

Lender of Last Resort Policy: What Reforms are Necessary?[☆]

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Abstract

The Northern Rock bail out has raised concerns about the ability of current supervisory systems to deal with banking crisis. This paper provides a formal model of a lender of last resort. I derive the optimal policy, extract policy implications and thereby suggest reforms to the current arrangements in the United Kingdom.

JEL classification numbers: G21, G28.

Key words: Lender of last resort policy, central bank, deposit insurance, banking supervision, Northern Rock crisis.

1. Introduction

In September 2007 the United Kingdom suffered from the first bank run on a British bank in more than 140 years.¹ Northern Rock, a large mortgage lender in the UK, had been suffering from liquidity problems since financial and interbank markets dried up in July 2007. When depositors knew, on the evening of Thursday 13 September 2007, that Northern Rock had asked the Bank of England for emergency financial support, they started to form queues outside the bank's branches to withdraw their savings. Public intervention

[☆]The views expressed herein are those of the author and do not necessarily represent the views of the institutions to which he is affiliated.

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¹The previous bank run in the United Kingdom took place in May 1866 at the time of the collapse of Overend, Gurney & Co.

in the form of last resort loans was confirmed the following day.² The bank run was only stopped on 20 September 2007 when the Treasury reassured account holders that all their deposits were guaranteed by the government. Finally, the bank was nationalized in February 2008.

The Northern Rock crisis has raised concerns about the efficiency of banking regulation³ in the United Kingdom. The report by the Treasury Committee of the UK House of Commons (hereafter House of Commons 2008) gives an overview of these concerns. In summary, the report expresses concerns about the failure of the Financial Services Authority (the financial supervisor) to prevent the problems that have come to the forefront since August 2007; and about imperfections on the Financial Services Compensation Scheme (the deposit insurer) that may explain the bank run.⁴ A second type of concern, which is the focus of this paper, is about the efficiency of the arrangements to manage banking crises.⁵

The purpose of this paper is to derive the optimal lender of last resort policy to deal with liquidity problems in individual banks. I provide a formal model in which different bank regulators may perform the lender of last resort function (which is a feature of a large number of countries around the

²On 14 September 2007 it was “confirmed that the Bank [of England], in its role of lender of last resort, stood ready to make available facilities, both to Northern Rock and to other institutions that might face short-term liquidity difficulties in comparable circumstances, for the duration of the current period of market turbulence.” ([Bank of England, 2007](#), p.11) Approximately £25 billion (or 100 percent of the bank’s deposits) were lent to Northern Rock.

³I use the term “banking regulation” in a broad sense. It includes not only formal rules but also banking supervision, deposit insurance and lending of last resort.

⁴The Financial Services Compensation Scheme offered a limited guarantee to depositors: it insured up to £31,700 per depositor (the coverage was extended up to £35,000 in October 2007). Moreover, “the Financial Services Compensation Scheme could take months, maybe years, to reimburse the depositors of a large failed institution.” ([House of Commons, 2008](#), Paragraph 240) Finally, depositors might be unaware of the existence of the deposit insurance scheme because bank failures have been a rare event in the UK in recent times.

⁵The current arrangements establish that the management of a financial crisis relies on a Tripartite Standing Committee integrated by the HM Treasury, the Bank of England and the Financial Services Authority ([HM Treasury et al., 2006](#), paragraphs 14 to 16). According to [House of Commons \(2008\)](#), “We cannot accept, ..., that the Tripartite system operated ‘well’ in this crisis....for a run on a bank to have occurred in the United Kingdom is unacceptable, and represents a significant failure of the Tripartite system.” (Paragraph 276)

world). I also derive policy implications and thereby suggest reforms to the current arrangements in the United Kingdom. In the model, bank regulators may have different opinions on whether or not to support an illiquid bank. One reason for this is that the deposit insurer has to liquidate the bank and compensate depositors if the bank fails but neither the central bank nor the bank supervisor has such liability. Another reason is that the bank supervisor tries to avoid the political costs of bank failures; thus the supervisor prefers that illiquid banks be bailed out.⁶ Policy makers will allocate the lender of last resort responsibilities to the regulator whose lending decision maximizes expected social welfare. This allocation may be contingent on the size of the bank's liquidity shortfall because this information is assumed to be verifiable.⁷ I find that the (second-best) optimal institutional allocation of the lender of last resort responsibilities is characterized as follows: for small liquidity shortfalls the central bank should be the lender of last resort, while for large shortfalls the illiquid bank should always be supported.

The intuition for this result is the following. The deposit insurer is concerned with downside risk only. It disregards the upside potential for profits that the survival of the bank may imply. Consequently, the deposit insurer is biased towards liquidation and policy makers will prefer to bail out illiquid banks in order to avoid too many bank closures. This policy is not optimal in all situations, however. The central bank's expected loss from lending to an illiquid bank increases in the size of the loan. For this reason, the central bank, in providing a last resort loan, will always require a positive level of solvency that is increasing in the size of the bank's liquidity shortfall. The central bank is always tougher than the bank supervisor (who prefers to bail out banks). However, the central bank will be softer than the deposit insurer (i.e., the central bank will be willing to lend to less solvent banks than the deposit insurer) if the liquidity needs of the troubled bank are small. Consequently, the central bank's lending decision will be the closest to the first-best, and policy makers should allocate the lending of last resort responsibilities to it, for small liquidity shortfalls.

⁶The inclination of bank supervisors towards forbearance is well documented. For example, it is identified as one of the causes of the savings and loan debacle in the 1980s in the United States (see [Benston and Kaufman, 1997](#), and the references therein).

⁷The model in this paper is inspired by [Dewatripont and Tirole's \(1994\)](#) incomplete contracts model (see also [Aghion and Bolton, 1992](#)). Following this literature, the allocation of control can be contingent on any information that is verifiable.

The optimal institutional allocation of the lender of last resort responsibilities may encourage bankers to manipulate their banks' liquidity needs in order to be unconditionally supported. Indeed, bankers have a broad set of mechanisms to propel their bank's liquidity shortfalls.⁸ I show that if policy makers commit to penalize those bankers whose banks receive support in large amounts (e.g., by applying corrective actions on the bank that are costly to the banker), then bankers will take measures to prevent the occurrence of big liquidity problems.

If the central bank's last resort loans are guaranteed (i.e., if the central bank is a senior creditor), it will be willing to support all illiquid banks. This suggests a natural manner to implement the optimal policy: the central bank should act as lender of last resort, the deposit insurer should guarantee those central bank's loans that exceed a pre-specified threshold and the provision of such loans should trigger corrective actions on the bank to be applied by the supervisory authorities. These regulatory arrangements highlight the links among bank regulators in modern economies. Two reasons justify the election of the deposit insurer as guarantor of central bank's large loans. First, it reduces taxpayers' exposure and makes more transparent the way in which losses are distributed because, generally, deposit insurance schemes are financed by the banking industry. Second, the deposit insurer receives incentives to improve the deposit insurance scheme.

This paper's results imply that the Bank of England should take the decision of supporting illiquid banks. This suggests a first reform to the current arrangements for banking regulation in the United Kingdom because they imply that lending of last resort decisions should be taken by the Tripartite

⁸For example, "The high-risk, reckless business strategy of Northern Rock, with its reliance on short- and medium-term wholesale funding and an absence of sufficient insurance and a failure to arrange standby facility or cover that risk, meant that it was unable to cope with the liquidity pressures placed upon it by the freezing of international capital markets in August 2007." ([House of Commons, 2008](#), paragraph 31) Another possibility is available to bankers because depositors may react strategically to the information coming to them. According to [House of Commons \(2008\)](#), "Before the provision of emergency liquidity assistance by the Bank of England to Northern Rock could be announced formally, the outlines of the operation were reported by the BBC Several witnesses argued that the premature disclosure of the support operation in this way was instrumental in the run that followed." (Paragraph 147) The question is whether insiders to Northern Rock used this channel; but it is clear that premature disclosure of "bad" news had big effects on the size of the bank's liquidity needs and on the response by the government.

