidity shock ( $k = L$ ) or no shock at all ( $k = N$ ). At date  $t = 2$  returns on investment are divided between depositors and a bank's shareholders.

## 2.1 Bank and depositors

As in Diamond and Dybvig (1983), banks serve a large number of risk-averse depositors that need intertemporal insurance because they face idiosyncratic shocks about the timing of their consumption needs.

We normalize the riskless interest rate to zero. Implicit behind this assumption is the idea that the CB conducts "regular" liquidity management operations, for reason of monetary policy implementation, irrespective of financial stability. We also assume the existence of a DIF that guarantees all deposits. Deposit insurance is financed by actuarially fair premia. Since depositors are fully insured by the DIF, the optimal contract offered to depositors allows them to withdraw the amount initially deposited  $D$  in each period. Fully insured depositors are totally passive in the model. In modern banks a sizeable portion of deposits is held by large uninsured depositors. However, in many crisis resolutions, large depositors often have been de facto fully insured as well, thus for simplicity we assume that there is only one category of depositors and that they are fully insured.

We neglect internal agency problems within banks, and assume that risk-neutral bank managers (henceforth bankers) endeavor to maximize the bank's shareholders value. We assume that there exists a supervisory agency, which we call the Financial Services Authority (FSA), in charge of providing incentives for bankers to invest in "safe and sound" projects. The FSA can refuse to charter a bank at  $t = 0$  if it does not satisfy certain regulatory conditions that will be specified later (essentially a capital adequacy requirement) and can also close a bank (at  $t = 1$ ) if it finds out that it is insolvent. We abstract from agency conflicts between DIF, CB and supervisors.<sup>3</sup>

A crucial element in our discussion will be whether supervision is efficient (i.e. insolvent banks are detected and closed) or not, and whether efficient closure rules can be implemented, whereby although insolvent banks are not detected by supervisors, they can be given incentives to declare bankruptcy at  $t = 1$ . We will consider three cases:

- efficient supervision in Section 3: insolvent banks are detected and closed at  $t = 1$ .
- efficient closure rules in Section 4: insolvent banks are not detected but are given incentives to declare bankruptcy at  $t = 1$ .
- regulatory forbearance in Section 6: insolvent banks are not closed and gamble for resurrection by investing in inefficient projects in the hope of surviving.

At date  $t = 0$  bankers raise the amount  $D + E$  (deposits plus equity), pay the deposit insurance premium,  $P$ , and invest  $I$  by making loans; the budget constraint of a bank is

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<sup>3</sup>For an analysis of this issue see Repullo (2000) and Kahn and Santos (2001).

thus:

$$I + P = D + E. \quad (1)$$

We assume that the supply of deposits is infinitely elastic at the (zero) market rate. Equity is fixed. There is a perfectly competitive, risk-neutral, interbank market ready to lend any amount at fair rates from  $t = 1$  to  $t = 2$ . There is no aggregate liquidity shock. Since liquidity is available at fair rates at  $t = 1$ , it is optimal for banks to keep zero reserves.<sup>4</sup> Investment is subject to constant returns to scale. The gross rate of return at  $t = 2$  of the investment is  $\tilde{R} = R_1$  in case of success and  $\tilde{R} = R_0$  in case of failure, with  $R_1 > 1 > R_0 > 0$ .

## 2.2 Liquidity and solvency shocks

The state  $k = S, L, N$  is privately observed by the banker. In state  $S$  (solvency shock), which occurs with probability  $\beta_S$ , the banker learns that his bank is insolvent, i.e. that the probability of success of its investment at  $t = 2$  is zero. In other words  $\tilde{R} = R_0$  for sure. If state  $S$  does not occur, the probability of success ( $\tilde{R} = R_1$ ) is  $p$ , but the bank can be hit by a liquidity shock (state  $L$ ), which occurs with unconditional probability  $(1 - \beta_S) \beta_L$ . In state  $L$ , the bank is illiquid: it faces a deposit withdrawal that for computational simplicity we assume is proportional to bank assets,  $\ell \equiv \lambda I$ , with  $0 < \lambda < 1$ . If the bank cannot find sufficient liquidity to serve these withdrawals, it is forced to liquidate prematurely. For simplicity, the liquidation value of assets is equal to  $R_0 I$  (the same as when the bank fails). Finally with complementary probability  $(1 - \beta_S) \beta_N$  (with  $\beta_N + \beta_L = 1$ ) the bank is in state  $N$  (no shock)<sup>5</sup>.

Figure 1 summarizes the different possibilities in our model.

[Figure 1 about here]

## 2.3 Bankers' incentives

The role of banks in our model is to channel funds to finance "safe and sound" projects. We model two types of actions that bankers can take in this respect:

- screening projects at  $t = 0$ : i.e. choosing projects that have a reasonable probability of being successful;

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<sup>4</sup>When aggregate liquidity is scarce reserve holdings become important (see e.g. Bhatthacharya and Gale 1987).

<sup>5</sup>An alternative modelling assumption could be that banks can be hit by a liquidity shock and a solvency shock. Thus we would have a fourth possibility where an insolvent bank may be illiquid. If this bank does not borrow  $\lambda I$  it is forced to close. If it does borrow  $\lambda I$ , to stay in business it would have to use the loan to repay the impatient depositors and thus it could not use it to gamble for resurrection. Since nothing would change in our analysis, for simplicity we maintain the assumption that there are three states of the world, i.e. the insolvent bank has no liquidity needs.

- monitoring projects at  $t = 1$ : i.e. ensuring that borrowers will fulfil their repayment obligations as much as they can.

Supervisors' actions (e.g. closing insolvent banks) as well as those of the Central Bank (e.g. providing emergency liquidity assistance to illiquid banks) will affect bankers' profits and their incentives to screen and monitor their loans. Let  $B_k^j \geq 0$  denote the profit rate<sup>6</sup> (i.e. per unit of investment) of the banker at date  $t = 2$ , after state  $k = S, L, N$  and conditionally on success ( $j = 1$ ) or failure ( $j = 0$ ). Similarly, let  $B_S$  denote the profit rate of the banker in state  $S$  (in which case failure is certain). Notice that since the  $t = 2$  return is observable<sup>7</sup> and the bankers are risk neutral, it is optimal to set  $B_k^0 = 0$  when  $k = L, N$ , that is when a solvent bank fails. This allows us to simplify the notation so that  $B_k^1$  will be denoted simply  $B_k$ ,  $k = L, N$ .

In this paper we abstract from the analysis of contagion that may arise when a bank fails (see among others Freixas and Parigi 1998 for contagion via the payment system) and that is often invoked to justify CB lending. Thus we assume that when an insolvent bank is closed at  $t = 1$  or a bank fails at  $t = 2$  ( $\tilde{R} = R_0$ ) there are no systemic repercussions on the banking system as a whole.

