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Lender of last resort policy: What reforms are necessary? ☆

Jorge Ponce *

Toulouse School of Economics (GREMAQ), 21 allée de Brienne 31000 Toulouse, France
Banco Central del Uruguay, 777 Diagonal J.P. Fabini 11100 Montevideo, Uruguay

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ABSTRACT

The Northern Rock bailout has raised concerns about the ability of current supervisory arrangements to deal with banking crises. This paper uses a formal model of a lender of last resort to derive policy implications regarding the optimal allocation of decision-making authority. Thereby, it contributes to the policy debate in the United Kingdom by proposing reforms to the current supervisory arrangements.

1. Introduction

In September 2007 the United Kingdom saw its first bank run on a British bank in approximately 130 years.[1] Northern Rock, a large mortgage lender in the United Kingdom, 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 in the form of last resort loans was confirmed the following day.[2] The bank

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

* Address: Banco Central del Uruguay, J.P. Fabini 777, Montevideo 11100, Uruguay.
E-mail address: jponce@bcu.gub.uy

[1] According to Collins and Baker (2003), "1878 proved to be the last time there was to be a general run on commercial bank deposits in England" (p. 80). The collapse of the City of Glasgow Bank in October 1878, which had been engaged in fraudulent activities, was followed by a run on a number of British banks. There have been subsequent bank failures in England, but none caused a run: Barings in 1890 and 1995, several secondary banks failed or were rescued by a lifeboat operation in 1973–1974, and the Bank of Credit and Commerce International was closed by the authorities in July 1991.

[2] On 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% of the bank's deposits) were lent to Northern Rock.

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run was only stopped on 20 September 2007 when the Treasury reassured account holders that their deposits were fully guaranteed by the government. Finally, the bank was nationalized in February 2008.

The Northern Rock crisis has raised concerns about the efficiency of banking regulation[3] in the United Kingdom. The report by the Treasury Committee of the United Kingdom House of Commons (hereafter House of Commons, 2008) gives an overview of these concerns. First, the report expresses concerns about the failure of the Financial Services Authority (the supervisory agency) to prevent the problems that have come to the forefront since August 2007, and about imperfections in the Financial Services Compensation Scheme (the deposit insurance arrangement) that may explain the bank run.[4] Reform proposals became significantly concrete in these areas (see HM Treasury, 2007, 2008a,b) to such an extent that the aim of the Banking Act 2009 included preventing failure and improving the framework for resolution of failing institutions and for compensation of depositors. It did so by introducing heightened supervision, a special resolution regime for failing banks, and a faster and more credible compensation of deposits scheme.

A second sort of concern, which is the focus of this paper, regards inefficiencies in the arrangements for dealing with troubled banks. The Tripartite Standing Committee, constituted by the HM Treasury, the Bank of England and the Financial Services Authority, proved to be a slow decision-making mechanism at a critical time. This may be explained by three factors: first, a lack of coordination and information sharing between the Financial Services Authority and the Bank of England since the latter, which has no role to play in the supervision of individual banks, seems to have been unaware of the problems at Northern Rock until August 2007. Second, a conflict of interest between self-interested agencies that care to varying degrees about a potential bank failure. The Financial Services Authority, which has supervisory responsibilities, strongly supported the illiquid bank while the Bank of England, which cares about systemic financial stability, refused to provide emergency assistance until depositors ran the bank. Third, the Memorandum of Understanding underpinning the Tripartite system did not set out with sufficient clarity the duties and responsibilities of each agency. The policy debate in the United Kingdom is currently focussed on these issues. The Labour party believes that the Tripartite system is the best framework for regulating financial institutions. Meanwhile, the Conservative party has adopted as policy the abolition of the Tripartite system and the investiture of full responsibility to the Bank of England for the prudential regulation of all financial institutions, as was the case prior to the FSMA Act 2000 (see The Conservative Party, 2009).