Standing Committee integrated by the HM Treasury, the Bank of England and the Financial Services Authority ([HM Treasury et al., 2006](#), paragraphs 14 to 16). A second reform should give the Financial Services Authority the responsibilities of running the deposit insurance scheme and guaranteeing large (relative to the size of the bank) Bank of England last resort loans. Since the Financial Services Authority will be economically liable if a large liquidity shortfall occurs (in its role as deposit insurer), it will have incentives to act promptly in order to avoid its occurrence (in its role as supervisor). A third group of reforms should set the basis for supervisory corrective actions triggered by the provision of large last resort loans, and should introduce changes in the deposit insurance scheme to improve its efficiency.

This paper builds on the previous literature on the institutional allocation of bank regulatory powers, borrowing extensively from its insights.⁹ The papers most closely related to this are by [Repullo \(2000\)](#), who employs the same incomplete contracts approach (inspired by [Dewatripont and Tirole, 1994](#)) as I do to study the allocation of the lender of last resort responsibilities between the central bank and the deposit insurer, and by [Kahn and Santos \(2005; 2006\)](#), who extend Repullo’s framework to analyze the allocation of supervisory responsibilities and the incentives of bank regulators to share information. This paper works with Repullo’s framework, extends it in several key respects and reaches different conclusions. Repullo considers allocating the lender of last resort responsibilities to either the central bank or the deposit insurer, who will then decide whether to support an illiquid bank. He finds that the central bank should be the lender of last resort if liquidity shortfalls are small, and that such responsibilities should be transferred to the deposit insurer if liquidity shortfalls are large. I also consider the opinion of the bank supervisor, who will always prefer to support illiquid banks in order to avoid the political costs of bank failures, and show that the use of this “unconditional bailout rule” is socially desirable when liquidity

⁹See [Bagehot \(1873\)](#) and [Thornton \(1802\)](#) on the “classical” justification for allocating the lender of last resort activity to central banks; [Freixas et al. \(2000; 2004\)](#) and [Rochet and Vives \(2004\)](#) on the rationale for public intervention in the form of a lender of last resort policy based on interbank market failures arising from asymmetry of information; [Diamond and Dybvig \(1983\)](#) on the role of demand deposits and deposit insurance; [Rochet \(2004\)](#) on the optimal organization of banking regulation in the presence of macroeconomic shocks; and [Freixas et al. \(1999\)](#), [Freixas and Rochet \(2008, pp. 242-248\)](#) and [Santos \(2006\)](#) for surveys of the literature.

shortfalls are large. In contrast with Repullo, and Kahn and Santos who assume that bankers are passive agents, I assume that bankers play an active role to determine the magnitude of their banks' liquidity problems. Then, I show that for the lender of last resort policy to be efficiently implemented it has to be complemented by corrective actions on the bank to be applied by the bank supervisor.

The next section describes the basic model setup. Section 3 characterizes the optimal lender of last resort policy and derives policy implications. Section 4 discusses the robustness of the results and potential extensions. Finally, Section 5 concludes with a brief summary and suggestions to reform current arrangements in the United Kingdom. Technical proofs can be found in the Appendix.

2. The Basic Model

2.1. Agents, Technology, Shocks and Information

The model has three types of agents: depositors, a banker, and bank regulators. All agents are risk neutral. There are four dates, labeled 0, 1/2, 1, and 2. There is no time discounting.

There is a continuum of depositors. At date 0, they make demand deposits on a commercial bank. Deposits can be withdrawn at either date 1 or date 2 and are fully insured by a deposit insurer. For simplicity, the interest rate paid on deposits is assumed to be zero.

The commercial bank is run by the banker. The “banker” category includes not only bank managers but also the board of directors and shareholders. I neglect the agency problem between bank managers and other stakeholders to focus on the distinction between the economic institution (i.e., the bank) and the person, or group of people, running it (i.e., the banker). This distinction is important because, under some circumstances, it may be efficient to control bankers' incentives by committing to penalize them (e.g., by applying corrective actions that are costly to the banker) rather than by using the socially more costly bank closure policy.¹⁰

Banking regulation is defined in a broad sense. It includes not only formal rules but also supervision, deposit insurance and lending of last resort. The deposit insurance function is carried out by a deposit insurer. It is funded

¹⁰I am grateful to Javier Suarez for making this suggestion.

by banks through deposit insurance premiums. For simplicity, the flat-rate deposit insurance premium is normalized to zero.¹¹ Banking supervision (i.e., the responsibilities of gathering private information from banks and applying corrective actions to them) can be allocated either to the deposit insurer, to the central bank or to an exclusive-purpose supervisor. Any of these regulators may be in charge of the lending of last resort responsibilities (i.e., to decide whether to support or not illiquid banks and eventually to fund the operation). The central bank is a natural source of liquidity. The deposit insurer has either sufficient liquid funds or is able to borrow from the central bank. Even though the bank supervisor does not have the financial capacity to fund last resort loans, she may decide whether an illiquid bank should be supported; then, other agency (e.g., the central bank) provides the loan.

At date 0, the banker has access to an illiquid, risky investment technology (e.g. bank loans). It yields a binomial, random return \tilde{R} at date 2: either loans succeed, $\tilde{R} = R$, or fail, $\tilde{R} = 0$. Bank loans are ex ante profitable: $E(\tilde{R}) > 1$. There is no market for the bank's assets at date 1; asymmetry of information implies that the bank has no access to the interbank market.¹² However, the deposit insurer can liquidate the bank at this date, in which case the liquidation value of the assets is $L \in (0, 1)$. For simplicity, I assume that the bank has no capital¹³ and that its size (i.e., the amount of deposits it collects) is equal to 1.

A bank failure (i.e., if $\tilde{R} = 0$ at date 2 or if the bank is liquidated at date 1) generates social costs c . They include, for example, bankruptcy costs and the costs imposed by contagion effects on other banks, by the breaking-up of valuable lender-borrower relationships and by the disruption in the payment system. I assume that c is smaller than $(1 - L)/L$.

The bank is subject to two sorts of shocks: a shock to liquidity demand by

¹¹Section 4.3 shows that the introduction of a deposit insurance premium in the range in which it is frequently observed in practice (i.e., less than 1 percent of insured deposits) will not affect the qualitative results.

¹²Investors in the interbank market may face a “coordination failure” which implies that some solvent banks would not find liquidity in it. [Rochet and Vives \(2004\)](#) and [Freixas et al. \(2004\)](#) argue that public intervention in the form of a lender of last resort policy has its rationale in this market failure.

¹³Section 4.2 presents an extension to the basic model in which the bank holds a positive amount of capital and shows that this assumption does not affect the results.

its depositors and a shock on the probability of success of its loans. At date 1 a fraction $v \in [0, 1]$ of the deposits are withdrawn. Deposit withdrawals are stochastic: v is a realization of a random variable \tilde{v} with cumulative distribution function G . v is assumed to be publicly observable and verifiable at date 1. I will focus on those situations in which the intervention of a lender of last resort is necessary by assuming that the bank holds no liquid reserves (i.e., the bank invests all deposits in illiquid loans). Thus, the banker has to ask for a last resort loan to honor the deposits that are withdrawn at date 1; otherwise, her bank will go (maybe inefficiently) bankrupt.