The screening decision of the banker is modelled as follows: exerting a screening effort at time  $t = 0$  costs the banker  $e_0$  and limits the probability of a solvency shock to  $\beta_S$ . Absent the screening effort, the probability of a solvency shock becomes  $\beta_S + \Delta\beta$ , with  $\Delta\beta > 0$ . The banker will exert the screening effort (which we assume to be efficient) if and only if his ex ante expected profit from screening exceeds that without screening, namely;

$$\beta_S B_S + (1 - \beta_S) p(\beta_N B_N + \beta_L B_L) - e_0 \geq (\beta_S + \Delta\beta) B_S + (1 - \beta_S - \Delta\beta) p(\beta_N B_N + \beta_L B_L) \quad (2)$$

which simplifies to

$$p(\beta_N B_N + \beta_L B_L) \geq \frac{e_0}{\Delta\beta} + B_S, \quad (MH_0). \quad (3)$$

We call this the moral hazard constraint at  $t = 0$  (or screening constraint).

Similarly the monitoring decision of the banker is modelled as follows: exerting a monitoring effort at  $t = 1$  costs the banker  $e_1$  and ensures a probability of success of  $p$ . Absent the monitoring effort, the probability of success is only  $p(1 - \delta)$ , with  $0 < \delta < 1$ . We assume that it is always efficient that the banker exerts this monitoring effort. The banker will exert the monitoring effort after state  $k$  if and only if

$$pB_k - e_1 \geq p(1 - \delta) B_k, \quad (4)$$

which simplifies in

$$B_k \geq \frac{e_1}{\delta p}, \quad k = L, N, \quad (MH_1). \quad (5)$$

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<sup>6</sup>The formulas for these profit rates will be developed later, as a function of the different institutional arrangements that we consider.

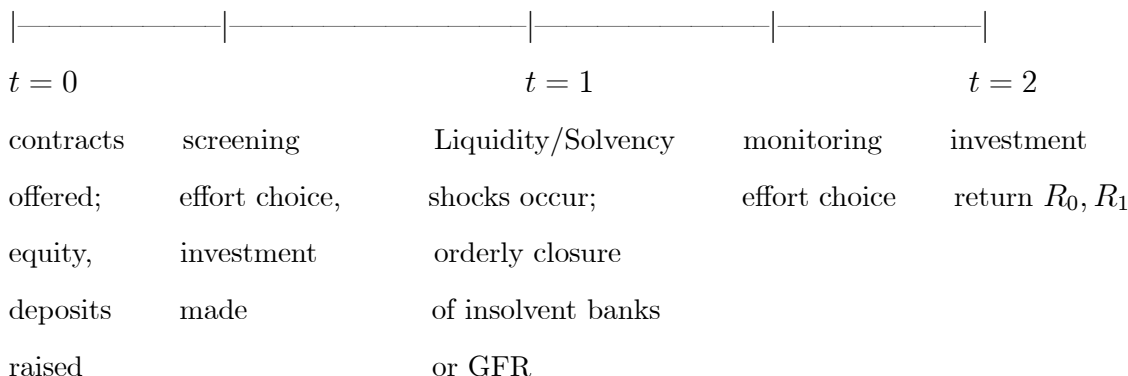
<sup>7</sup>Aghion et al. (1999) as well as Mitchell (2001) have shown that if the returns are unobservable there may be an asymmetric information rent for the banks.



We call this the moral hazard constraint at  $t = 1$  (or monitoring constraint).

Notice that closure or continuation decisions made at  $t = 1$  are fully anticipated and will have a different impact on screening effort (decided before  $t = 1$ ). The difference between the expected profit in case of solvency,  $\beta_N B_N + \beta_L B_L$ , and the expected profit in case of insolvency  $B_S$  is a measure of market discipline. A large difference between the two, characteristic of market discipline, will provide banks with the right incentives to screen.

The sequence of the events is summarized in the following diagram.



## 2.4 Prudential regulation

In our model prudential regulation is justified by the fact that depositors cannot control the screening and monitoring activities of bankers. Regulation is there to ensure that bankers have appropriate incentives to do their job (i.e. exert screening and monitoring effort) and that the DIF does not lose money in expected terms.

Regulation can be seen as a contract between the FSA (representing the interest of the depositors) and the bankers. This contract specifies  $I$  (how much a bank can lend) and the profit rates of the bankers in different states of the world, as a function of  $E$  (the equity of the banker) and the parameters characterizing investments and bankers' actions. At this stage, we don't discuss the implementation of the optimal contract. In particular we do not specify how liquidity needs of banks are financed at  $t = 1$ .

The time  $t = 0$  budget constraint,  $I = E + D - P$ , states that bank's assets are financed with equity  $E$ , plus deposits  $D$ , with zero remuneration, but insured at the cost  $P$ . This imposes a constraint on the depositors' participation. This comes from the fact that the total expected return on the project,  $I\bar{R}$ , where  $\bar{R} \equiv \beta_S R_0 + (1 - \beta_S)(pR_1 + (1 - p)R_0)$  is the expected rate of return at  $t = 0$  on the projects financed by the bank, has to be distributed among the two types of claim holders, insured depositors (entitled to a net payoff  $D - P$ ) and equity holders, but there is a minimum expected profit rate that is needed to provide bankers with appropriate incentive,  $\bar{\pi} \equiv \beta_S B_S + p(\beta_L B_L + \beta_N B_N)(1 - \beta_S)$ .

For the project to be able to pay to all its claim holders, we need

$$I\bar{R} \geq \bar{\pi}I + D - P$$

and replacing  $D - P$  from equation (1) the resulting constraint for outside investors at

$t = 0$  is

$$I(\bar{R} - 1) \geq \bar{\pi}I - E, \quad (IP). \quad (6)$$

This constraint states that the expected net return on bank's assets, that is the social surplus (left hand side of the inequality) is at least equal to the expected increase in shareholder value (or equivalently that the bank has not been subsidized by outsiders). We assume that at  $t = 0$  projects have a positive expected NPV, i.e.  $\bar{R} > 1$ , and that the bank need capital, i.e.  $\bar{R} < 1 + \bar{\pi}$ . In turn  $\bar{R} > 1$  implies that  $pR_1 + (1 - p)R_0 > 1$ , that is an illiquid bank has a positive expected NPV from continuation.

Notice that constraint (IP) can be restated as a capital adequacy requirement,

$$\frac{E}{I} \geq K, \quad (7)$$

where  $K \equiv \bar{\pi} + 1 - \bar{R}$  is the capital ratio and it is positive by assumption.

It is worth pointing out that this formulation introduces an endogenous opportunity cost of capital. Any increase in the aggregate amount of equity  $\Delta E$ , results in an increase in the size of banks and therefore in an increase of the banking sector  $\Delta I = \frac{\Delta E}{K}$ , which generates an increase in the expected output  $\Delta I(\bar{R} - 1)$ .

Finally, we assume that liquidity shocks are small with respect to the rate of return on the investment, i.e.  $\lambda < R_0$ . This reflects the idea that "the probability that a modern bank is solvent, but illiquid, and at the same time lacks sufficient collateral to obtain regular central bank funding is [...] quite small" (Padoa Schioppa 1999).<sup>8</sup> For example, in the U.S. discount window loans in a typical day amount to few hundred millions dollars.<sup>9</sup>

### 3 Efficient supervision: detection and closure of insolvent banks

To begin with, we examine the case where the shocks at  $t = 1$  are public information: thus insolvent banks are detected and closed at  $t = 1$ . This benchmark case corresponds to the ideal framework where supervisors have perfect information about banks' shocks. In practice regulators may not be able to detect and/or close insolvent banks, a point we examine in the next section.