This paper attempts to inform this debate. I provide a formal model to study the optimal allocation of the lender of last resort responsibilities, as well as other bank regulatory and supervisory responsibilities, in order to deal with liquidity problems in individual banks. The results suggest the following reforms to the current arrangements in the United Kingdom: first, the Bank of England should be responsible for conducting the lender of last resort policy. It should be able to decide whether or not an illiquid bank receives emergency liquidity assistance, and it should fund the operation. Since the Financial Services Authority may prefer not to reveal supervisory information to the Bank of England in critical times, the latter should have the authority to gather private information from individual banks in order to meet its responsibilities as lender of last resort. Second, the Financial Services Authority should manage the deposit insurance scheme and guarantee large emergency loans (relative to the size of the bank) granted by the Bank of England. Since the Financial Services Authority will be economically liable when a large liquidity shortfall occurs (in its role as deposit insurer and guarantor of large emergency loans), it will have an incentive to act promptly in order to prevent the occurrence of such shortfalls (in its role as bank supervisor). Third, the provision of a large emergency loan by the Bank of England should trigger the application of punitive actions (e.g., suspension of dividends and management fees, demotion of managers and expropriation of shareholders) against the bank that re-

[3] I 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.

[4] The 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, and up to £50,000 in October 2008). 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 United Kingdom in recent times.

ceives such a loan. Since these actions imply penalties to bankers, they will be incentivized to avoid the occurrence of large liquidity problems in their banks.

In the model, an emergency loan is required whenever a bank suffers from a liquidity shortfall at an interim date. Last resort lending is socially optimal when the bank has high quality assets, but the quality of the assets is not verifiable, and hence it is not contractible.[5] Bank regulators (a central banker and a deposit insurer) have information about the quality of the bank's assets and select a lender of last resort policy in order to maximize their own expected utilities. Bank regulators care about their agencies' net income and suffer a political cost when a bank fails. The deposit insurer is concerned with downside risk because the deposit insurance agency has to compensate depositors when the bank fails. Moreover, the deposit insurance agency manages the closure of failing banks and gets the liquidation value of their assets. Consequently, the deposit insurer is biased towards the liquidation of the bank at the interim date. The central banker, in providing an emergency loan, requires a minimum quality of the bank's assets that is increasing in the size of the bank's liquidity shortfall because the central bank's expected loss from lending is increasing in the size of the loan.

The policy maker must decide (*ex ante*) who gets to enact a lender of last resort policy. The policy maker may also instruct the central bank (who is a natural source of liquidity) to provide an emergency loan regardless of the quality of the bank's assets (i.e., to follow an "unconditional bailout rule"). I assume that the size of the bank's liquidity shortfall is verifiable and thus that the allocation of lender of last resort responsibilities may be contingent upon this information. In this setting, the (second-best) optimal allocation of lender of last resort responsibilities at the interim date is for the central banker to decide whether to lend to an illiquid bank when the size of its shortfall is small, and to instruct the central bank to unconditionally bailout the bank when its liquidity shortfall is large.

An alternative way to implement this policy is for the central banker always to decide whether to provide an emergency loan, but to require the deposit insurance agency to guarantee emergency loans over the liquidity shortfall that ought to trigger unconditional bailouts. This arrangement has some advantages: first, it reduces taxpayers' exposure and makes transparent the way in which the costs of the policy are borne because the deposit insurance scheme is financed by the banking industry. Second, the deposit insurer perceives incentives to enhance the quality of the deposit insurance scheme; since the deposit insurance agency is economically liable for large emergency loans, the deposit insurer will attempt to avoid the occurrence of large shortfalls by improving depositors' protection.

Similar reasoning suggests that the deposit insurer should conduct banking supervision (i.e., the responsibilities of gathering private information from banks and applying a set of regulatory rules and policies to them) because she will have incentives to act promptly in order to avoid the occurrence of large liquidity shortfalls. However, this allocation may damage the capacity of the central banker to conduct the lender of last resort policy because the deposit insurer may prefer not to provide supervisory information to the central banker. Consequently, the central banker should have the authority to gather private information from banks in order to meet his responsibilities as lender of last resort.

Establishing these arrangements *ex ante* gives the banker incentives to increase the likely size of her bank's liquidity shortfall, so as to increase the likelihood that it receives a bailout.[6] Hence, the (second-best) optimal policy *ex ante* combines the interim optimal bailout with punishments for the banker when her bank's shortfall is large enough for bailouts to be unconditional. Since bank regulators may find

[5] The 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.