In contrast with [Repullo \(2000\)](#) and [Kahn and Santos \(2005\)](#), who assume that the banker is a passive agent, I assume that the banker plays an active role. Bankers have a broad set of mechanisms to influence the size of their banks' liquidity shortfalls. For example, by choosing a reckless, and absent of sufficient insurance and standby facilities to cover liquidity risk business strategy, bankers make their banks very prone to suffer from large shortfalls. Moreover, the fact that depositors acquire the information that a bank is (or will be) in trouble may encourage the withdrawal of deposits and make big liquidity shortfalls more likely.¹⁴ Consequently, bankers may propel their banks' liquidity needs by disclosing negative information about the future of their banks (see footnote 8). We model these possibilities in reduced form by assuming that the banker privately chooses the cumulative distribution function G from the set $\mathcal{G} \equiv \{G_b, G_m\}$, where G_m (the distribution function under manipulation) dominates G_b (the baseline distribution function) in the sense of first-order stochastic dominance.

The bank is also subject to a shock on the profitability of its loans. As of date 1/2, the probability with which they will succeed at date 2 (i.e., $\tilde{R} = R$) is $u \in [0, 1]$, which is assumed to be a realization of a random variable \tilde{u} with cumulative distribution function F . This solvency signal u is privately observed by the banker and by bank regulators through supervision. However,

¹⁴The fact that deposits are fully insured by a deposit insurance scheme does not preclude the occurrence of strategic withdrawals. The Northern Rock crisis presents a clear example. According to [House of Commons \(2008\)](#), "Under the current system, where depositors' funds can be tied up for months upon the failure of a financial institution, depositors have a clear and strong incentive to join a bank run and withdraw their deposits. This incentive would remain, even if depositors were guaranteed eventually to receive 100% of all of their deposits, if the inconvenience of being unable to access savings for prolonged periods is not tackled." (Paragraph 201)

it is non-verifiable by third parties because it may be based on confidential information and it may contain subjective judgements about the quality of the bank's assets. This assumption is crucial to the analysis because, following the literature on incomplete contracts (in particular, [Aghion and Bolton, 1992](#); [Dewatripont and Tirole, 1994](#)), the lender of last resort policy cannot be ex ante specified as a function of the solvency signal u . It can be made contingent on the size of the liquidity shortfall v , however.

2.2. Timing

The timing unfolds as follows:

Date 0.

- The lender of last resort policy is designed.
- The banker collects 1 unit of deposits and invests them in illiquid, risky loans.

Date 1/2.

- The banker and bank regulators observe the solvency signal u .
- The banker decides whether to manipulate the liquidity shortfall (i.e., she chooses $G = G_m$) or not to manipulate it (i.e., she chooses $G = G_b$).

Date 1.

- The liquidity shortfall v is publicly observable and verifiable.
- The lender of last resort policy is applied. If the bank obtains liquidity in the form of a last resort loan, it will remain open. Otherwise, the deposit insurer liquidates the bank's assets and reimburses depositors.

Date 2.

- Conditionally on continuation, bank's assets payoff. If the bank fails (i.e., if $\tilde{R} = 0$), the deposit insurer reimburses depositors.

2.3. The Objectives of Bank Regulators

Bank regulators may be confronted with complex incentive structures. First, bank regulators may have budgetary responsibilities. Second, a bank failure is likely to have political costs for regulators. To capture these ideas in a simple way I assume that a regulator's utility function is

$$U = I - \mathbf{1}_{\{failure\}}C,$$

where I is the expected value of the regulator's net income, $\mathbf{1}_{\{failure\}}$ is equal to 1 if the bank fails and zero otherwise, and C is the regulator's political cost of bank failure. Regulators may incur different political costs: the central

bank incurs a fraction $\alpha \in (0, 1)$ of the social cost c (i.e., $C_{CB} = \alpha c$), the deposit insurer incurs a fraction $\beta \in (0, 1)$ of c (i.e., $C_{DI} = \beta c$), and the bank supervisor incurs a fraction $\gamma \in (0, 1)$ of c (i.e., $C_S = \gamma c$).

2.4. Policy Instruments

I define the set of policy instruments available for policy makers in a broad sense. As in [Repullo \(2000\)](#) and [Kahn and Santos \(2005\)](#), it includes the allocation of the lender of last resort responsibilities to either the central bank or the deposit insurer.

I enlarge this set by considering two more instruments. First, I also consider the lending of last resort decision of the bank supervisor. Second, many regulatory arrangements specify a series of triggers to increase the efficiency of banking regulation (e.g., “prompt corrective actions” in the United States). In the aftermath of the Northern Rock crisis many UK policy makers visualized the request for emergency liquidity assistance as a trigger for supervisory intervention. I allow for this possibility. More precisely, I assume that the provision of a last resort loan may trigger corrective actions on the bank (e.g., banker demotion: to fire bank managers and to take over the bank from incumbent shareholders) to be applied by the bank supervisor.¹⁵

3. The Optimal Lender of Last Resort Policy

3.1. Date 1: Lending Decisions

I start analyzing the behavior of bank regulators when deciding whether to support an illiquid bank.

Benchmark. The socially optimal (first-best) lending decision is derived by maximizing expected social welfare under the assumption that both the liquidity shortfall v and the solvency signal u are verifiable. Given the liquidity

¹⁵The application of corrective actions to demote incumbent bankers has not been a rare practice on the resolution of troubled banks. For example, such actions were used on the resolution of Continental Illinois (a wholesale funded bank in the United States) in 1984, and on the resolution of the Scandinavian banking crisis in 1992 and the Uruguayan banking crisis in 2002. In these cases, troubled banks were nationalized for a nominal sum and thus shareholders lost their investments. Then, the government put in new management and the restructured banks were re-privatized. The takeover of Midland Bank by HSBC in the United Kingdom in 1991 is another example of the application of corrective actions.

shortfall v , expected social welfare is

$$\begin{aligned} W &\equiv E \left\{ \mathbf{1}_{\{LLR\}} [uR - (1 - u)c] + (1 - \mathbf{1}_{\{LLR\}}) (L - c) \right\} \\ &= E \left\{ \mathbf{1}_{\{LLR\}} [u(R + c) - L] \right\} + (L - c), \end{aligned}$$

where $\mathbf{1}_{\{LLR\}}$ is equal to 1 if the last resort loan is provided and 0 otherwise, $[uR - (1 - u)c]$ is the bank's expected continuation value net of the expected social cost of bank failure at date 2, and $(L - c)$ is the bank's liquidation value net of the social cost of bank failure at date 1. The socially optimal lending decision depends on the sign of $[u(R + c) - L]$. Thus, there exists a threshold u^* such that it is socially optimal to support the illiquid bank if

$$u \geq \frac{L}{R + c} \equiv u^*.$$

Otherwise, it is socially optimal to liquidate the bank.