The closure of an insolvent bank could, nevertheless, be obtained, for some parameter constellation, if the implementation of the efficient interbank lending structure leads banks to self selection. If so, the first best is achieved in spite of the lack of information regarding the solvency shocks, a point we examine in subsection 3.3.

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<sup>8</sup>If the liquidity shock is large ( $\lambda > R_0$ ) loans cannot be fully collateralized. Bailing out banks may cause losses and thus may require additional resources. The additional resources may involve taxpayer money from the Treasury if bank insolvency may cause systemic risk or from the Deposit Insurance fund otherwise.

<sup>9</sup>However, they reached the level of \$46 billion in the day after the 9/11 terrorist attacks (Bartolini and Prati 2003).



We introduce here the structure of the problem of finding the optimal contract. The mathematical treatment will be the same in this section and in sections 4 and 6 where we consider the two other regulatory frameworks. Our approach will be to look for the optimal allocation and then introduce the institutional arrangements to implement it.

### 3.1 The optimal allocation when supervision is efficient

The optimal allocation can be obtained by solving a two-stage program by backward induction. The second stage consists in maximizing the size of the investment, under the investor participation constraint (or capital adequacy requirement), i.e.

$$\max I \text{ s.t. } (IP). \quad (8)$$

The first stage consists in finding bankers' expected profit rates in the various states that minimize bankers's ex ante expected profits  $\bar{\pi}$  under the limited liability and the moral hazard constraints, solving the following program ( $\wp^1$ ); namely:

$$\min_{B_L, B_N, B_S} \bar{\pi} \text{ s.t.} \quad (9)$$

$$B_S \geq 0, \quad (LL) \quad (10)$$

$$p(\beta_N B_N + \beta_L B_L) \geq \frac{e_0}{\Delta\beta} + B_S, \quad (MH_0) \quad (11)$$

$$B_k \geq \frac{e_1}{p\delta}, \quad k = L, N, \quad (MH_1). \quad (12)$$

The solution of ( $\wp^1$ ) is characterized in the following proposition.<sup>10</sup>

**Proposition 1.** *When supervision is efficient, the optimal allocation specifies a zero profit rate for insolvent banks (state  $S$ ) and the same profit rate in the two other states  $L$  and  $N$ :  $B_S = 0$  ;  $B_N = B_L = \max\left(\frac{e_1}{p\delta}, \frac{e_0}{p\Delta\beta}\right)$ .*

Proof. See the Appendix.

### 3.2 Implementing the optimal allocation

Let us now adopt a positive viewpoint and determine what institutional arrangements are needed in order to implement the efficient allocation characterized above. First notice that  $B_S = 0$  is obtained simply by closing the insolvent banks and fully expropriating bankers, as in a standard bankruptcy procedure. The second characteristic of the optimal allocation is that bankers obtain the same profit rate in the two remaining states, i.e. whether or not a bank experiences a liquidity shock ( $B_N = B_L$ ). Since illiquid banks (state  $L$ ) have to borrow  $\lambda I$  (in order to repay unexpected withdrawals at date 1) their profit rate in case of success at date 2 is

$$B_L = R_1 - \frac{(D - \lambda I) + \rho}{I} \quad (13)$$

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<sup>10</sup>Notice that the limited liability constraint can only bind in state  $S$ , since constraint ( $MH_1$ ) implies that  $B_k > 0$  for  $k = L, N$ .

where  $D - \lambda I$  represents the repayment to the depositors who have not withdrawn at date 1 and  $\rho$  is the repayment on the loan contracted at date 1. Since we have normalized the riskless interest rate to 0, the quantity  $\rho - \lambda I$  can be interpreted as the net cost of borrowing for the bank:

$$\rho - \lambda I = \sigma \lambda I \quad (14)$$

where  $\sigma$  is the spread charged by the lender to the borrowing bank. Since we assume a competitive interbank market, this spread is zero if the interbank loan is collateralized but positive if there is credit risk.

By contrast,  $N$  banks do not have to borrow at  $t = 1$ , so that their profit rate in case of success at  $t = 2$  is

$$B_N = R_1 - \frac{D}{I}. \quad (15)$$

Using relations (13), (14), (15) we see that  $B_N - B_L = \sigma \lambda$ .

Proposition 1 shows that efficiency requires that  $B_N = B_L$ , i.e. that there is no risk spread in the interbank market. This implies that the repayment of interbank market loans has to be fully guaranteed. In fact, the implementation needs not imply any direct involvement of the DIF, since interbank loans could be either senior to deposits or fully collateralized on the bank's assets which is possible since  $\lambda < R_0$ . Thus when supervision is efficient so that a bank is closed as soon as it becomes insolvent, there is no reason to penalize with a positive spread a bank that becomes illiquid.

In reality, however, interbank loans are typically unsecured, for example in the market for reserves where depository institutions lend reserves to each other at overnight maturity. Why would an unsecured interbank market possibly lead to an inefficient allocation? The answer is that when loans in the interbank market are risky, we have  $B_L = B_N - \sigma \lambda$ . However, because of the monitoring moral hazard constraint,  $B_L$  cannot be smaller than  $\frac{\epsilon_1}{p\delta}$ . This means that  $B_N$  has to be increased above this level, implying a reduction in the banks' lending capacity, an increase in the capital requirement, and a reduction in social surplus.<sup>11</sup>

The other tools for implementing the efficient allocation are the capital ratio and the DIF premium. Banks maximization of  $I$  yields the optimal level of investment  $\bar{I}$ . The capital ratio

$$K : K \leq \frac{E}{\bar{I}} \quad (16)$$

is chosen to coincide with the optimum so that

$$E = [\bar{\pi} - \bar{R} + 1] \bar{I} = \bar{K} \bar{I} \quad (17)$$

where  $\bar{K}$  denotes the capital ratio that solves (16) with equality. Since the Deposit Insurance premium is actuarially fair, we have that:

$$P = [\beta_S + (1 - \beta_S) \beta_N (1 - p)] [D - R_0 \bar{I}] + [(1 - \beta_S) \beta_L (1 - p)] [D - (R_0 + \lambda) \bar{I}]. \quad (18)$$

The bank's budget constraint at  $t = 0$  (equation 1) together with (18) determines the values of  $P$  and  $D$ .

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<sup>11</sup>Strictly speaking, when  $\frac{\epsilon_1}{\delta} < \frac{\epsilon_0}{\Delta\beta}$ , program  $\wp^1$  has multiple solutions, some of them being compatible with a (small) spread. For simplicity we focus on the solution described in Proposition 1.

