THE LENDER OF LAST RESORT: A 21st CENTURY APPROACH[1]

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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 aggregate 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 in the absence of systemic threats. 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 in crisis periods; if instead, the main source of moral hazard is loan 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.

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) points out, the banks that require the assistance of the LOLR are already under suspicion of being insolvent.[1] 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.

These arguments are so convincing that the Bagehot view of the LOLR is often 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. 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.[2] 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 Goodfriend-King, and Goodhart's criticisms we are simply left with no theory of the LOLR interventions. The main objective of this paper is to build such a new theory taking into account bankers' incentive problems and imperfections of the interbank market.

An important motivation for ELA is the prevention of systemic risk. Systemic risk

[1]Furfine (2001a) provides empirical evidence of banks' reluctance to borrow from the FED discount window for fear of the stigma associated with it.

[2]The imperfection of the interbank market could be illustrated for the UK where the effect of 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 were technically insolvent.

refers to two distinct issues: contagion on the one hand, and macroeconomic risk on the other. There is a large literature on the LOLR policies when contagion is at stake, namely when there is the risk that problems at individual financial institutions may trigger widespread financial crises and potentially impact the money supply. See for example the recent studies by Flannery (1996) for contagion via the payments system, Gorton and Huang (2002b) on the origin of Central Banking in relation to bank panics, Kaufman (1991) on the historical evolution of LOLR policies, Allen and Gale (2000), Freixas, Parigi and Rochet (2000) on coordination failures, and the surveys by Freixas et al. (1999), and De Bandt and Hartmann (2002). A common theme is that public support to individual banks may be justified to prevent contagion despite the encouragement of excessive risk-taking that banks bailout may encourage.

In this paper we abstract from contagion, but we focus instead on the incentive aspects of ELA and ask under which macroeconomic conditions ELA by the CB should happen and how should it operate. By focusing on the incentive issues of ELA and 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 banks' assets. In periods of crisis when banks' assets are very risky, 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) when the CB has the power to change the priority of claims 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 correspond to two important banks' tasks: screening loan applicants on the one hand (screening moral hazard) and monitoring borrowers after loans are granted on the other (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 when one of the two will be prevailing. In the screening moral hazard the problem is to provide bankers with the incentive to put effort to screen loan applicants to lower the probability of insolvency. The cost of effort depends on how difficult it is to identify the sound firms to lend to, that is it 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, different costs of setting up a business, 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. The problem here is to provide banks with incentives to put effort to monitor the borrowers they have financed. It has been argued that market discipline may play this role. Our view is that financial markets will provide information and then banks will monitor firms on the basis of this information, thus providing additional discipline. Thus the pure market discipline case would be the one where there is no monitoring moral hazard, a case we fully discuss in the present work.

Our main findings are that the role of LOLR depends both on the nature of the incentive problems faced by the banks and on the macroeconomic conditions. When the main type of moral hazard is monitoring borrowers, i.e. when market discipline is insufficient, there is no reason to lend at a penalty rate to banks seeking liquidity; hence a fully secured interbank market allows to implement the efficient allocation. When, instead, the main source of moral hazard is screening loan applicants, then ELA should be made at a penalty rate to discourage insolvent banks to borrow as if they were only illiquid; thus 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 lends against the assets of the bank. It can thus offer a better rate than the interbank market, but at a cost to the DIF. This should take place in times of crisis when markets spreads 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. Thus ours is a theory of the LOLR in crisis periods even in the absence of contagion threats.

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 incentive to screen their loan applicants, the interbank market has to be unsecured and the LOLR may intervene in order to limit excessive liquidation of assets by illiquid banks. 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 an arbitrary resolution of this trade-off by considering the overall efficiency in terms of the total value added of the banking industry. Thus, not surprisingly, our framework provides, as a by product, a recommendation for 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 introduce gambling for resurrection, 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 the 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 $t = 0$ equity is raised, 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 Banks 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 Deposit Insurance Fund that guarantees all deposits. Deposit insurance is financed by actuarially fair premiums. 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 we may 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.[3]

[3]For an analysis of this issue see Repullo (2000) and Kahn and Santos (2001).

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

$$I + P = D + E. \tag{1}$$

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 shortage. Investment is subject to constant returns to scale, a standard assumption in this literature (see e.g. Diamond and Dybvig 1983) that greatly simplifies the problem as it will become clear later. The gross rate of return of the investment at $t = 2$ is $\tilde{R} = R_1$ in case of success and $\tilde{R} = R_0$ in case of failure, with $R_1 > 1 > R_0 > 0$.

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 $t = 1$;
- inefficient suspension and 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;

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 β_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 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 we assume to be proportional to bank assets, $\ell \equiv \lambda I$, with $0 < \lambda < 1$.[4] Even if liquidity is available at fair rates from date 1 to date 2, an illiquid bank that does not serve its deposit withdrawals at date 1 is forced to liquidate. The liquidation value of assets is $R_0 I$, the same as when the bank fails. Finally with unconditional probability $(1 - \beta_S)\,\beta_N$ (with $\beta_N + \beta_L = 1$) the bank is in state N (no shock).[5]

[4] Alternatively we could assume that withdrawals are proportional to deposits. This would introduce computational complexity without adding any insight.