The Central Bank's Lending Decision. Assume the central bank is the lender of last resort. If it does not provide the last resort loan, the bank will fail and the central bank will bear the political cost of bank failure. Its utility will be $U_{CB}^{NO} = -\alpha c$. The central bank's utility if it lends v to the illiquid bank will be $U_{CB}^{YES} = -(1 - u)(v + \alpha c)$; the expected value of the central bank's net income will be $-(1 - u)v$ because the last resort loan will only be repaid if the bank succeeds at date 2, and the expected value of the political cost the central bank may bear is $(1 - u)\alpha c$. Thus, the central bank supports the illiquid bank if $(1 - u)(v + \alpha c) \leq \alpha c$. That is:

$$u \geq \frac{v}{v + \alpha c} \equiv u_{CB}(v).$$

The Deposit Insurer's Lending Decision. Assume the deposit insurer is the lender of last resort. If it does not support the illiquid bank, its net income will be $L - 1$ because it will receive the bank's liquidation value L and it will reimburse depositors. The deposit insurer will also bear the political cost of bank failure. Thus, its utility will be $U_{DI}^{NO} = L - 1 - \beta c$. If, however, the deposit insurer supports the bank, the expected value of its net income will be $-(1 - u)$ because it will pay back the remaining deposits (which are in amount $1 - v$) and it will lose its loan (which is in amount v) if the bank fails at date 2 (which happens with probability $1 - u$). The deposit insurer will also bear the expected value of the political cost. Its utility will be

$U_{DI}^{YES} = -(1-u)(1+\beta c)$. Thus, the deposit insurer supports the illiquid bank if $(1-u)(1+\beta c) \leq 1+\beta c-L$. This implies:

$$u \geq \frac{L}{1+\beta c} \equiv u_{DI}.$$

The Supervisor's Lending Decision (the Unconditional Bailout Rule). Assume the bank supervisor makes the decision to support an illiquid bank. Since the bank supervisor does not have the financial capacity to fund last resort loans, its expected net income will not be affected by its lending decision. However, the supervisor avoids the political cost of an immediate bank failure if it supports the bank (it will bear this cost only if the bank fails at date 2, which occurs with probability $1-u$): $U_S^{NO} = -\gamma c$ and $U_S^{YES} = -(1-u)\gamma c$. Thus, the bank supervisor prefers that all illiquid banks be supported; it follows an unconditional bailout rule:

$$u \geq 0 \equiv u_{UBR}.$$

Figure 1 shows these lending decision thresholds in the plane of the liquidity shortfall v and the solvency signal u . The lending decisions of the central bank, the deposit insurer and the bank supervisor do not coincide, in general, with the socially optimal one. On the one hand, the central bank and the deposit insurer disregard the upside potential for profits that the continuation of the bank may involve; i.e., none of them internalize the upside part of the expected continuation value of the bank, uR . Thus, these regulators are biased towards liquidation. On the other hand, it is clear that if the unconditional bailout rule is applied, too many last resort loans will be provided.

The deposit insurer has to compensate depositors if the bank fails, the central bank does not have such liability, and only the deposit insurer receives the liquidation value of the bank's assets, L , if the bank is liquidated at date 1. So, the same last resort loan may have different effects on the expected net income of these agencies. In addition to that, the political costs that they may incur can be different. These are the main reasons why these two regulators may have different views on whether to support an illiquid bank. Since the central bank's expected net income is decreasing in the size of the last resort loan, the central bank will be softer than the deposit insurer when liquidity shortfalls are small and tougher when they are large.

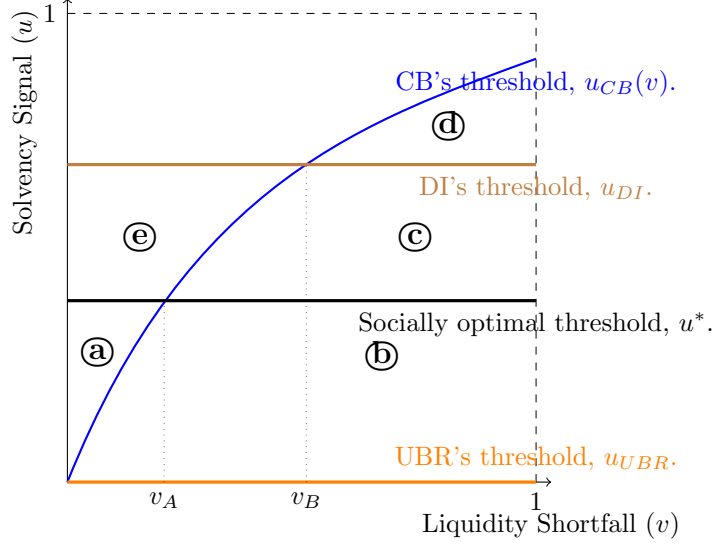


Figure 1: Lending Decisions. It is socially optimal to support those banks with solvency signals above u^* . In region ① the central bank (CB) provides socially non-desirable last resort loans; in regions ③ and ④ it does not provide socially desirable last resort loans. In regions ③ and ⑤ the deposit insurer (DI) does not provide socially desirable last resort loans. In regions ① and ②, socially non-desirable last resort loans are provided by following the unconditional bailout rule (UBR).

Let $v_A \equiv \frac{\alpha c L}{R-L+c}$ be the value for v such that $u_{CB}(v) = u^*$ and $v_B \equiv \frac{\alpha c L}{1-L+\beta c}$ the value for v such that $u_{CB}(v) = u_{DI}$. It is immediate that $0 < v_A < v_B$. Moreover, $c < \frac{1-L}{L}$ implies that $v_B < 1$.

Normalized Expected Social Welfare. Given the definition of the socially optimal lending decision threshold, $u^* \equiv \frac{L}{R+c}$, expected social welfare can be expressed as

$$\begin{aligned} W &= E \left\{ \mathbf{1}_{\{LLR\}} [u(R+c) - L] \right\} + (L-c) \\ &= E \left[\mathbf{1}_{\{LLR\}} (u - u^*) \right] (R+c) + (L-c). \end{aligned}$$

So, maximizing W is analogous to maximizing the normalized expected social welfare

$$w \equiv E \left[\mathbf{1}_{\{LLR\}} (u - u^*) \right].$$

Normalized expected social welfare is equal to

$$\begin{aligned} w_{CB}(v) &= \int_{u_{CB}(v)}^1 (u - u^*) dF(u), \\ w_{DI} &= \int_{u_{DI}}^1 (u - u^*) dF(u), \\ w_{UBR} &= \int_0^1 (u - u^*) dF(u), \end{aligned}$$

if the central bank is the lender of last resort, if the deposit insurer is the lender of last resort and if the unconditional bailout rule is applied, respectively. Lemma 1 proves some properties of these functions and Figure 2 shows them as a function of liquidity shortfalls v .

Lemma 1. *Assume $E(\tilde{u} \mid u \leq u_{DI}) > u^*$. Then,*

1. $w_{CB}(v)$ is increasing in v if $v < v_A \equiv \frac{\alpha c L}{R - L + c}$, decreasing if $v > v_A$, and has a global maximum at $v = v_A$.
2. $w_{CB}(0) = w_{UBR}$.
3. $w_{UBR} > w_{DI}$.
4. If $v < v_B \equiv \frac{\alpha c L}{1 - L + \beta c}$, then $w_{DI} < w_{CB}(v)$; otherwise $w_{DI} \geq w_{CB}(v)$.
5. $w_{DI} > w_{CB}(1) > 0$.