### 3.3 Implementing the efficient allocation under adverse selection

Theoretically, it would be possible to implement the efficient allocation even in the presence of adverse selection. We briefly examine this case, for the sake of completeness. The main benefit of showing what happens in this case is that it allows us to establish forcefully that any reasonable framework for the analysis of the interbank market and the LOLR has to take into account the existence of the bankers' incentives to avoid closure and remain in business.

Notice that when bank's type of shocks are not observable (adverse selection), it is still possible to implement the efficient allocation, as long as an insolvent bank cannot take actions that are detrimental to social welfare. This comes from the fact that returns on bank's assets are observable. Thus, whenever a bank fails ( $\tilde{R} = R_0$ ), the DIF is entitled to seize all its assets, implying  $B_N^0 = B_L^0 = 0$ , as we have assumed, and  $B_S = 0$ ; a secured interbank market which implies  $\sigma = 0$ , will then allow to obtain the efficient allocation with  $B_N = B_L$ . In particular no CB intervention for ELA is needed to implement the efficient allocation.

The situation changes if we introduce an additional feature (which we believe to be realistic) namely that the managers of an insolvent bank have an incentive to remain in business, either because of the possibility to divert assets from the bank or because they are able to gamble for resurrection. This is what we investigate in the next section.

## 4 Efficient closure

Rapid developments in technology and financial sophistication can impair the ability of regulators to maintain a safe and sound banking system (See e.g. Furfine 2001). To capture this, we suppose from now on that insolvent banks cannot be detected by regulators, and can attempt to gamble for resurrection (GFR). By this we mean that insolvent banks can borrow the same amount of liquidity  $\lambda I$  of illiquid banks and invest it without being detected. By assuming that insolvent and illiquid banks have the same liquidity needs we make it easier for an insolvent bank to mimic an illiquid, and as a result, we give the regulators the harder case to handle. Borrowing any amount different from  $\lambda I$  would immediately reveal that a bank is not illiquid.

We assume that this additional investment gives an insolvent bank a second chance, i.e. a positive (but small) probability of success  $p_g \equiv \alpha p$  (with  $0 < \alpha < 1$ ) for the bank's projects. We assume  $p_g (R_1 - R_0) < \lambda$ , that is this reinvestment has a negative expected NPV. In spite of this, managers of an insolvent bank may decide to use this reinvestment possibility in the hope that the bank recovers. We call this behavior "gambling for resurrection" by reference to the behavior of "zombie" Savings and Loans during the U.S. S&L crisis in the 1980s. The negative expected NPV from continuation implies that managers would actually be better off by "stealing" the money altogether at  $t = 1$ , if they could get away with it. Indeed the negative expected NPV assumption is equivalent to  $p_g R_1 + (1 - p_g) R_0 < \lambda + R_0$  so that "stealing" dominates "gambling for resurrection".

Akerlof and Romer (1993) document such looting behavior during the U.S. S&L crisis. Here we focus on GFR by assuming a large "cost of stealing", namely that "looters" get ultimately only a small fraction of what they steal, so that GFR is a more profitable behavior for bankers.

Providing bankers with the incentives not to gamble for resurrection implies that the bankers who declare bankruptcy at  $t = 1$  are allowed to keep a positive profit. We interpret this as a bail-out of the insolvent bank. The rate of profit  $B_S$  of the banker, following a bail-out, has to be larger or equal to the expected profit obtained from engaging in gambling for resurrection. Gambling for resurrection implies obtaining the same rate of profit in case of success as an  $L$  bank,  $B_L$ . However, an insolvent bank that gambles for resurrection has to make an additional investment  $\lambda I$ . Thus the profit rate from GFR in case of success is  $B_L - \lambda$ , and the expected profit rate is  $p_g(B_L - \lambda)$ . Thus GFR will be prevented if an insolvent bank obtains an expected profit rate at least equal to this value. This introduces a new constraint:

$$B_S \geq p_g(B_L - \lambda), \quad (GFR). \quad (19)$$

As we show in the sequel the possibility for an insolvent bank to GFR creates an externality between the interbank market and the DIF.<sup>12</sup>

## 4.1 Optimal allocation with orderly closure

The most efficient way to avoid gambling for resurrection is for the FSA to provide the monetary incentives to the managers of insolvent banks for spontaneously declaring bankruptcy (See Aghion et al. 1999 and Mitchell 2001). This means in practice that the FSA can organize an orderly closure procedure that allows to avoid gambling for resurrection (or asset substitution). In this procedure the bank managers are able to secure a profit rate  $B_S$  in spite of the failure of their bank. In contrast with the previous case of efficient supervision (where insolvent banks are detected and closed), the fact that bankers receive a strictly positive profit even in the event of insolvency implies that their ex ante expected rate of profit is higher. But this implies, in turn, that a bank will face ex ante a higher capital requirement and will invest less: this is the social cost of inefficient supervision.

The program that describes the optimal contract is again the one that maximizes the size of the investment under the capital adequacy requirement:

$$\max I \text{ s.t.} \quad (20)$$

$$I(\bar{R} - 1) \geq \tilde{\pi}I - E \quad (21)$$

where the ex ante expected profit rate of the bankers  $\tilde{\pi} \equiv \beta_S B_S + p(\beta_L B_L + \beta_N B_N)(1 - \beta_S)$

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<sup>12</sup>We have chosen to model GFR as the main preoccupation of bank supervisors. We could have assumed instead that bank managers are able to engage in inefficient assets substitution in order to expropriate value from the DIF. Our results would essentially carry over to this slightly different modelling assumption.

is found solving the following program ( $\wp^2$ )

$$\begin{aligned} \min_{B_L, B_N, B_S} \quad & \tilde{\pi} \text{ s.t.} \\ & (LL), (MH_0), (MH_1), (GFR). \end{aligned} \tag{22}$$

If  $\lambda > \frac{e_1}{\delta p}$ , then the GFR constraint does not bind, and the program ( $\wp^2$ ) has the same solutions as ( $\wp^1$ ). Therefore we assume henceforth  $\lambda < \frac{e_1}{\delta p}$ . We establish the following result.

**Proposition 2.** *If  $\lambda < \frac{e_1}{\delta p}$  then ( $\wp^2$ ) has a unique solution. This solution is such that bankers who declare insolvency receive the minimum expected profit that prevents them from gambling for resurrection:  $B_S = p_g \left( \frac{e_1}{\delta p} - \lambda \right) > 0$ . The profit rates in the other states ( $L$  and  $N$ ) depend on which moral hazard constraint binds.*

*If it is the monitoring constraint (Case a), which occurs if  $\frac{e_1}{\delta} \geq \frac{e_0}{\Delta\beta} + B_S$ , then  $B_N = B_L = \frac{e_1}{p\delta}$ . Bankers obtain the same profit rate whether or not they experience a liquidity shock.*

*On the contrary if the screening constraint dominates (Case b), i.e. when  $\frac{e_1}{\delta} < \frac{e_0}{\Delta\beta} + B_S$ , then the profit rate is higher for banks who do not experience a liquidity shock:  $B_N = \frac{1}{p\beta_N} \left( \frac{e_0}{\Delta\beta} + B_S \right) - \frac{\beta_L e_1}{\beta_N p\delta}$ ,  $B_L = \frac{e_1}{p\delta} < B_N$ .*

Proof. See Appendix.