[5] In reality liquidity and solvency schocks are positively correlated while in our model a bank is either illiquid or insolvent. An alternative modelling assumption is that banks can be hit by a liquidity shock and a solvency shock at the same time. This would introduce a fourth possibility where an insolvent bank may be illiquid. If this bank does not borrow λI it is forced to close. If it borrows λI, to stay in business, it has to use the loan to repay the impatient depositors and thus it cannot use it in the wasteful continuation of a project. Since nothing would change in our analysis as long as there is no aggregate shortage of liquidity, we maintain the assumption that there are three states of the world, i.e. the insolvent banks suffer no liquidity shock.

Although banks may hold reserves at date 0 it is in fact optimal for them not to do so for two reasons. First, there is no aggregate liquidity shock at date 1 and liquidity is available at fair rates.[6] Second, since the decision not to hold reserves is made when banks have no private information, it would not signal their type when they may seek liquidity at date 1.

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;
- 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) will affect bankers' profits and their incentives to screen and monitor their loans. As we noted below, and given our constant-returns-to-scale assumption, these incentives are determined by the expected profit rates of banks in different states. Let indeed $B_k^j \geq 0$ denote the expected profit rate[7] (i.e. per unit of investment) of the banker at date $t = 2$, after state $k = L, N$ 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[8] 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, $k = L, N$.[9]

The screening decision of the banker is modelled as follows: exerting the screening effort at time $t = 0$ costs the banker e_0 and improves the quality of the pool of loan applicants which limits the probability of a solvency shock to β_S. Absent the screening effort, the probability of a solvency shock is $\beta_S + \Delta\beta$, with $\Delta\beta > 0$. The banker will exert the screening effort (which we assume to be efficient)[10] if and only if his ex ante expected

[6] When instead aggregate liquidity is scarce, reserve holdings become important (see e.g. Bhatthacharya and Gale 1987).

[7] The formulas for these profit rates will be developed later, as a function of the different institutional arrangements that we consider.

[8] 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.

[9] Recall that in this paper we abstract from the analysis of contagion that may arise when a bank fails. Thus we assume that when an insolvent bank is closed at $t = 1$ or a bank fails at $t = 2$ $\left(\tilde{R} = R_0\right)$ there are no repercussions on the banking system as a whole.

[10] This is satisfied if e_0 is small and $\Delta\beta$ is large. See the precise conditions in equations (9) and (10) below.

profit from screening exceeds that without screening, namely;

$$\beta_S B_S + (1-\beta_S)\, p(\beta_N B_N + \beta_L B_L) - e_0 \geq (\beta_S + \Delta\beta)\, B_S + (1 - \beta_S - \Delta\beta)\, p\, (\beta_N B_N + \beta_L B_L) \tag{2}$$

which simplifies to

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

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 the monitoring effort at $t = 1$ (which we assume to be efficient)[11] costs the banker e_1 and ensures a probability of success of p of banks' investment. Absent the monitoring effort, the probability of success is only $p\,(1-\delta)$, with $0 < \delta < 1$. Monitoring effort increases the probability of success of banks' investments, because, for example, it limits the borrowers' scope for value reducing asset-substitution and profit diversion.

The banker will exert the monitoring effort after state k, $k = L, N$, if and only if

$$pB_k - e_1 \geq p\,(1-\delta)\, B_k, \tag{4}$$

which simplifies to

$$B_k \geq \frac{e_1}{\delta p}, \qquad (MH_1)\,. \tag{5}$$

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 the strength of market discipline.

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

$t=0$		$t=1$		$t=2$
contracts	screening	Liquidity/Solvency	monitoring	investment
offered;	effort choice,	shocks occur;	effort choice	return R_0, R_1
equity,	investment	closure/continuation	for solvent	
deposits	made	decision	banks	
raised				

2.4 Prudential regulation

In our model prudential regulation is justified on the ground that depositors cannot control the screening and monitoring activities of bankers. Regulation is there to ensure that

[11]This is satisfied if e_1 is small and δ is large. See the precise conditions in equations (9) and (10) below.

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 Deposit Insurance Fund) 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 bank) and the parameters characterizing investments and bankers' actions. It is important to understand what the regulators can do that other agents cannot. Regulators have the power to set capital requirements, deposit insurance premiums, grant potentially different profit rates for banks that declare their type, and revoke the licences to insolvent banks. Regulators have no information advantage with respect to other agents and their resources come only from fairly priced deposit insurance. We will show how these instruments allow regulators to provide the right incentive to bankers. At this stage, we don't discuss the implementation of the optimal contract between the FSA and the bankers. In particular we do not specify how banks' liquidity needs are financed at $t = 1$.