[6] Indeed, bankers have access to a broad set of instruments if they want to influence the size of their banks' liquidity shortfalls. For 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; however, it is clear that premature disclosure of "bad" news had major effects on the size of the bank's liquidity needs and on the response by the government.

it hard to punish faulty bankers, an unconditional bailout by the central bank should trigger (in the spirit of the United States' FDICIA) the application of mandatory, punitive actions against the bank that receives it. Moreover, the severity of these actions should increase as the quality of the bank's assets decreases.

This paper builds on the previous literature on the institutional allocation of bank regulatory powers, borrowing extensively from its insights.[7] Closely related papers are by Repullo (2000), who employs the incomplete contracts setup of Dewatripont and Tirole (1994) to study the allocation of lender of last resort responsibilities between a central bank and a deposit insurance agency, 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. Repullo 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 insurance agency if liquidity shortfalls are large. This paper extends Repullo's framework in several key respects and reaches different conclusions. First, I allow the policy maker to instruct the central bank to provide an emergency loan regardless of the quality of the bank's assets, and show that the use of this "unconditional bailout rule" is socially desirable when liquidity shortfalls are large. Second, in contrast with Repullo, and Kahn and Santos, I distinguish between the economic institutions (i.e., banks and bank regulatory agencies) and those controlling them (i.e., bankers and bank regulators, respectively), and assume that bankers may play an active role manipulating the magnitude of their banks' liquidity shortfalls. Thus, I show that the lender of last resort policy should be complemented by punishments to the banker that are triggered by an unconditional bailout of her bank. Moreover, I show that the first-best optimal lender of last resort policy can be implemented by setting up an adequate compensation scheme for the central banker. Third, while Kahn and Santos (2006) show that the central bank does not have an incentive to provide supervisory information to the deposit insurance agency, I show that the deposit insurer does not have an incentive to truthfully reveal supervisory information to the central banker.

Section 2 describes the setup of the model. Section 3 characterizes the optimal allocation of lender of last resort responsibilities. Section 4 characterizes the optimal compensation scheme for the central banker and derives policy implications. Section 5 analyzes the incentives of bank regulators to share supervisory information and discusses the optimal allocation of supervisory responsibilities. Section 6 discusses the robustness of the results. Finally, Section 7 proposes reforms to the current arrangements for banking regulation in the United Kingdom. Technical proofs can be found in Appendix A.

2. The model

2.1. Agents, technology, shocks and information

The model has three types of agents: depositors, a banker, and bank regulators (i.e., a deposit insurer and a central banker). 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 sign demand deposit contracts with a commercial bank. Deposits can be withdrawn at either date 1 or date 2 and are fully insured. For simplicity, the interest rate paid on deposits is normalized to zero.

The commercial bank is run by the banker, which captures not only bank managers but also the board of directors and shareholders. I neglect the internal 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

[7] See Bagehot (1873) and Thornton (1802) on the "classical" justification for allocating the lender of last resort activity to the central bank; 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.

it may be efficient to control bankers' incentives by committing to penalize them rather than by using the socially more costly bank closure policy.[8]

I make the same distinction between bank regulators (i.e., the deposit insurer and the central banker) and the agencies that they manage (i.e., the deposit insurance agency and the central bank, respectively). This distinction is important because the policy maker may design the compensation schemes of bank regulators in order to increase the efficiency of banking regulation.

The deposit insurance function is carried out by the deposit insurance agency. It is funded by banks through deposit insurance premiums. For simplicity, the flat-rate deposit insurance premium is normalized to zero.[9] The central bank is a natural source of liquidity. The deposit insurer and the central banker may decide whether to provide emergency loans to illiquid banks and may carry out banking supervision (i.e., the responsibilities of gathering private information from banks and applying a set of regulatory rules and policies to them).

At date 0, the banker has access to an illiquid, risky investment technology (e.g., bank loans). It yields a random return $\widetilde{R}$ at date 2: either loans succeed, $\widetilde{R} = R$, or fail, $\widetilde{R} = 0$. Bank loans are *ex ante* profitable: $E\left(\widetilde{R}\right) > 1$. 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.[10] However, the deposit insurance agency can liquidate the bank at this date, in which case the liquidation value of the assets is $L \in (0, 1)$. For simplicity, the bank has no capital[11] and its size (i.e., the amount of deposits it collects) is normalized to 1.