## 4.2 Implementing the optimal allocation with orderly closure

Proposition 2 characterizes the optimal allocation in the case where supervision is inefficient (i.e. the insolvent banks are not detected at  $t = 1$ ) but the FSA (or the DIF) has the power to provide direct monetary incentives to the owner-managers of an insolvent bank who spontaneously declares bankruptcy at  $t = 1$ . In such a way, gambling for resurrection is avoided.

It is important to stress that this way of handling bank closure contrasts with the conventional wisdom, that states that a generous bail-out policy hampers market discipline and generates moral hazard. Our results shows that this conventional wisdom may be an oversimplified view of the world, and points out at the trade-off between the benefits of market discipline and the costs of gambling for resurrection when insolvency is not detected. By modelling explicitly screening and moral hazard constraints and the possibility to gamble for resurrection, we account for a rich array of possible bankers' behaviors that generate complex interactions. It is true that guaranteeing a positive profit  $B_S$  to the bankers who spontaneously declare bankruptcy at  $t = 1$  makes it more difficult for the FSA to prevent moral hazard at date 0 and imposes an additional cost to the DIF. However, by knowing that the expected profit rate of an insolvent bank is less than that of a solvent bank ( $B_S < \beta_L B_L + \beta_N B_N$ ), bankers have the right incentives to exert effort at  $t = 0$  to avoid being insolvent. To summarize, thus,  $B_S$  has to be sufficiently high to induce self selection of an insolvent bank, and  $\beta_L B_L + \beta_N B_N$  has to be increased accordingly in order to keep the bankers' incentives to screen intact. For these reasons,

the ex ante capital requirement has to be increased. This has a cost in our model, since it implies that  $K$  increases in the capital requirement constraint  $KI \leq E$ , and therefore that, for a given level of equity, the size of the banking sector is reduced. As we will show in section 6, this cost is unavoidable, even if insolvency is a highly unlikely event, in the sense that if we allow a bank to gamble for resurrection it will secure the level of profits  $B_S$  at a higher cost to society, since  $\beta_L B_L + \beta_N B_N$  cannot be decreased and therefore the size of the banking sector cannot be increased.

Still this is the most efficient way to prevent gambling for resurrection (or more generally asset substitution). Once insolvency has occurred, it would be inefficient (both ex post and ex ante) to impose penalties on the bank who spontaneously declares insolvency, since this would encourage gambling for resurrection, a behavior costly to society. From a policy view point, this justifies a crisis resolution mechanism involving some kind of bail out of a failing bank. Such a mechanism has been advocated recently by Aghion et al. (1999), Mitchell (2001) and Gorton and Huang (2002). However, there is an obvious criticism to such a mechanism, namely that it can lead to regulatory forbearance and possibly to corruption. If the FSA (or the DIF) has all discretion to distribute money to the owners-managers of banks, organized frauds can be envisaged, at least if the banks supervisors are not above all suspicion. This is why we examine in Section 6 an alternative set of assumptions where such monetary transfers are ruled out.

Regarding the difference between Case (a) and Case (b), in Case (a), ( $B_N = B_L$ ,  $B_S > 0$ ) the monitoring constraint is binding and the implementation is the same as before. Provided that interbank market loans are either senior or fully collateralized, the efficient allocation will be implemented by the interbank market without any need of CB intervention.

In Case (b), though,  $B_N > B_L$  implies that loans must be made with an interest rate spread  $\sigma^*$  which can be computed from the above values:

$$B_N - B_L = \sigma^* \lambda = \frac{1}{p\beta_N} \left( \frac{e_0}{\Delta\beta} + \frac{e_1}{\delta p} (p_g - p) - p_g \lambda \right). \quad (23)$$

However, the actual interbank market spread when loans are not fully collateralized is determined by the condition of zero expected return, implying in the case that the insolvent bank is bailed out ( $\beta_S = 0$ )

$$\sigma(0) = \frac{1-p}{p}. \quad (24)$$

Thus, it is only if  $\sigma(0) = \sigma^*$  that the efficient allocation will be reached by the interbank market. In general, the efficient allocation will not be reached, and we will have to consider two possible cases, depending on whether  $\sigma(0) < \sigma^*$  or the opposite inequality holds.

In the first case,  $\sigma(0) < \sigma^*$ , it is optimal that an illiquid bank borrows at a penalty rate, but this is incompatible with the normal functioning of the interbank market. Notice that the rationale for "lending at a penalty rate" is here completely different from the one in Bagehot. In our framework the issue of efficient reserves management does not arise. Lending with a penalty is desirable only as a mean to reduce the profits from GFR and therefore the cost of bailing-out banks.

In summary, when the monitoring constraint is binding (Case a), interbank market loans have to be fully secured in order to implement the efficient allocation. Instead, when the screening constraint is binding (Case b) the efficient solution in general is not implementable, unless restrictions are put on the functioning of interbank markets. This means that the presence of interbank markets puts a limit to the power of the incentive scheme that the FSA can use to encourage bankers to exert screening efforts.

## 5 Central Bank Lending

Once we recognize the impossibility for the Central Bank to provide ELA at a higher rate than the interbank market, the potential role of the CB is limited to situations where  $\sigma(0) > \sigma^*$ . In this case though, the CB has an advantage over the interbank market in that it can override the priority of the DIF claims and thus lend under better terms than the market. Gorton and Huang (2002) argue precisely that governments cannot improve upon a coalition of banks in providing liquidity unless they have more power than private agents, e.g. they can seize assets. In practice, Lender of Last Resort operations are almost always the responsibility of the Central Bank while the Deposit Insurance Fund is usually managed by a public agency or the banking industry itself (See Kahn and Santos 2001 and Repullo 2000). We study in the next section how and when this ELA can be provided.

### 5.1 The operational framework

Goodfriend and Lacker (1999 p.12 and 14) provide detailed evidence for the fact that, in the U.S., lending by the FED is in general collateralized and favored in bank failure resolution with the FDIC assuming "the borrowing's bank indebtedness to the FED in exchange for the collateral, relieving the FED of the risk of falling collateral value" (p.14). Of course the risk is shifted on the DIF.

Similarly, all credit operations by the Eurosystem must be collateralized<sup>13</sup> with the Eurosystem accepting a broader class of collateral than the FED. Under the ELA arrangements, LOLR in the Eurosystem is conducted mainly at the NCBs level at the initiative of the NCBs and not of the ECB. NCBs can make collateralized loans up to a threshold without prior authorization from the ECB. Larger operations that may have a potential impact on monetary policy must be approved by the ECB. Since the costs and risks of ELA operations conducted autonomously by the NCBs are to be borne at the national level, NCBs would have some leeway in relation to collateral policy, as long as some national authority takes the risk (e.g. inform of a guarantee).<sup>14</sup>

<sup>13</sup>Art 18.1 of the ECB/ESCB Statute (Issing et al. 2001).