The need to provide incentives to bankers lowers the income that can be paid to depositors and thus imposes a constraint on the depositors' participation. Indeed, 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 project's expected rate of return at $t = 0$, has to be distributed among the two types of claim holders, the insured depositors and the bankers. The insured depositors are entitled to a net payoff $D - P$: deposits D offer zero remuneration but are insured for a fair premium P. To provide the bankers with appropriate incentives a minimum expected profit rate, $\bar{\pi} \equiv \beta_S B_S + p(\beta_L B_L + \beta_N B_N)(1 - \beta_S)$, must be granted to them. For the project to be able to pay to all its claim holders, we need therefore

$$I\bar{R} \geq \bar{\pi} I + D - P. \tag{6}$$

Replacing $D - P$ from equation (1) in equation (6) the resulting investor participation constraint (IP) for outside investors at $t = 0$ is

$$I\left(\bar{R} - 1\right) \geq \bar{\pi} I - E, \qquad (IP). \tag{7}$$

This constraint states that the expected net return on bank's assets, that is the social surplus (left-hand side of the inequality (7)) is at least equal to the expected increase in shareholder value (the right-hand side of inequality (7)), 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 banks 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,

$$\frac{E}{I} \geq K, \tag{8}$$

where $K \equiv \bar{\pi} + 1 - \bar{R}$ is the capital ratio which we assume to be positive.

It is worth pointing out that this formulation introduces an endogenous opportunity cost of capital. Any increase in the aggregate amount of equity ΔE, 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 $\Delta I \left(\bar{R} - 1\right)$.

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 shocks, a point we examine in Subsection 3.3.

We introduce here the structure of the problem to find 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. As we will see in the sequel, Central Bank lending is the institutional arrangement to implement the optimal allocation when supervision is not efficient and the CB can provide loans at better terms than the interbank market.

3.1 The optimal allocation when supervision is efficient

We focus on the case where it is optimal to induce the bank to screen applicants $t = 0$ and monitor them at $t = 1$. This is guaranteed by the conditions that the NPV of the bank's investment with (without) efforts at date 0 and at date 1 is positive (negative), namely

$$(\bar{R} - 1 - e_0 - (1 - \beta_S)e_1) > 0 \tag{9}$$

$$[(\beta_S + \Delta\beta) R_0 + (1 - \beta_S - \Delta\beta) (p (1 - \delta) R_1 + (1 - p (1 - \delta)) R_0)] < 0. \tag{10}$$

Conditions (9) and (10) are satisfied if e_0 and e_1 are small and δ (the increase in the probability of success) and $\Delta\beta$ (the reduction in the probability of solvency) are large. In this case the optimal allocation is obtained by maximizing the expected NPV of the bank's investment with efforts (LHS of equation 9) under the participation constraint of investors (IP) and the incentive compatibility constraints for the banker: (LL), and (MH).

Recall that constraint (IP) is equivalent to the capital adequacy requirement (8) while I does not appear in the three other constraints (due to our constant-returns-to-scale assumption). Therefore (8) is necessarily binding, $I = E/(\bar{\pi} + 1 - \bar{R})$ and the maximization of the expected NPV of banks investment can be split into a two-stage problem. Therefore the optimal allocation can be obtained by minimizing the bankers's ex ante expected profits rate $\bar{\pi}$ under the limited liability and the moral hazard constraints, solving the following program $(\wp^1)$; namely:

$$\min_{B_L,B_N,B_S} \ \bar{\pi} \text{ s.t.} \tag{11}$$

$$B_S \geq 0, \qquad (LL) \tag{12}$$

$$p\left(\beta_N B_N + \beta_L B_L\right) \geq \tfrac{e_0}{\Delta\beta} + B_S, \qquad (MH_0) \tag{13}$$

$$B_k \geq \tfrac{e_1}{p\delta}, \quad k = L, N, \qquad (MH_1)\,. \tag{14}$$

The solution of $(\wp^1)$ is characterized in the following proposition.[12]

Proposition 1. *When supervision is efficient, the optimal allocation specifies a zero profit rate for insolvent banks (state S) and the same positive 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 banks' shareholders, 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 λI (in order to repay unexpected withdrawals at $t = 1$) their profit rate in case of success at $t = 2$ is:

$$B_L = R_1 - \frac{(D - \lambda I) + \rho}{I} \tag{15}$$

where $D - \lambda I$ represents the repayment to the depositors who have not withdrawn at $t = 1$ and ρ is the repayment on the loan contracted at $t = 1$. 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:

$$\rho - \lambda I = \sigma\lambda I \tag{16}$$

where σ 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

$$B_N = R_1 - \frac{D}{I}. \tag{17}$$

Using relations (15), (16), (17) we see that $B_N - B_L = \sigma\lambda$.

[12] Notice that the limited liability constraint can only bind is state S, since constraint (MH_1) implies that $B_k > 0$ for $k = L, N$.

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. Thus we need to distinguish two conditions on the magnitude of the shocks. If the shocks are small with respect to the value of the asset that banks can pledge as collateral in the worst case scenario ($\lambda < R_0$) then the implementation of the optimal allocation need not imply any direct involvement of the DIF, since interbank loans could be either senior to deposits or fully collateralized. Shocks are likely to be small if the time horizon involved is short. Thus small shocks reflect the idea expressed by Padoa Schioppa (1999) 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". For example, in the U.S. discount window loans in a typical day amount to few hundred millions dollars.[13]

If the shocks are large ($\lambda > R_0$) loans cannot be fully collateralized. Thus the optimal allocation cannot be implemented unless interbank loans are guaranteed, e.g. by the DIF. Bailing out banks may cause losses and thus may require additional resources. The additional resources may be from the Deposit Insurance Fund thus increasing DIF premium and lowering the size of the investment or may involve taxpayer money if bank insolvency may cause contagion.