Proof. See Appendix. ■

Policy makers will allocate policy instruments to maximize expected social welfare. Since the size of liquidity shortfalls v is verifiable but the solvency signal u is not, this allocation can be contingent on the former but not on the latter. Lemma 1 implies the following (second-best) optimal allocation:

Proposition 1. *Assume $E(\tilde{u} \mid u \leq u_{DI}) > u^*$. Then, if the liquidity shortfall is smaller than a threshold $v^* \in (v_A, v_B)$, it is optimal to allocate the lender of last resort responsibilities to the central bank. If the liquidity shortfall is bigger than v^* , it is optimal to apply the unconditional bailout rule.*

The intuition for this result is as follows. Condition $E(\tilde{u} \mid u \leq u_{DI}) > u^*$ implies that, choosing a bank at random, it is more probable that its assets would be of average quality (i.e., $u \in [u^*, u_{DI}]$) than of low quality (i.e., $u \in [0, u^*)$). So, it is more probable that the deposit insurer does not provide socially desirable last resort loans than that low quality banks benefit from the unconditional bailout rule. Consequently, policy makers prefer to bail

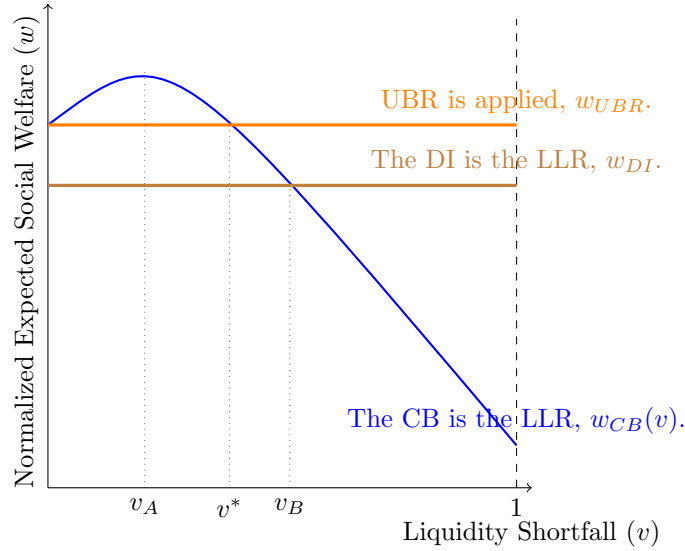


Figure 2: Normalized Expected Social Welfare. The optimal allocation of the lender of last resort activity is associated with the upper envelope of these functions: for $v < v^*$ the central bank maximizes w ; for $v \geq v^*$ the unconditional bailout rule maximizes w .

out illiquid banks over the alternative of giving the deposit insurer the power to decide whether to support them.

To always support illiquid banks is not optimal in all situations, however. On the one hand, when liquidity shortfalls are large the central bank is too tough and the unconditional bailout rule maximizes expected social welfare by avoiding too many bank closures. On the other hand, when liquidity shortfalls are small, the lending decision threshold of the central bank is the closest to the socially optimal one. So, to have the central bank deciding whether to support illiquid banks when their liquidity needs are small is socially optimal.

3.2. Date 1/2: Liquidity Manipulation

Now, I will analyze the banker's behavior.

Benchmark. Given the allocation of the lender of last resort responsibilities characterized in Proposition 1, ex ante normalized expected social welfare is

equal to

$$\begin{aligned} E(w) &= \int_0^{v^*} w_{CB}(v) dG(v) + \int_{v^*}^1 w_{UBR} dG(v) \\ &= G(v^*) \{E[w_{CB}(v) | v < v^*] - w_{UBR}\} + w_{UBR}. \end{aligned}$$

The term in brackets is positive because $w_{CB}(v) \geq w_{UBR}$ for all $v < v^*$. So, ex ante normalized expected social welfare is maximal when $G(v^*)$ is as large as possible. Since G_m (the distribution function of the liquidity shortfall under manipulation) dominates G_b (the baseline distribution function) in the sense of first-order stochastic dominance, it follows that $G_b(v) \geq G_m(v)$ for all v . Consequently, it is socially optimal that the banker decides not to manipulate her bank's liquidity needs.

Liquidity Manipulation. The banker may prefer to manipulate, however. Consider a liquidity shortfall in the region in which the central bank should be the lender of last resort. Then, if the bank generates a small solvency signal, it will be liquidated, and the banker will get nothing, with a high probability. Consequently, the banker will try to avoid liquidity shortfalls in this region. Moreover, she will try to increase the likelihood of the region in which the bank is unconditionally bailed out. Formally, the banker's behavior is characterized as follows:

Proposition 2. *If the banker observes a small enough solvency signal, she will manipulate her bank's liquidity shortfall to increase the probability of being unconditionally bailed out.*

Proof. At date 1, the banker will get the expected value of the bank, $u(R-1)$, if the bank is supported by a last resort loan. Otherwise, she will get zero. Assume the banker observes a solvency signal $u < u_{CB}(v^*)$. As of date 1/2, the probability with which the bank will be supported at date 1 is

$$\int_0^{v_{CB}(u)} dG(v) + \int_{v^*}^1 dG(v) = G(v_{CB}(u)) + 1 - G(v^*),$$

where $v_{CB}(u) \equiv \frac{u\alpha c}{1-u}$ is the CB's lending decision threshold expressed as a function of the solvency signal u . The first integral is the probability with which the bank receives the last resort loan from the central bank. The second

integral measures the probability with which the bank is unconditionally bailed out. So, the banker's problem is:

$$\max_{G \in \{G_b, G_m\}} u(R-1) [G(v_{CB}(u)) + 1 - G(v^*)].$$

Equivalently:

$$\max_{G \in \{G_b, G_m\}} G(v_{CB}(u)) + 1 - G(v^*).$$

When u tends to zero, $G(v_{CB}(u))$ tends to zero. Thus, the banker will choose $G = G_m$ (i.e., to manipulate) to make $1 - G(v^*)$ (the probability of being unconditionally bailed out) as big as possible. ■

3.3. Date 0: Optimal Policy

Policy makers face a trade-off. On the one hand, given a sufficiently large liquidity shortfall at date 1 they will find it optimal to use the unconditional bailout rule. On the other hand, the use of this rule may induce bankers to manipulate liquidity shortfalls at date 1/2, lowering expected social welfare. Standard moral hazard analysis suggests that bankers should be rewarded for the realization of small liquidity shortfalls and penalized otherwise. Indeed, by committing to apply corrective actions on the bank (e.g., to demote the banker) if a large liquidity shortfall occurs (i.e., if the unconditional bailout rule is applied) policy makers will destroy the banker's incentive to manipulate the liquidity shortfall.

Proposition 3. *The optimal lender of last resort policy is characterized as follows: the central bank should act as lender of last resort for small liquidity shortfalls (i.e., $v \leq v^*$), the unconditional bailout rule should be applied for larger than v^* shortfalls (i.e., the optimal allocation characterized in Proposition 1), and the application of the unconditional bailout rule should trigger corrective actions on the bank (e.g., banker demotion).*

Proof. The threat of demotion removes the banker's incentive to manipulate. The banker's problem is

$$\max_{G \in \{G_b, G_m\}} u(R-1) \int_0^{\min\{v_{CB}(u), v^*\}} dG(v).$$

because she will get nothing (she will be demoted even if the bank continues) if the bank is unconditionally supported (i.e., if $v > v^*$). This problem is equivalent to

$$\max_{G \in \{G_b, G_m\}} G(\min\{v_{CB}(u), v^*\}),$$

which has $G = G_b$ as a solution. ■

Proposition 3 characterizes an optimal lender of last resort policy for two reasons. First, given a small liquidity shortfall society is better off (expected social welfare is bigger) if the central bank acts as lender of last resort. Secondly, the threat of applying corrective actions makes the occurrence of small liquidity shortfalls more probable. Consequently, it is less likely that the unconditional bailout rule will be applied and more likely that society benefits from the central bank's lending decision.

3.4. Policy Implications

In this section I will offer some reflections on the ways in which the optimal lender of last resort policy can be implemented by an adequate design of the regulatory system.

Proposition 4. *The optimal lender of last resort policy (characterized in Proposition 3) can be implemented by the following organization of the regulatory system:*

- *the central bank acts as lender of last resort;*
- *the deposit insurer guarantees those central bank's last resort loans bigger than the threshold v^* ; and,*
- *the provision of such loans triggers corrective actions on the bank (e.g., banker demotion) to be applied by the supervisory authorities.*

Proposition 4 highlights the links between the central bank (the lender of last resort) and other institutions of the regulatory system. For the lender of last resort policy to be efficient it is important not only who acts as lender of last resort, but also the responsibilities of other bank regulators. As we have already discussed, the lender of last resort policy will be optimal only if the banker is penalized when her bank suffers from large liquidity shortfalls. Thus, supervisory intervention to apply corrective actions on the bank (in particular to demote the incumbent banker) should be triggered by the provision of a large last resort loan by the central bank.