<sup>14</sup>The operational procedures through which the two Central Banks lend money to banks for regular liquidity management have become more similar recently (Bartolini and Prati 2003), with the FED converging toward a system of Lombard-type facility. First with the Special Lending Facility around Y2K and then at the beginning of 2003 the FED has begun to make collateralized loans to banks on a no-question-asked-basis and at penalty rates over the target federal funds rate (Bartolini and Prati 2003) as opposed to rates 0.25 point to 0.50 point below the fund rate over the last 10 years. Similarly in the Eurosystem one of the main pillars of liquidity management is the Marginal Lending Facility which



## 5.2 The terms of Central Bank Lending

The terms at which the CB has to offer ELA, in order to implement the efficient allocation are directly deduced from Proposition 2. Formally:

**Proposition 3.** *If the screening constraint is binding, and if the optimal spread  $\sigma^*$  is lower than the interbank spread  $\sigma(0)$ , then the CB can improve upon the unsecured interbank market solution by lending at a rate  $\sigma^*$  against good collateral .*

Several observations are in order. First, the possibility of ELA by the CB allows to reach the efficient allocation by increasing the  $L$  bank profit rate up to its efficiency level. This is possible by using the discount window facility and lending to illiquid banks at better terms than the market, so that they are not penalized by the high interbank market spreads.

Second, there is a trade off between lending to illiquid banks at better terms, and discouraging insolvent banks from GFR. This trade off and the interaction between regulation and liquidity provision are captured by the constraint  $B_S \geq p_g (B_L - \lambda)$  which shows that  $B_L$  has to be lowered if one wants to decrease the profit  $B_S$  left to insolvent banks. This is the condition that allows to sort illiquid from insolvent banks. Indeed, an insolvent bank is less profitable than an illiquid bank for two reasons: it needs an additional investment  $\lambda I$  and it succeeds with a lower probability,  $p_g = \alpha p < p$ . Thus the insolvent bank cannot afford to borrow at the same interest rate than the illiquid bank. By charging a suitably high interest rate, the CB discourages an insolvent bank from borrowing.<sup>15</sup> Moreover by requiring good collateral and therefore effectively overriding the priority of the DIF claims, the CB can lend at better terms than the interbank market.

Third, it is important to stress that the type of ELA envisioned here - collateralized CB lending in the amount  $\lambda I$  - does not result in the use of tax payer money, but in a higher DIF premium that lowers bank's size. Observing that a failing bank's assets are no longer  $R_0 I$  but  $(R_0 - \lambda) I$ , because the CB has priority over  $\lambda I$ , and that  $I$  is smaller than in the case where the insolvent bank is detected, the new DIF premium becomes

$$P = [\beta_S + (1 - \beta_S) \beta_N (1 - p)] [D - R_0 I] + [(1 - \beta_S) \beta_L (1 - p)] [D - (R_0 - \lambda + \lambda) I] \quad (25)$$

which is larger than the one in (18) where GFR is not an option.

Fourth, remark that a fully secured interbank market will be here inefficient. In Case (b) the solution requires a spread between  $B_N$  and  $B_L$ ,  $B_N = B_L + \lambda \sigma$ ; when  $\sigma(0) < \sigma^*$ , banks would generate a lower surplus with collateralized loans than with the optimal spread  $\sigma^*$ . If instead  $\sigma(0) > \sigma^*$ , then a fully secured interbank market would prevent the Central Bank from lending and reaching the efficient solution.

Finally, notice that by making explicit ex ante the rules of ELA from the Central Bank and thus by making explicit the profits that insolvent banks can receive if they accepts an

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banks can access at their own discretion to borrow reserves at overnight maturity from the Eurosystem at penalty rates (Issing et al. 2001).

<sup>15</sup>Notice that the  $N$  bank has no incentive to borrow  $\lambda I$  from the CB and lend it again to the market at a higher rate, because no bank would be ready to borrow at such a rate, which is higher than what they pay when they borrow from the CB.



orderly closure, is an effective way to deal with the issue of moral hazard and gambling for resurrection. This is to be contrasted with the notion that constructive "ambiguity" with respect to the conduct of the CB in crisis situations would reduce the scope for moral hazard.

### 5.3 When is CB intervention useful?

Proposition 3 gives two conditions that characterize the cases in which there is a role for ELA by the CB. These conditions require that the screening constraint be binding:

$$\frac{1 - \alpha}{\delta} e_1 \leq \frac{e_0}{\Delta\beta} - \alpha p \lambda \quad (26)$$

and that the interbank market spread be larger than the optimal spread, which, using (23) and (24), gives

$$\frac{e_0}{\Delta\beta} - e_1 \left( \frac{1 - \alpha}{\delta} \right) + p \lambda (\beta_N - \alpha) < \lambda \beta_N. \quad (27)$$

After simple manipulations, we can see that these two constraints amount to

$$p < \frac{\frac{e_0}{\Delta\beta} - e_1 \left( \frac{1 - \alpha}{\delta} \right)}{\alpha \lambda} < p + (1 - p) \frac{\beta_N}{\alpha}. \quad (28)$$

This means that ELA by the CB is justified in our model only under very specific conditions: first  $\frac{e_0}{\Delta\beta} - e_1 \left( \frac{1 - \alpha}{\delta} \right)$  has to be positive, which means that the screening constraint (ex ante moral hazard) has to dominate the monitoring constraint; second  $\beta_N$  has to be large, or rather the probability of a liquidity shock  $(1 - \beta_N)$  has to be small,<sup>16</sup> which means that the use of the discount window has to be limited to exceptional circumstances; finally  $p$  has to be small, or rather the probability of bank failure  $(1 - p)$  has to be high enough, which means that ELA is more likely to be needed during a recession or a banking crisis.  $\beta_S$  is here irrelevant as the insolvent bank spontaneously declares bankruptcy.

Therefore the main conclusion of this Section is that CB intervention is not needed when  $p$  is high (expansionary phase of the cycle). On the contrary the CB is necessary to provide ELA during crisis periods ( $p$  low) essentially because market spreads are too high.

## 6 Optimal allocation in the presence of GFR

Offering a subsidy to bail out banks that are experiencing financial distress may pose difficulties for regulators. It may well be difficult to prove that the money is well spent as it prevented banks from GFR, which is not observed if the policy is successful. Regulatory forbearance may therefore result. This may happen for example if the supervisors do not

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<sup>16</sup>We also assume that  $\alpha$  is small so that  $\beta_N > \alpha$ , in which case the third term in the above formula decreases with  $p$ . This ensures that both conditions are satisfied when  $p$  is small enough.

have the discretion to distribute money to bankers and/or if this is not feasible for political reasons. For these reasons in this section, we investigate the case where GFR cannot be avoided because the FSA is not allowed to bail-out insolvent banks.