In reality, however, interbank loans are typically unsecured (Kane and Demirguc-Kunt 2001), for example when 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 B_L is reduced due to a credit risk spread; that is $B_L = B_N - \sigma\lambda$. However, because of the monitoring moral hazard constraint, B_L cannot be smaller than $\frac{e_1}{p\delta}$. 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.[14]

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 from (8)

$$K \leq \frac{E}{\bar{I}} \tag{18}$$

is chosen to coincide with the optimum so that

$$E = \left[\bar{\pi} - \bar{R} + 1\right] \bar{I} = \bar{K}\bar{I} \tag{19}$$

where $\bar{K}$ denotes the capital ratio that solves (18) with equality. The actuarially fair Deposit Insurance Premium is:

$$P = [\beta_S + (1-\beta_S)\,\beta_N\,(1-p)]\left[D - R_0\bar{I}\right] + [(1-\beta_S)\,\beta_L\,(1-p)]\left[D - (R_0+\lambda)\,\bar{I}\right]. \tag{20}$$

The bank's budget constraint at $t = 0$ (equation 1) together with (20) determines the values of P and D.

[13] However, they reached the level of $46 billion in the day after the 9/11 terrorist attacks (Bartolini and Prati 2003).

[14] Strictly speaking, when $\frac{e_1}{\delta} < \frac{e_0}{\Delta\beta}$, 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 ($\widetilde{R} = R_0$), 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 the additional feature (which we believe to be realistic) 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 2001b). 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 at date 1 insolvent banks can borrow the same amount of liquidity λI of illiquid banks and invest it without being detected. By assuming that insolvent and illiquid banks have the same liquidity demand we make it easier for an insolvent bank to mimic an illiquid one, and a as result, we give the regulators the harder case to handle. Recall that reserve management cannot be used to signal banks' type. 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.[15] However, we assume that an insolvent bank that continues to invest destroys wealth, i.e. its reinvestment has a negative expected NPV, $p_g (R_1 - R_0) < \lambda$. 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"

[15] Alternatively we could assume that the more the insolvent bank borrows and invests, the higher is the increase in its probability of success at date 2. Still it would be optimal for an insolvent bank to borrow exactly λI because any different amount reveals its type.

Savings and Loans during the U.S. S&L crisis in the 1980s.[16]

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 bailout of the insolvent bank. The rate of profit B_S of the banker, following a bailout, has to be at least equal to the expected profit obtained from engaging in gambling for resurrection. An insolvent bank that gambles for resurrection obtains 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 λI. Thus the profit rate from gambling for resurrection in case of success is $B_L - \lambda$, and the expected profit rate is $p_g (B_L - \lambda)$. Thus gambling for resurrection will be prevented if an insolvent bank obtains an expected profit rate at least equal to this value which introduces the new constraint:

$$B_S \geq p_g (B_L - \lambda), \qquad (GFR). \tag{21}$$

As we show in the sequel the possibility for an insolvent bank to gamble for resurrection creates an externality between the interbank market and the DIF.[17] Figure 1 summarizes the different possibilities in our model.

[Figure 1 about here]

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 contrast with the previous case of efficient supervision (where insolvent banks are detected and closed) bankers receive a strictly positive profit B_S even in the event of insolvency which 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.

To find the optimal contract we proceed as in the case of efficient supervision (subsection 3.1) observing that the binding capital adequacy requirement becomes

$$I \left(\bar{R} - 1\right) \geq \tilde{\pi} I - E \tag{22}$$

[16] 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.

[17] 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.

where the ex ante expected profit rate of the bankers

$$\tilde{\pi} \equiv \beta_S B_S + p\left(\beta_L B_L + \beta_N B_N\right)\left(1 - \beta_S\right) \tag{23}$$

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

$$\begin{aligned} &\min_{B_L, B_N, B_S} \tilde{\pi} \text{ s.t.} \\ &(LL), (MH_0), (MH_1), (GFR). \end{aligned} \tag{24}$$

Before establishing the optimal contract we have to impose conditions on the magnitude of the shock. Above we distinguished two cases depending on whether the shock exceeds the bank's assets in the worst case scenario. The presence of a GFR constraint introduces a new element: if the shock is large w.r.t. the cost of effort in relationship to the increase of the probability of success that it induces ($\lambda > \frac{e_1}{\delta p}$) the GFR constraint does not bind. Hence an insolvent bank will not find it convenient to gamble for resurrection, and the program $(\wp^2)$ has the same solutions as $(\wp^1)$. Therefore we concentrate on the case $\lambda < \frac{e_1}{\delta p}$.

We establish the following result.

Proposition 2. *If shocks are small* $\left(\lambda < \frac{e_1}{\delta p}\right)$ *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 the monitoring constraint binds (Case (a), $\frac{e_1}{\delta} \geq \frac{e_0}{\Delta\beta} + B_S$*) then bankers obtain the same profit rate whether or not they experience a liquidity shock:* $B_N = B_L = \frac{e_1}{p\delta}$.

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

Proof. See appendix.

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.

In the next Section we use the distinction between Case (a) and Case (b) to assess the potential role of the CB to implement the optimal allocation identified above when there is an interbank market that provides liquidity at fair rates at date 1.