A bank failure (i.e., if $\widetilde{R} = 0$ 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. For simplicity, I assume that c is smaller than $(1 - L)/L$.

The bank is subject to two sorts of shocks: a shock on liquidity demand by its depositors and a shock on the probability of success of its assets. At date 1 a fraction $v \in [0, 1]$ of the deposits is withdrawn. Deposit withdrawals are stochastic: v is a realization of a random variable $\tilde{v}$ with cumulative distribution function G, $G(0) = 0$ and $G'(0) > 0$. v is assumed to be publicly observable and verifiable at date 1. I will focus on 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 banker invests all deposits in illiquid loans). Thus, the banker has to ask for an emergency loan to honor the deposits that are withdrawn at date 1; otherwise, her bank will go (perhaps 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 may play an active role. Bankers have access to a broad set of instruments if they want to influence the size of their banks' liquidity shortfalls. For example, if some depositors strategically withdraw their deposits after acquiring information that a bank is (or will be) in trouble,[12] then bankers may increase their banks' liquidity needs by disclosing negative information about the future of their banks. Footnote 6 presents more examples. I model these possibilities in reduced form by assuming that the banker privately chooses the cumulative distribution function G from the set $\mathscr{G} \equiv \{G_b, G_m\}$, where G_m (the cumulative distribution function under manipulation) dominates G_b (the baseline cumulative distribution function) in the sense of first-order stochastic dominance.

The bank is also subject to a shock on the profitability of its assets. As of date 1/2, the probability with which the bank succeeds at date 2 (i.e., $\widetilde{R} = R$) is $u \in [0, 1]$, the realization of a random variable $\tilde{u}$

[8] I am grateful to Javier Suarez for making this suggestion.

[9] Section 6.3 shows that a deposit insurance premium in therange in which it isfrequently observed in practice (i.e., less than 1% of insured deposits) will not affect the qualitative results.

[10] Investors 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.

[11] Section 6.2 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.

[12] The 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).

with cumulative distribution function F. This "solvency signal" u is privately observed by the banker and by bank regulators through supervision. However, 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 (i.e., she chooses $G = G_b$).

Date 1.
- The liquidity shortfall v is publicly observed.
- The lender of last resort policy is applied. If the bank obtains liquidity in the form of an emergency loan, it will remain open. Otherwise, the deposit insurance agency liquidates the bank's assets and reimburses depositors.

Date 2.
- Conditionally on continuation, bank's assets pay off. If the bank fails (i.e., if $\widetilde{R} = 0$), the deposit insurance agency reimburses depositors.

2.3. The objectives of bank regulators

The mandate of many bank regulatory agencies is multidimensional. They are commonly supposed to promote and maintain confidence and stability in the banking system, and to protect consumers (particularly small and unsophisticated depositors) by supervising banks and applying a set of rules and policies. In addition, they are asked to perform these activities at a reasonable cost.

According to Tirole (1994), the multidimensionality of goals *per se* does not preclude policy makers from using powerful incentive schemes to motivate bank regulators. A clearly specified compensation scheme with explicit weights on all dimensions of performance would suffice. Nevertheless, he identifies two difficulties. First, while some dimensions of performance are relatively easy to measure (e.g., the costs incurred by a regulatory agency are stated in its profit and loss accounts), others are not. For example, whether a bank regulator is actually working to promote banking stability, adequately monitoring banks or correctly enforcing policies is difficult for third parties to observe and measure. However, the failure of a bank is publicly observed and signals that a bank regulator has failed to achieve her agency's objectives. Second, the multiplicity of objectives raises the issue of their relative weights. Consequently, the policy maker should make it clear that the evaluation of a bank regulator's performance will include a budgetary responsibility (i.e., she will be punished for her agency's cost overruns) and a political responsibility (i.e., she will be punished in case of a bank failure), as well the relative weight of both responsibilities.

To capture these ideas in a simple way, I assume that a regulator's objective function is

$$U = I - \psi \mathbb{1}_{\{\text{failure}\}} c, \tag{1}$$

where I is the regulatory agency's net income, $\mathbb{1}_{\{\text{failure}\}}$ is equal to 1 if the bank fails and 0 otherwise, and $\psi \in (0, \infty)$ is the relative weight of the political responsibility with respect to the budgetary responsibility. For simplicity, the utility loss of a bank regulator in case of a bank failure (the "political cost" of bank failure) is assumed to be equal to ψc (recall that c denotes the social cost generated by the failure of a bank).