Although the deposit insurer should not act as lender of last resort, it plays an important role in the implementation of the optimal policy. If the central bank's last resort loans are collateralized (i.e., if it is a senior creditor),

it will lend regardless of the solvency condition of the bank because it is certain to always recover the full amount of its loans and it might avoid the political cost of a bank failure. Consequently, if the deposit insurer guarantees those central bank's last resort loans that are larger than v^* (and the bank supervisor applies corrective actions), the optimal lender of last resort policy will be implemented.

Two reasons justify the election of the deposit insurer over other agencies (e.g., the Treasury) as guarantor for central bank's last resort loans. First, taxpayer's money is not involved. Moreover, the deposit insurer's guarantee makes the way in which losses are distributed transparent. Deposit insurance schemes are funded by the banking industry through deposit insurance premiums; consequently, banks will bear the downside risk associated to the lender of last resort policy. Second, the deposit insurer gets incentives to improve the deposit insurance scheme: if the deposit insurer is economically liable for large last resort loans, it will attempt to avoid the occurrence of large liquidity shortfalls. So, it will improve depositors' protection (not only on coverage but also on the time needed to reimburse deposits, the quality of the information that is provided to depositors and the quality of the overall services) to reduce the possibility of strategic deposit withdrawals and the pernicious effects of bankers' manipulations.

4. Extensions

4.1. Costly Corrective Actions

Until now I have assumed that applying corrective actions on the bank is costless. In this section I will discuss what happens when the model is extended to incorporate costly corrective actions.

I model the cost of applying corrective actions as a reduction in the probability of success. More precisely, I assume that the probability of success will be equal to $(1 - \delta)u$, where u is the solvency signal as before and $\delta \in [0, 1]$, if corrective actions are applied. The larger δ , the higher the cost of applying corrective actions. δ is assumed to be observable and verifiable, then contractible, at date 1. Proposition 5 characterizes the optimal lender of last resort policy in this setting.

Proposition 5. *There exists a threshold value δ^* for the cost of applying corrective actions such that the optimal lender of last resort policy is characterized as follows:*

– If the cost of applying corrective actions is small (i.e., $\delta \leq \delta^*$), there exists a threshold value $v^*(\delta)$ for the liquidity shortfalls such that for small ones (i.e., $v \leq v^*(\delta)$) the central bank should act as lender of last resort, and for large liquidity shortfalls (i.e., $v > v^*(\delta)$) the unconditional bailout rule should be used and corrective actions should be applied on the bank.

– If the cost of applying corrective actions is large (i.e., $\delta > \delta^*$), there exists a threshold value v_B for the liquidity shortfalls such that for small ones (i.e., $v \leq v_B$) the central bank should act as lender of last resort, and for large liquidity shortfalls (i.e., $v > v_B$) the deposit insurer should act as lender of last resort.

Proof. See Appendix. ■

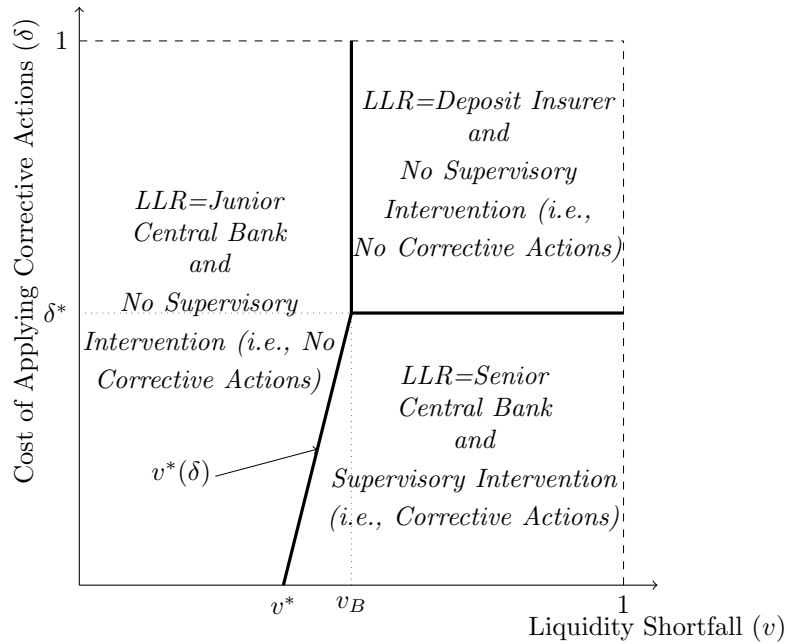


Figure 3: The Optimal Policy with Costly Corrective Actions.

Figure 3 shows the optimal lender of last resort policy in the plane of the liquidity shortfall v and the cost of applying corrective actions δ . Let first analyze the case in which a large liquidity shortfall occurs (i.e., $v > v_B$). If applying corrective actions were costless, Proposition 3 implies that it will be

optimal to use the unconditional bailout rule and to apply corrective actions. The expected social welfare associated with this policy decreases in δ . Moreover, it will be equal to zero if applying corrective actions were prohibitive (i.e., if $\delta = 1$). However, if the deposit insurer acts as lender of last resort, no corrective actions will be necessary; the banker does not have incentives to manipulate the liquidity shortfall because the deposit insurer's lending decision is not contingent on the bank's liquidity shortfall v . Consequently, if the cost of applying corrective actions is large enough (i.e., $\delta > \delta^*$), the deposit insurer should act as lender of last resort. Otherwise, the optimal policy can be implemented as before by making the central bank a senior creditor and by applying corrective actions.

If the liquidity shortfall is small (i.e., $v \leq v_B$), the deposit insurer's intervention as lender of last resort will never be optimal because the central bank's lending decision is always closer to the first-best policy than the deposit insurer's one. However, when liquidity shortfalls are large (in the sense that they are close to v_B), the central bank may be too tough. Thus, to use the unconditional bailout rule and to apply corrective actions on the bank may be the optimal policy. Whether the central bank should be a junior creditor, or its loans should be guaranteed by the deposit insurer and corrective actions should be applied depends crucially, as in the previous case (i.e., $v > v_B$), on the cost of applying such actions.

4.2. Bank Capital

In the basic model it is assumed that the bank has no capital. In this section I will show that the optimal lender of last resort policy I have derived under this assumption (see Proposition 3) is still optimal if the bank funds a proportion k of its loans at date 0 with equity capital and a proportion $1 - k$ with retail deposits.

The argument is simple and follows in two steps. First, neither the first-best lending decision, nor the lending decisions of the central bank and the bank supervisor are affected by k . The socially optimal (first-best) lending decision is derived from the comparison between the bank's expected continuation value net of the expected social cost of bank failure at date 2 and the bank's liquidation value net of the social cost of bank failure at date 1 (see Section 3.1). Thus, the first-best lending decision depends on the assets side of the bank's balance sheet (and on the social cost of bank failure) but not on the liability side. Since the expected income of the central bank (either if it supports the illiquid bank or if it does not) does not depend on k and the

bank supervisor cares only about political costs, it follows that their lending decisions are the same as before (i.e., the central bank will support the bank if $u \geq u_{CB}(v)$ and the bank supervisor will apply the unconditional bailout rule). Second, the deposit insurer is tougher than before. Its utility from supporting the illiquid bank is $U_{DI}^{YES} = (1 - u)(k - 1 - \beta c)$, while its utility from liquidating the bank is $U_{DI}^{NO} = L + k - 1 - \beta c$ because the deposit insurer's liability with depositors is now $1 - k$ (instead of 1) if the bank fails. The deposit insurer supports the bank if $u \geq u_{DI}^k \equiv \frac{L}{1 + \beta c - k} \geq \frac{L}{1 + \beta c} = u_{DI}$. Consequently, policy makers prefer not to allocate the lender of last resort responsibilities to the deposit insurer and the optimal lender of last resort policy is characterized by Proposition 3.