5 Central Bank lending

5.1 Central Bank lending and interbank market

When market discipline is weak and thus the main regulatory concern is to induce bankers to monitor their loans at date 1 (Case (a)), there is no need to penalize a solvent but illiquid bank borrowing at date 1 ($B_N = B_L$). As a consequence the implementation of the efficient allocation is the same as when illiquid and insolvent banks can be identified (Section 3). Provided that interbank market loans are either senior or fully collateralized, the efficient allocation can be implemented by the interbank market without any need for CB intervention.

A novel set of issues arises instead when market discipline is so strong that the monitoring moral hazard constraint is redundant (Case (b)). The important problem here is to induce bankers to exert effort to screen loan applicants at date 0. To implement the efficient allocation under these conditions, date 1 loans to any bank, including the illiquid, will have to be set at a penalty rate, that is with a spread σ^* such that $B_N - B_L = \sigma^* \lambda$.

The need for a spread raises the issue of the feasibility of the efficient allocation under the presence of an interbank market and limits the role of the CB to situations in which the interbank market spread is higher than the CB spread. The interbank market spread is determined by the condition of zero expected return, that we denote $\sigma(\beta_S = 0)$ when the insolvent bank is bailed out.[18] Thus, only when the interbank spread and the optimal spread coincide ($\sigma(\beta_S = 0) = \sigma^*$) 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 cases, depending on whether the optimal spread exceeds the interbank spread $\sigma^* > \sigma(\beta_S = 0)$ or the opposite inequality holds.

In the first case, $\sigma^* > \sigma(\beta_S = 0)$, it is impossible for the CB to provide ELA at the optimal penalty rate σ^*.[19] Thus the potential role of the CB is limited to situations where the optimal spread is lower than the interbank market spread, $\sigma^* < \sigma(\beta_S = 0)$. The presence of an interbank market puts a limit to the power of the incentive scheme that the FSA can use to encourage bankers to exert screening efforts.

In summary, when the main type of moral hazard is monitoring (Case (a)), an fully secured interbank market allows to implement the efficient allocation. When, instead, the main source of moral hazard is screening (Case (b)), the interbank market should be unsecured and there may be a role for Central Bank lending.

5.2 The operational framework

Having established that the role of the CB is limited to situations in which screening loan applicants requires incentives and the interbank market spread is higher than the optimal

[18] For the computations of the spreads σ^* and $\sigma(\beta_S = 0)$ see the appendix.

[19] 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 at a penalty rate is desirable only to reduce the profits from GFR and therefore the cost of bailing out banks.

spread we now turn to the question of how the CB can implement the efficient allocation and undercut the interbank market. The CB can lend at better terms than the market because it can make loans collateralized by banks' assets. However, collateralized loans are possible only if $\lambda < R_0$, the condition we focus on. When the magnitude of the shocks is such that $\lambda > R_0$ collateralized loans cannot be made and the optimal allocation cannot be implemented.

In many countries there is a legal requirement that CB loans must be collateralized although what constitute eligible collateral varies substantially. The rationale for collateralized loans is to avoid that the CB becomes creditor of a failing bank, which, in turn, may result in charges against the capital of the CB or conflicts of interest when the CB becomes creditor of a regulated entity (Delston and Campbell 2002). The CB has thus the advantage over the interbank market in that it can override the priority of the DIF claims. Gorton and Huang (2002a) argue precisely that governments can improve upon a coalition of banks in providing liquidity only because 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 DIF is usually managed by a public agency or the banking industry itself (See Kahn and Santos 2001 and Repullo 2000).

Kaufman (1991) and Goodfriend and Lacker (1999) 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" (Goodfriend and Lacker 1999 p.14). Of course the risk is shifted onto the DIF.[20] In the Eurosystem all credit operations by the European System of Central Banks (ESCB) must be collateralized[21] with the ESCB accepting a broader class of collateral than the FED. Under the ELA arrangements, LOLR in the Eurosystem is conducted mainly at the National Central Banks (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 money supply 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.[22] Similarly, IMF loans enjoy a de facto preferred creditor status even if there is no legal basis for this condition.[23] On the contrary the Swiss National Bank follows the principle of

[20] See Sprague (1986 pp. 88-92) for an account of the resulting conflicts between FED and FDIC.

[21] Art 18.1 of the ECB/ESCB Statute (Issing et al. 2001).

[22] 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 to address the Y2K issue 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 previous 10 years. Similarly in the Eurosystem one of the main pillars of liquidity management is the Marginal Lending Facility which banks can access at their own discretion to borrow reserves at overnight maturity from the Eurosystem at penalty rates (Issing et al. 2001).

[23] See Penalver (2004) for a discussion of the issue and a model of the IMF's preferred creditor status to mitigate financial crises.

providing assistance to the market as a whole rather than to individual banks (Kaufman 1991). In the UK no formal authority offers guidance to the provision of ELA by the Bank of England (see the Memorandum of Understanding 1997), which, on its side stresses the need to follow a discretionary and not predictable approach.