Thus at  $t = 1$  insolvent banks (which are not detected because supervisors are inefficient) do not have incentives to declare bankruptcy and thus they are not closed: they borrow  $\lambda I$  at the same terms than illiquid banks and invest it with probability of success  $p_g < p$ . The interbank market is then plagued by adverse selection, which leads to a high spread. The probability of repayment of an interbank loan is smaller than in the case in which gambling for resurrection can be prevented, namely

$$p_{GFR} \equiv \frac{\beta_S p_g + (1 - \beta_S) \beta_L p}{\beta_S + (1 - \beta_S) \beta_L} < p \quad (29)$$

where the RHS (LHS) of (29) is the probability of repayment of an interbank loan when GFR can (cannot) be prevented. Thus the repayment required at the equilibrium of the interbank market is

$$\rho = \frac{\lambda I}{p_{GFR}}, \quad (30)$$

and the interbank market solution has a spread equal to

$$\frac{\rho}{\lambda I} - 1 = \frac{1}{p_{GFR}} - 1 = \sigma(\beta_S) \quad (31)$$

which is increasing in  $\beta_S$ .<sup>17</sup>

However, the efficient allocation is such that the profit rates of bankers in the different states is unchanged. For example, for an insolvent bank it is still equal to  $B_S = p_g(B_L - \lambda)$ , but the interpretation is different since this expected profit is now obtained by GFR. The optimal incentive scheme for bankers is the same as in Proposition 2 and in particular, the ex ante expected profit rate of bankers is  $\tilde{\pi} \equiv \beta_S B_S + p(\beta_L B_L + \beta_N B_N)(1 - \beta_S)$ . But the fact that an insolvent bank gambles for resurrection lowers the overall expected return from  $\bar{R}$  to

$$\hat{R} = \beta_S [p_g R_1 + (1 - p_g) R_0 - \lambda] + (1 - \beta_S) (p R_1 + (1 - p) R_0). \quad (32)$$

The program that describes the efficient solution is again the one that maximizes the size of the investment subject to the investors' participation constraint:

$$\max I \text{ s.t.} \quad (33)$$

$$I(\hat{R} - 1) \geq \tilde{\pi} I - E \quad (34)$$

where  $\tilde{\pi}$  is found solving program  $(\wp^2)$ . We immediately deduce the following proposition.

**Proposition 4.** *When GFR cannot be prevented, in the optimal allocation the profit rates obtained by bankers are the same as in Proposition 2. However, the overall net return on bank's assets is lower and the market spread on interbank loans is higher.*

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<sup>17</sup>Notice that when  $p = p_g$ , the market spread becomes independent of  $\beta_S$ ;  $\sigma(\beta_S) = \sigma(0)$ .

Several comments are in order. Like in the previous case, where GFR could be prevented by efficient closure rules, the efficient allocation requires that interbank loans are not collateralized. Therefore we suppose from now on that interbank loans are junior (deposits are senior).

The overall deposit insurance premium when GFR occurs is

$$P = [\beta_S (1 - p_g) + (1 - \beta_S) \beta_N (1 - p)] [D - R_0 I] + [(1 - \beta_S) \beta_L (1 - p)] [D - (R_0 + \lambda) I]. \quad (35)$$

We now compare the capital ratio and the investment level under orderly closure,  $K^*, I^*$  and in the interbank market solution,  $\hat{K}, \hat{I}$  with GFR. From the capital adequacy requirement constraints,

$$E = I^* (\tilde{\pi} - \bar{R} + 1) = I^* K^* \quad (36)$$

$$E = \hat{I} (\tilde{\pi} - \hat{R} + 1) = \hat{I} \hat{K}, \quad (37)$$

since  $\hat{R} < \bar{R}$  and the ex ante expected profit for bankers,  $\tilde{\pi}$ , are the same in the two supervisory regimes, it follows that  $\hat{I} < I^*$  and  $\hat{K} > K^*$ . Therefore the social cost of inefficient closure rules is a lower level of investment.

Comparing these results with those of Section 5 (orderly closure) we notice that the market spread there was  $\sigma(0) = \lambda \left( \frac{1}{p} - 1 \right)$  which is smaller than the interbank spread when gambling for resurrection cannot be prevented ( $\sigma(\beta_S)$  from equation 31) because of (29). Thus it is more likely that the CB can improve matters when GFR occurs. This implies that the less efficient supervision, the more likely that CB has a role to play in ELA. Or to put it differently, forbearance by banking supervisors makes the ELA by the CB more likely to be needed.

As a consequence, the conclusions of Proposition 3 carry over to an environment where gambling for resurrection cannot be prevented provided that we replace  $\sigma(0)$  by  $\sigma(\beta_S)$ . The interpretation though will be slightly different since now CB lending through the discount window will be justified not only for high  $\beta_N$  and low  $p$ , but also for high  $\beta_S$ . This comes from the fact that, absent bail-outs, the interbank market spread increases with the probability that a bank is insolvent. Collateralized CB loans would shift the losses on the DIF that would charge a higher premium than the one in (35) by the same argument of equation (25).

Once again, the less efficient bank supervision (the bigger  $\beta_S$ ) the more important is the role of the CB.

Notice that when incentives for orderly closure are not provided, separation of insolvent and illiquid banks does not take place, investment in the wasteful continuation of projects cannot be prevented, and in providing ELA the CB may end up lending to an insolvent bank as well.

## 7 Policy Implications and Conclusions

Our analysis allows us to make a number of policy recommendations. First, our study has implications for the optimal design of the interbank market. When market discipline is the most important feature of an efficient banking system, because it gives the bankers the incentives to screen their borrowers, the interbank market has to be unsecured and the LOLR may intervene in order to limit illiquid bank's excessive liquidation of assets. On the other hand, if market discipline is not required in the interbank market (as it is provided through another class of liabilities), a secured interbank market can reach the efficient allocation, either through a repo market or by making senior the interbank market claims. Notice, though, that the extreme market discipline position that advocates the no intervention policy of the LOLR is incompatible with our results, since potentially there is always the possibility that market discipline in the interbank market becomes crucial and the LOLR has to intervene.

Second, there are fundamental externalities between the CB, interbank markets and the banking supervisor. When supervision is not perfect, so that the insolvent bank cannot be detected, interbank spreads are high, and there should be a Central Bank acting as a LOLR. By contrast if supervision is efficient, interbank markets function well and the CB has only (if any) a limited role to play as a Lender of Last Resort.

Third, although we have abstracted from agency conflicts between the CB, the banking supervisor and the DIF, our model offers some indications about the optimal design of their functions. If the CB is not in charge of supervision (like in our model) there is no fear of regulatory capture. Furthermore the ability of the CB to shift losses from ELA on the DIF strengthens the incentives of the supervisor to detect and close insolvent banks. Our policy recommendation is therefore to have an independent CB providing ELA under specific circumstances and a separate supervisor acting on behalf of DIF who bears the losses in case of bank failure.

A fourth implication, connected with the previous point, is that the issue of the LOLR intervention leads to a wider set of issues. The consistent design of an efficient market for liquidity has to be based on the interaction between the following five regulatory instruments: interbank lending (secured or unsecured), closure policy, capital requirement, DIF premium, ELA lending terms. These instruments, although controlled by potentially different and independent institutions, should be designed in an integrated fashion.