4.3. Positive Deposit Insurance Premium

In this section I will discuss a variation of the model in which the flat-rate deposit insurance premium is positive rather than zero as it was assumed in the basic model. In what follows I assume that at date 0 the bank collects 1 unit of deposits, pays a deposit insurance premium p and invests $1 - p$ in illiquid, risky loans. For simplicity, I also assume that social costs associated with a bank failure (e.g., costs imposed by the breaking-up of valuable lender-borrower relationships) are proportional to the bank's illiquid investment: $(1 - p)c$.

In this setting, the socially optimal (first-best) lending decision is the same as in the basic model (i.e., it is socially optimal to support the illiquid bank if $u \geq u^*$). The central bank is now tougher than in the basic model because its utility from supporting the bank, $U_{CB}^{YES} = -(1 - u)[v + (1 - p)\alpha c]$, increases by $(1 - u)p\alpha c$, while its utility from liquidating the bank, $U_{CB}^{NO} = -(1 - p)\alpha c$, increases by $p\alpha c$. The central bank will support the illiquid bank if $u \geq \frac{v}{v + (1 - p)\alpha c} \equiv u_{CB}^p(v)$. The deposit insurer is softer than before. It will support the illiquid bank if $1 + (1 - p)\beta c - (1 - p)L \geq (1 - u)[1 + (1 - p)\beta c]$. This implies: $u \geq \frac{(1 - p)L}{1 + (1 - p)\beta c} \equiv u_{DI}^p$. The main reason for this result is that the liquidation value of the bank's assets is now lower than in the basic model (it is now $(1 - p)L$), thus the deposit insurer's monetary loss if it does not support the bank (i.e., $1 - (1 - p)L$) is bigger.

The deposit insurer's lending decision threshold, u_{DI}^p , is decreasing in p . Thus, if p is large, the intervention of the deposit insurer as lender of last resort may generate a higher normalized expected social welfare than the application of the unconditional bailout rule (i.e., $w_{DI}^p = \int_{u_{DI}^p}^1 (u - u^*) dF(u) \geq$

$\int_0^1 (u - u^*) dF(u) = w_{UBR}$). However, since the response of u_{DI}^p to changes in p is less than proportional (i.e., $\left| \frac{\partial u_{DI}^p}{\partial p} \right| = \frac{L}{[1+(1-p)\beta c]^2} < 1$), it follows that p has to be too large for the allocation of the lender of last resort responsibilities to the deposit insurer to be optimal. A simple example will illustrate this point. Using the same parametrization that [Repullo \(2000, pp. 591-592\)](#) (i.e., $F(u) = u^2$, $R = 1.65$, $L = 0.45$, $\beta = 0.5$ and $c = 0.1$) I find that the deposit insurance premium should be at least 10.45 percent for the intervention of the deposit insurer as lender of last resort to be optimal. However, cross-country evidence presented by [Demirgüç-Kunt et al. \(2005, Table A.1.4\)](#) show that deposit insurance premiums are at most 2 percent and that the most frequent premiums are smaller than 1 percent.

In sum, the introduction of a deposit insurance premium in the range in which it is frequently observed in practice (i.e., less than 1 percent of insured deposits) will not affect the optimal lender of last resort policy characterized by [Proposition 3](#).

4.4. Banking Supervision

In the basic model it is assumed that the lender of last resort agency observes the solvency signal u independently of who acts as bank supervisor (i.e., who gathers such information from the bank). In this section I will show that the allocation of the supervisory responsibilities has important implications for the lender of last resort policy.

Information sharing among bank regulators is not frictionless. [Kahn and Santos \(2006\)](#) show that the central bank has incentives not to share its supervisory information with the deposit insurer. I will show that the same reasons that make the deposit insurer's lending decision different from the central bank's one may imply that the deposit insurer will not truthfully reveal its private information to the central bank.

Proposition 6. *Assume that the central bank is the lender of last resort, that it is a junior creditor, and that only the deposit insurer gathers information about the bank's solvency signal u (i.e., it is also the bank supervisor). Then, there exist values of u such that the deposit insurer will not truthfully reveal such information to the central bank, except possibly in the implausible case in which the lending decisions of both agencies coincide under perfect information.*

Proof. See Appendix. ■

As a corollary to this Proposition the central bank (who should act as lender of last resort according to this paper’s results) can only meet its responsibilities if it also is the bank supervisor or if it gathers the information already gathered by the supervisor.¹⁶ The last option implies costs of duplicating the information gathering activity. Thus, it is rational to allocate banking supervision to the central bank.

However, other reasons may suggest different allocations of the supervisory responsibilities. If the bank supervisor not only gathers information but also has the right to apply corrective actions to those banks that do not meet the rules dictated by regulation (e.g., to require capital injections and liquidity reserves, to close banks and to demote bankers), there may be a rationale for allocating banking supervision to the deposit insurer. Since the deposit insurer will be economically liable if a large liquidity shortfall realizes (see Proposition 4), it will have incentives to act promptly in order to avoid its occurrence.

Other arguments for and against giving supervisory responsibilities to the central bank have been proposed and should be taken into account.¹⁷ The main argument in favor is to preserve the stability of the financial system. The main opposition is that bank supervision could conflict with monetary policy and reduce its efficiency.¹⁸ In addition to that, the increasing complexity of financial systems provides another reason to allocate financial surveillance (including banking supervision) to the deposit insurer or to

¹⁶In Proposition 6 the bank supervisor is also the deposit insurer. If the supervisory responsibilities were allocated to an exclusive-purpose agency and the central bank were the (junior) lender of last resort, a stronger result may be proved. Since the exclusive-purpose supervisor will always prefer that an illiquid bank be supported by the central bank, the former will not provide any information to the latter: the bank supervisor will always claim that the bank is perfectly solvent. Evidence that support this result can be found in [House of Commons \(2008\)](#): to the question asked by a member of Treasury Committee “So neither you nor the Governor [of the Bank of England] realized how exposed Northern Rock was until the middle of August?”, the answer by Sir John Gieve –the Bank of England’s deputy governor in charge of financial stability and also a non-executive director of the Financial Services Authority– was: “Did I know the details of Northern Rock’s position before this blew up? No, I did not.” (Transcript of oral evidence HC 999-i, question 37)

¹⁷See [Goodhart and Schoenmaker \(1995\)](#) for a detailed analysis.

¹⁸However, [Peek et al. \(1999\)](#) show that to have access to supervisory information may improve the efficiency of monetary policy because it helps the central bank to better forecast economic variables.

an exclusive-purpose agency like the Financial Services Authority. Consequently, the optimal allocation of banking supervision will depend on the characteristics of the financial system and on the balance among the trade-offs we have mentioned. This topic exceeds the scope of this paper.

The previous discussion suggests that it is difficult to avoid some duplication in order to implement the optimal lender of last resort policy. For example, in modern, complex financial systems it may be optimal to allocate banking supervision to an agency other than the central bank; it may also be optimal to give the central bank the right to gather some private information from banks in order to meet its responsibilities as lender of last resort.