5.3 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. *When loans can be collateralized ($\lambda < R_0$) if the screening constraint is binding, and if the optimal spread σ^* is lower than the interbank spread $\sigma(\beta_S = 0)$, then the CB can improve upon the unsecured interbank market solution by lending at a rate σ^* 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 illiquid bank's 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 gambling for resurrection. 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 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 λI 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.[24] Third, 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. Note that the type of ELA envisioned here 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 λI, the new DIF premium becomes

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

The premium in (25) exceeds that in (20), where gambling for resurrection is not an option, because I is smaller than in the case where the insolvent bank is detected. Fourth, remark that a fully secured interbank market would be here inefficient. In Case (b) the efficient solution requires a spread between B_N and B_L, $B_N = B_L + \lambda\sigma$; when $\sigma(\beta_S = 0) < \sigma^*$, banks would generate a lower surplus with collateralized loans than with the optimal spread σ^*.

[24] Notice that the N bank has no incentive to borrow λI 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.

The conditions on the size of the shocks play an important role in establishing an ELA by the CB. Small shocks may pose no contagion threats but make gambling for resurrection attractive thus blurring the distinction between illiquid and insolvent banks. However, only when shocks are small can all loans be collateralized which may allow the CB to implement the efficient allocation. The provision of ELA by the CB may thus be justified even in the absence of contagion. This is not to say that ELA by the CB should be ruled out when there are contagion concerns. But when shocks are large loans cannot be collateralized, hence the efficient allocation cannot be implemented and additional resources are needed to bail out insolvent banks.

Notice furthermore that making explicit ex ante the rules of ELA from the Central Bank and thus making explicit the profits that insolvent banks can receive if they accept an orderly closure is an effective way to deal with moral hazard and gambling for resurrection. This is to be contrasted with two pieces of conventional wisdom about CB intervention. On the one hand there is the notion that "constructive ambiguity" with respect to the conduct of the CB in crisis situations would reduce the scope for moral hazard. On the other hand there is the fear that a generous bailout policy hampers market discipline and generates moral hazard.

Our results show that this conventional wisdom may be oversimplified, and points out at the trade-off between the benefits of market discipline and the costs of gambling for resurrection. 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 $t = 0$ and imposes an additional cost to the DIF. However, since 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 ex ante incentive to exert effort at $t = 0$ to avoid being insolvent. 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 intact the bankers' incentive to screen. 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 volume of lending is reduced.

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. From a policy view point, this justifies a crisis resolution mechanism involving some kind of bailout of a failing bank. Such a mechanism has been advocated recently by Aghion et al. (1999), Mitchell (2001) and Gorton and Huang (2002a). 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. This is why we examine in Section 6 an alternative set of assumptions where such monetary transfers are ruled out.

5.4 When is Central Bank intervention useful?

Proposition 3 gives two conditions that characterize the role for ELA by the Central Bank in implementing the efficient allocation. These conditions require that the screening constraint be binding:

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

and that the interbank market spread be larger than the optimal spread, which, using equations (45) and (46) in the appendix, gives:

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

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

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

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 has to dominate the monitoring constraint; second β_N has to be large, or rather the probability of a liquidity shock $(1-\beta_N)$ has to be small,[25] 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 in times of economic downturn or a banking crisis. β_S is here irrelevant as the insolvent bank spontaneously declares bankruptcy.

The main conclusion of this Section is that the role of the CB as LOLR depends on several factors. First, a necessary condition for CB lending is inefficient supervision that fails to detect and close insolvent banks. A second requirement is that market discipline is so strong to make the monitoring moral hazard constraint redundant, but scarce ex ante information makes it difficult to screen sound projects. Third CB intervention is not needed during the expansionary phase of the cycle (p high). On the contrary the CB is necessary to provide ELA when the economy as a whole is in crisis because of the low probability of success of the investment (p low) and market spreads are high. Finally, the shock must be small w.r.t. to bank's assets so that CB loans can be collateralized.

6 Optimal allocation in the presence of gambling for resurrection

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 gambling for resurrection, which is not observed if the policy is successful. Regulatory forbearance may therefore result. This may happen for example if

[25] We also assume that α is small so that $\beta_N > \alpha$, in which case the third term in equation (28) decreases with p. This ensures that both conditions are satisfied when p is small enough.

the supervisors do not 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 gambling for resurrection cannot be avoided because the FSA is not allowed to bail out insolvent banks. We concentrate on the case $\lambda < R_0$.

Thus at $t = 1$ insolvent banks (which are not detected because supervisors are inefficient) do not have incentive to declare bankruptcy and thus they are not closed: they borrow λI 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 higher spread than in the case in which gambling for resurrection can be prevented (See the appendix for the calculations).