Finally, the conditions for the access to ELA should be made known in advance to all interested parties, as already advocated in the "classical" view. This recommendation contrasts with the notion of "constructive ambiguity" often invoked to reduce the moral hazard allegedly associated with a CB safety net. On the contrary by making explicit ex ante that ELA will be structured to penalize insolvent banks ( $B_S < \beta_L B_L + \beta_N B_N$ ), provides bankers with the strongest incentives to reduce the probability of insolvency.

To summarize, the traditional doctrine of the Lender of Last Resort has been criticized on at least three important grounds. First, with modern interbank markets, it is not clear that the CB has a specific role to play anymore in providing emergency liquidity assistance to individual banks in distress. Second, it is not possible to distinguish clearly insolvent banks from illiquid banks. Third, the presence of a Lender of Last Resort may generate moral hazard by banks.

In this paper these three criticisms are taken into account. In particular we consider two different forms of moral hazard by banks: on the screening of borrowers (before loans are granted), on the monitoring (after loans are granted, but before they have been repaid), and we allow for gambling for resurrection by insolvent banks.

We explicitly introduce into our model efficient interbank markets that can also provide emergency liquidity assistance to the banks that have sufficient collateral or are ready to pay competitive credit market rates. Our first main finding is that there is a potential role for ELA by the CB but only during crisis periods, when market spreads are too high. In the other periods liquidity provision by the interbank market is sufficient. Second, the main superiority of the CB over the interbank lenders is that it can change the priority of claims, and therefore lend at lower rates than the market.

In the end, unlike its "classical" predecessor, the LOLR of the 21st Century lies at the intersection of monetary policy, supervision and regulation of the banking industry, and design of the interbank market. The issue is not "what are the rules the LOLR should follow?" but rather "what architecture for the liquidity markets?".

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## 8 Appendix

**Proof of Proposition 1.** It is obviously optimal to set  $B_S = 0$ . Then program  $(\wp^1)$  reduces to:

$$\min_{B_N, B_L} p(\beta_N B_N + \beta_L B_L) \quad (38)$$

$$p(\beta_N B_N + \beta_L B_L) \geq \frac{e_0}{\Delta\beta} \quad (39)$$

$$B_k \geq \frac{e_1}{p\delta}, \quad k = L, N. \quad (40)$$

The set of solutions depends on whether  $\frac{e_0}{\Delta\beta} < \frac{e_1}{\delta}$  or not. In the first case there is a unique solution:  $B_L = B_N = \frac{e_1}{p\delta}$ . In the second case any feasible couple  $B_L, B_N$  such that the first constraint is binding is a solution. For simplicity we focus on the particular solution  $B_L = B_N = \frac{e_0}{p\Delta\beta}$ .

**Proof of Proposition 2.** Denote with  $\gamma_i$ ,  $i = 1, 2, 3, 4$ , the Lagrange multipliers of the constraints of the program  $(\wp^2)$ . The Lagrangean becomes

$$\begin{aligned} \Lambda = & \tilde{\pi} - \gamma_1 \left( pB_N - \frac{e_1}{\delta} \right) - \gamma_2 \left( pB_L - \frac{e_1}{\delta} \right) - \gamma_3 (B_S - p_g \lambda [B_L - \lambda]) - \\ & \gamma_4 \left( \beta_N p B_N + \beta_L p B_L - \left( \frac{e_0}{\Delta\beta} + B_S \right) \right). \end{aligned} \quad (41)$$

Thus

$$\frac{\partial \Lambda}{\partial B_N} = (1 - \beta_S) \beta_N - \gamma_1 - \gamma_4 \beta_N = 0 \quad (42)$$

$$\frac{\partial \Lambda}{\partial B_L} = (1 - \beta_S) \beta_L - \gamma_2 - \gamma_4 \beta_L + \gamma_3 \lambda \frac{p_g}{p} = 0 \quad (43)$$

$$\frac{\partial \Lambda}{\partial B_S} = \beta_S - \gamma_3 + \gamma_4 = 0. \quad (44)$$

Using the last equation, we obtain  $\gamma_3 \geq \beta_S > 0$ . From the first equation we have  $\gamma_1 = (1 - \beta_S - \gamma_4) \beta_N \geq 0$ , implying  $\gamma_4 \leq 1$ . The second equation  $\gamma_2 = (1 - \beta_S - \gamma_4) \beta_L + \gamma_3 \lambda \frac{p_g}{p} \geq 0$ , entails  $\gamma_2 > 0$  since  $\gamma_3 > 0$ . Thus the corresponding inequalities are always binding:  $B_L = \frac{e_1}{p\delta}$ ,  $B_S = p_g \left[ \frac{e_1}{\delta p} - \lambda \right]$ .

Therefore

$$B_N = \max \left( \frac{e_1}{p\delta}, \frac{1}{p\beta_N} \left( \frac{e_0}{\Delta\beta} + B_S \right) - \frac{\beta_L}{\beta_N} B_L \right). \quad (45)$$

In other words there are two cases:

- a)  $\gamma_4 = 0, \gamma_1 > 0$ .  $B_N = \frac{e_1}{p\delta} = B_L$ ,  $B_S > 0$  since  $\lambda < \frac{e_1}{\delta p}$  and  $\rho = \ell$ .
- b)  $\gamma_1 = 0, \gamma_4 = 1$ .  $p(\beta_N B_N + \beta_L B_L) = \left( \frac{e_0}{\Delta\beta} + B_S \right)$ . This allows to determine  $B_N (> B_L)$ ,  $\rho > \ell$ .



After replacing  $B_L$ , condition  $\frac{e_1}{p\delta} > \frac{1}{p\beta_N} \left( \frac{e_0}{\Delta\beta} + B_S \right) - \frac{\beta_L}{\beta_N} \frac{e_1}{\delta p}$  is equivalent to  $\frac{e_1}{\delta} > \frac{e_0}{\Delta\beta} + B_S$ , where  $B_S = p_g \left[ \frac{e_1}{\delta p} - \lambda \right]$  thus proving Proposition 2.

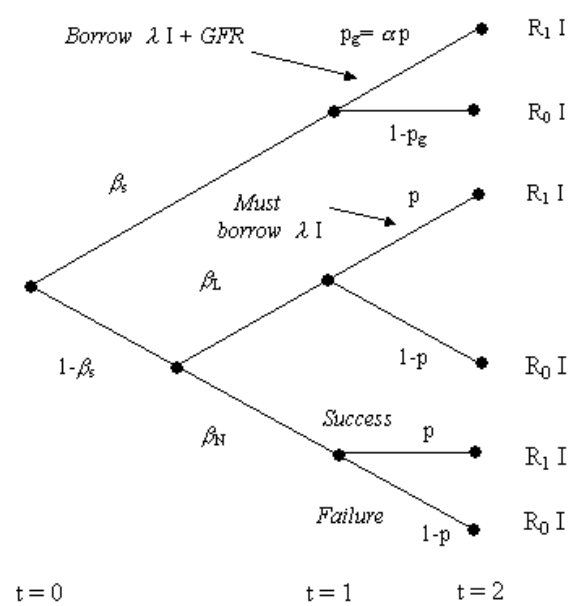


Figure 1: Events, Actions, Returns

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