5. Concluding Remarks

I derive the optimal lender of last resort policy in a model in which different bank regulators may perform the lender of last resort function (which is a feature of a large number of countries around the world). I derive policy implications and show that the central bank should decide whether to support illiquid banks, the deposit insurer should guarantee large (relative to the size of the bank) central bank last resort loans, and the bank supervisor should apply corrective actions (e.g., banker demotion) on those banks that receive such loans.

These results suggest reforms to the current arrangements in the United Kingdom. A first reform should entail transferring the lending of last resort responsibilities from the Tripartite Standing Committee to the Bank of England, who should then apply its criteria to decide whether to support an illiquid bank. The development and complexity of the financial system in the United Kingdom provide a rationale to maintain supervisory responsibilities to the Financial Services Authority. Consequently, the discussion in Section 4.4 suggests that the Bank of England should assess individual institutions to gather the information it needs to meet its responsibilities as lender of last resort.

A second reform should give the Financial Services Authority the responsibilities of running the deposit insurance scheme and guaranteeing large (relative to the size of the bank) Bank of England last resort loans. Since the Financial Services Authority will be economically liable if a large liquidity shortfall occurs (in its role as deposit insurer), it will have incentives to act promptly in order to avoid its occurrence (in its role as supervisor).

Finally, a third group of reforms should set the basis for supervisory corrective actions triggered by the provision of large last resort loans. Even though I do not model the quality of the deposit insurer's services, the evidence about imperfections on the Financial Services Compensation Scheme (in particular the fact that depositors' funds can be tied up for months upon a bank failure) suggests that some reforms are needed in order to increase its efficiency.

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Appendix

Proof of Lemma 1

1. The first derivative of $w_{CB}(v)$ is: $w'_{CB}(v) = -u'_{CB}(v) [u_{CB}(v) - u^*] f(u)$, where f is the density function of the random variable \tilde{u} . Since $u'_{CB}(v)$ and $f(u)$ are positive for all v and u , $w_{CB}(v)$ is increasing in v if $u_{CB}(v) < u^*$, decreasing if $u_{CB}(v) > u^*$, and has a global maximum for $u_{CB}(v) = u^*$. Since $u'_{CB}(v) > 0$ and v_A is such that $u_{CB}(v_A) = u^*$ (see Figure 1), the result follows.
2. Since $u_{CB}(0) = 0 = u_{UBR}$, then $w_{CB}(0) = w_{UBR}$.
3. Assume $w_{UBR} - w_{DI} \leq 0$. Then $\int_0^1 (u - u^*) dF(u) - \int_{u_{DI}}^1 (u - u^*) dF(u) \leq 0$, $\int_0^{u_{DI}} (u - u^*) dF(u) \leq 0$, $[E(\tilde{u} | u \leq u_{DI}) - u^*] F(u_{DI}) \leq 0$, and $E(\tilde{u} | u \leq u_{DI}) \leq u^*$. A contradiction.
4. Since v_B is such that $u_{CB}(v_B) = u_{DI}$, then $w_{CB}(v_B) = w_{DI}$. Properties 1 to 3 imply that $w_{DI} < w_{UBR} \leq w_{CB}(v)$ for $v < v_B$ and that $w_{DI} \geq w_{CB}(v)$ for $v \geq v_B$.

5. Since $v_B < 1$, Property 4 implies that $w_{DI} > w_{CB}(1)$. $w_{CB}(1) = \int_{u_{CB}(1)}^1 (u - u^*) dF(u) = [E(\tilde{u} | u > u_{CB}(1)) - u^*] [1 - F(u_{CB}(1))]$. Since $u^* = \frac{L}{R+c} < \frac{1}{1+ac} = u_{CB}(1) < 1$ both factors are positive, then $w_{CB}(1) > 0$. ■

Proof of Proposition 5

When the unconditional bailout rule is used and corrective actions are applied on the bank, normalized expected social welfare is equal to

$$w_{UBR\&CA}(\delta) = \int_0^1 [(1 - \delta)u - u^*] dF(u).$$

$\delta^* \equiv \frac{[E(\tilde{u}|u \leq u_{DI}) - u^*]F(u_{DI})}{E(\tilde{u})} \in (0, 1)$ is the value for δ such that $w_{UBR\&CA}(\delta) = w_{DI}$.

Case 1: $\delta \leq \delta^$.* Since $w_{UBR\&CA}(\delta)$ is decreasing in δ , then $w_{UBR\&CA}(\delta) \geq w_{DI}$ and the deposit insurer's intervention is not optimal. Since $w_{CB}(0) \geq w_{UBR\&CA}(\delta)$ (because $w_{CB}(0) = w_{UBR}$ by Property 2 in Lemma 1, $w_{UBR} = w_{UBR\&CA}(0)$ and $w_{UBR\&CA}(\delta)$ is decreasing in δ) and $w_{DI} > w_{CB}(1)$ (by Property 5 in Lemma 1), then $w_{CB}(0) \geq w_{UBR\&CA}(\delta) > w_{CB}(1)$. Property 1 in Lemma 1 holds, then there exists $v^*(\delta)$ such that if $v \leq v^*(\delta)$ then $w_{CB}(v) \geq w_{UBR\&CA}(\delta)$, and if $v > v^*(\delta)$ then $w_{CB}(v) < w_{UBR\&CA}(\delta)$.

Case 2: $\delta > \delta^$.* Since $w_{UBR\&CA}(\delta) < w_{DI}$, it is not optimal to use the unconditional bailout rule and to apply corrective actions. Property 4 in Lemma 1 implies that if $v < v_B$ then $w_{CB}(v) > w_{DI}$, and if $v \geq v_B$ then $w_{CB}(v) \leq w_{DI}$. ■

Proof of Proposition 6

Let z denote the probability with which the central bank lends to an illiquid bank. Then, the expected value of the deposit insurer's utility is

$$\begin{aligned} E(U_{DI}) &= z(1 - u)(v - 1 - \beta c) + (1 - z)(L - 1 - \beta c) \\ &= L - 1 - \beta c + z[v - L + u(1 + \beta c - v)]. \end{aligned}$$

Let $u_0(v) \equiv \frac{L-v}{1-v+\beta c}$ be the value for u such that if $u < u_0(v)$, then the deposit insurer will prefer that the central bank does not support the bank while if $u \geq u_0(v)$, it will prefer that the central bank supports the bank.

Given a liquidity shortfall v the deposit insurer will observe the solvency signal u and will send a message m to the central bank. The deposit insurer's

strategy is a function $m(u) : [0, 1] \rightarrow [0, 1]$. The central bank will observe the deposit insurer's message and will support the bank with probability z . The central bank's strategy is then a function $z(m) : [0, 1] \rightarrow [0, 1]$.

In any Nash equilibrium

$$\begin{cases} u < u_0(v) & \Leftrightarrow m \in \underline{m} \equiv \{m : z(m) = 0\} \\ u \geq u_0(v) & \Leftrightarrow m \in \bar{m} \equiv \{m : z(m) = 1\}. \end{cases}$$

The message is truthful if $m(u) = u$. Thus, a necessary condition for any equilibrium to be a truthful revelation equilibrium is that

$$\begin{cases} u < u_0(v) & \Leftrightarrow u \in \{m : z(m) = 0\} \\ u \geq u_0(v) & \Leftrightarrow u \in \{m : z(m) = 1\}, \end{cases}$$

which is satisfied for all $u \in [0, 1]$ only if the lending decisions of both agencies coincide under perfect information. That is if

$$\begin{cases} u < u_0(v) & \Leftrightarrow u \in \{u : z(u) = 0\} \\ u \geq u_0(v) & \Leftrightarrow u \in \{u : z(u) = 1\}. \blacksquare \end{cases}$$

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