However, the efficient allocation is such that the profit rates of bankers in the different states are 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 gambling for resurrection. 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

$$\hat{R} = \beta_S [p_g R_1 + (1 - p_g) R_0 - \lambda] + (1 - \beta_S)(p R_1 + (1 - p) R_0). \tag{29}$$

To find the optimal solution we proceed as in program $(\wp^2)$ observing that the binding capital adequacy requirement becomes

$$I\left(\hat{R} - 1\right) = \tilde{\pi} I - E \tag{30}$$

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.*

Several comments are in order. Like in the case where gambling for resurrection 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 gambling for resurrection occurs is

$$P = [\beta_S (1 - p_g) + (1 - \beta_S) \beta_N (1 - p)] [D - R_0 I] + [(1 - \beta_S) \beta_L (1 - p)] [D - (R_0 + \lambda) I]. \tag{31}$$

We now compare the capital ratio and the investment level under orderly closure (Section 5), K^*, I^* and in the interbank market solution, $\hat{K}, \hat{I}$ with gambling for resurrection. From the capital adequacy requirement constraints,

$$E = I^* \left(\tilde{\pi} - \bar{R} + 1\right) = I^* K^* \tag{32}$$

$$E = \hat{I} \left(\tilde{\pi} - \hat{R} + 1\right) = \hat{I} \hat{K}. \tag{33}$$

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 we notice that the market spread there was $\sigma(\beta_S = 0)$ which is smaller than the interbank spread when gambling for resurrection cannot be prevented $\sigma(\beta_S > 0)$ (See the appendix for the calculations). Thus it is more likely that the CB can improve matters when gambling for resurrection occurs. This, in turn, 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 $\sigma(\beta_S = 0)$ by $\sigma(\beta_S > 0)$. The interpretation though will be slightly different since now CB lending through the discount window will be justified not only for high β_N and low p, but also for high β_S. This comes from the fact that, absent bailouts, the interbank market spread increases with the probability that a bank is insolvent. Collateralized CB loans would shift the losses onto the DIF that would charge a higher premium than the one in (31) by the same argument of equation (25). Once again, the less efficient bank supervision (the bigger β_S in this case) 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 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 not perfect and bankers must be given incentives to screen their loan applicants, the interbank market has to be unsecured and the LOLR may intervene in order to limit the excessive liquidation of assets by illiquid banks. On the other hand, if market discipline is quite strong because the financial markets provide information, a secured interbank market can reach the efficient allocation, either through a repo market or by making senior the interbank market claims.

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 onto the DIF strengthens the incentive 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 the DIF who bears the losses in case of banks' failure.

A fourth implication, connected with the previous point, is that the analysis 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 policy instruments: interbank lending (secured or unsecured), closure policy, capital requirement, Deposit Insurance premiums, ELA lending terms. These instruments, although they have to be controlled by different and independent institutions, should be designed in an consistent 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 incentive 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 the banks.

In this paper these three criticisms are taken into account. Moreover we consider two different forms of moral hazard by banks: on the screening of applicants (before loans are granted), on the monitoring of borrowers (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 main finding is that there is a potential role for ELA by the CB but only when the following conditions are satisfied: supervision is inefficient so that insolvent banks are not detected; it is very costly to screen sound firms; interbank market spreads are high which happens during crisis periods. Our model offers a theory of ELA in crisis periods even in the absence of contagion. The main superiority of the CB over the interbank lenders stems from its ability to change the priority of claims, and therefore lend at lower rates than the interbank market. When banks do not have sufficient collateral to post, ELA requires additional resources which strengthens the case for an integrated design of regulatory instruments and ELA.

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 provision to banks?".

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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:

$$\min_{B_N, B_L} p\left(\beta_N B_N + \beta_L B_L\right) \tag{34}$$

$$p\left(\beta_N B_N + \beta_L B_L\right) \geq \frac{e_0}{\Delta\beta} \tag{35}$$

$$B_k \geq \frac{e_1}{p\delta}, \qquad k = L, N. \tag{36}$$

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 constraint (35) 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 γ_i, $i = 1, 2, 3, 4$, the Lagrange multipliers of the constraints of the program $(\wp^2)$. The Lagrangean becomes

$$\Lambda = \tilde{\pi} - \gamma_1\left(pB_N - \frac{e_1}{\delta}\right) - \gamma_2\left(pB_L - \frac{e_1}{\delta}\right) - \gamma_3\left(B_S - p_g\left[B_L - \lambda\right]\right) -$$
$$\gamma_4\left(\beta_N pB_N + \beta_L pB_L - \left(\frac{e_0}{\Delta\beta} + B_S\right)\right). \tag{37}$$

Thus

$$\frac{\partial\Lambda}{\partial B_N} = (1 - \beta_S)\beta_N - \gamma_1 - \gamma_4\beta_N = 0 \tag{38}$$

$$\frac{\partial\Lambda}{\partial B_L} = (1 - \beta_S)\beta_L - \gamma_2 - \gamma_4\beta_L + \gamma_3\frac{p_g}{p} = 0 \tag{39}$$

$$\frac{\partial\Lambda}{\partial B_S} = \beta_S - \gamma_3 + \gamma_4 = 0. \tag{40}$$

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 $\gamma_2 = (1 - \beta_S - \gamma_4)\beta_L + \gamma_3\frac{p_g}{p} \geq 0$, entails $\gamma_2 > 0$ since $\gamma_3 > 0$. Thus the corresponding inequalities are always binding: $B_L = \frac{e_1}{p\delta}$,

$$B_S = p_g\left[\frac{e_1}{\delta p} - \lambda\right]. \tag{41}$$

Therefore

$$B_N = \max\left(\frac{e_1}{p\delta}, \frac{1}{p\beta_N}\left(\frac{e_0}{\Delta\beta} + B_S\right) - \frac{\beta_L}{\beta_N}B_L\right). \tag{42}$$

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 $(B_N > B_L)$, $\rho > \ell$.

After replacing

$$B_L = \frac{e_1}{p\delta} \tag{43}$$

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 $\frac{e_1}{\delta} > \frac{e_0}{\Delta\beta} + B_S$, thus proving Proposition 2 and determining

$$B_N = \frac{1}{p\beta_N}\left(\frac{e_0}{\Delta\beta} + p_g\left[\frac{e_1}{\delta p} - \lambda\right]\right) - \frac{\beta_L}{\beta_N}\frac{e_1}{p\delta} \tag{44}$$

Calculations of interest rate spreads

Orderly closure

In Case (b), $B_N > B_L$ implies that loans must be made with an interest rate spread σ^* which can be computed from $(44), (43)$:

$$B_N - B_L = \sigma^*\lambda = \frac{1}{p\beta_N}\left(\frac{e_0}{\Delta\beta} + \frac{e_1}{\delta p}(p_g - p) - p_g\lambda\right). \tag{45}$$

The interbank market spread when loans are not fully collateralized is determined by the condition of zero expected return. Denoting with ρ the repayment on the loan λI, the condition of zero expected return in the case that insolvent banks are bailed out $(\beta_S = 0)$ is

$$\rho p + (1-p) R_0 = \lambda I$$

implying a spread

$$\sigma(\beta_S = 0) = \frac{\rho}{\lambda I} - 1 = \frac{\lambda I - (1-p) R_0}{p\lambda I} - 1. \tag{46}$$

Gambling for resurrection

Since $p_g < p$ the probability of repayment of an interbank loan when gambling for resurrection cannot be prevented (p_{GFR}) is smaller than in the case in which GFR can be prevented (p), namely

$$p_{GFR} \equiv \frac{\beta_S p_g + (1-\beta_S)\beta_L p}{\beta_s + (1-\beta_S)\beta_L} < p. \tag{47}$$

Thus the repayment ρ_{GFR} required at the equilibrium of the interbank market is obtained from the zero expected profit constraint

$$\rho_{GFR} p_{GFR} + (1 - p_{GFR}) R_0 = \lambda I \tag{48}$$

implying a spread

$$\frac{\rho_{GFR}}{\lambda I} - 1 = \frac{\lambda I - (1 - p_{GFR}) R_0}{\lambda I p_{GFR}} - 1 \equiv \sigma(\beta_S > 0) \tag{49}$$

which is increasing in β_S. When $p = p_g$, the market spread is independent of β_S; $\sigma(\beta_S > 0) = \sigma(\beta_S = 0)$. Because of (47) it follows that $\sigma(\beta_S > 0) > \sigma(\beta_S = 0)$.

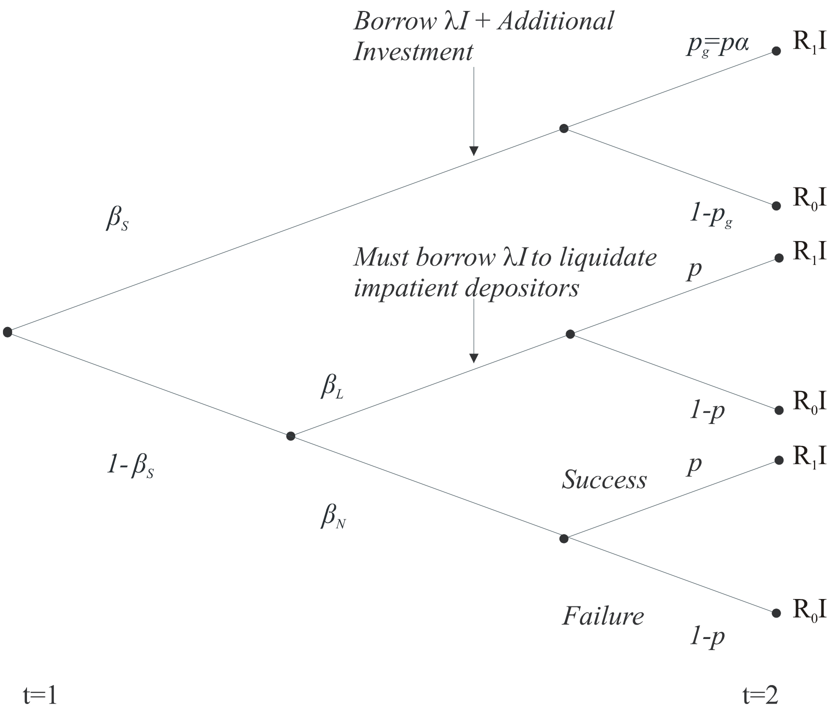

Figure 1: **Events, Actions, Returns**. The picture describes the events, the actions and the returns when bankers exert effort to screen and to monitor and no early liquidation takes place. Notes: β_S = probability of a solvency shock; β_N = probability of no shock for solvent banks; $\beta_L = 1 - \beta_N$ probability of a liquidity shock for solvent banks; R_1 = investment return in case of success; R_0 = investment return in case of failure; p = probability of success for solvent banks; p_g = probability of success for insolvent banks that gamble for resurrection; λ = size of shock; I = investment size.