The policy maker will optimally determine the relative weight, ψ, in the compensation schemes of bank regulators (see Section 4.1). However, while powerful compensation schemes (high ψ) may be desirable for incentive reasons, such schemes may discourage bank regulators from participating. Consequently, the policy maker must take into account their participation constraints. More precisely, I assume that the reservation utilities of bank regulators are such that ψ cannot be greater than 1. Thus, let $\psi = \alpha \in (0, 1]$ and $\psi = \beta \in (0, 1]$ denote the relative weights that are available to the policy maker that designs the compensation schemes of the central banker and the deposit insurer, respectively.

2.4. Policy instruments

I define the set of policy instruments that is available to the policy maker in a broad sense. As in Repullo (2000) and Kahn and Santos (2005), it includes the allocation of decision-making authority to either the central banker or the deposit insurer. I enlarge this set by considering two more instruments. First, the policy maker may also instruct the central bank to provide an emergency loan whenever a bank requires it; i.e., to follow an "unconditional bailout rule". Second, bank regulators may take actions against faulty bankers in order to control their incentives. For example, bank regulators may impose the suspension of dividends and management fees, the demotion of managers and the expropriation of shareholders.[13] More precisely, I assume that bank regulators may apply punitive actions that reduce the expected income accruing to the banker by a proportion $d \in (0, 1]$.

3. Who should decide on emergency liquidity assistance?

3.1. Date 1: lending decisions

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

3.1.1. 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 shortfall v, expected social welfare is

$$W \equiv E\{\mathbb{1}_{\{\text{LLR}\}}[uR - (1-u)c] + (1 - \mathbb{1}_{\{\text{LLR}\}})(L - c)\} = E\{\mathbb{1}_{\{\text{LLR}\}}[u(R+c) - L]\} + (L - c), \tag{2}$$

where $\mathbb{1}_{\{\text{LLR}\}}$ is equal to 1 if an emergency 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 lend to the illiquid bank if

[13] Some of these provisions are enacted in the United States' FDICIA (see Benston and Kaufman, 1997, Table 1, for details). Moreover, supervisory intervention to demote incumbent bankers has not been a rare practice on the resolution of troubled banks. For example, it was 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, shareholders expropriated and managers lost their jobs (and their reputation). After the resolution of the crisis, 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.

$$u \geqslant \frac{L}{R+c} \equiv u^*. \tag{3}$$

Otherwise, it is socially optimal to liquidate the bank.

3.1.2. The central banker's lending decision

If the central banker does not provide an emergency loan, the bank will fail and the central banker will bear the political cost of bank failure. Her utility will be $U_{\text{CB}}^{\text{NO}} = -\alpha c$. If a loan of amount v is provided to the bank, the central banker's utility will be $U_{\text{CB}}^{\text{YES}} = -(1-u)(v+\alpha c)$: the expected value of the central bank's net income is $(1-u)(-v)$, because the last resort loan will be repaid only if the bank succeeds at date 2, and the expected value of the political cost for the central banker is $(1-u)\alpha c$. Thus, the central banker prefers to lend to the illiquid bank if $(1-u)(v+\alpha c) \leqslant \alpha c$. That is

$$u \geqslant \frac{v}{v+\alpha c} \equiv u_{\text{CB}}(v). \tag{4}$$

3.1.3. The deposit insurer's lending decision

If the deposit insurer does not provide an emergency loan, the deposit insurance agency's 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, her utility will be $U_{\text{DI}}^{\text{NO}} = L-1-\beta c$. If, however, the deposit insurer decides to provide an emergency loan, her utility will be $U_{\text{DI}}^{\text{YES}} = -(1-u)(1+\beta c)$: if the bank fails at date 2 (which happens with probability $1-u$), the deposit insurance agency has to reimburse depositors and the deposit insurer incurs the political cost of bank failure. Thus, the deposit insurer prefers to lend to the illiquid bank if $(1-u)(1+\beta c) \leqslant 1+\beta c-L$. This implies

$$u \geqslant \frac{L}{1+\beta c} \equiv u_{\text{DI}}. \tag{5}$$

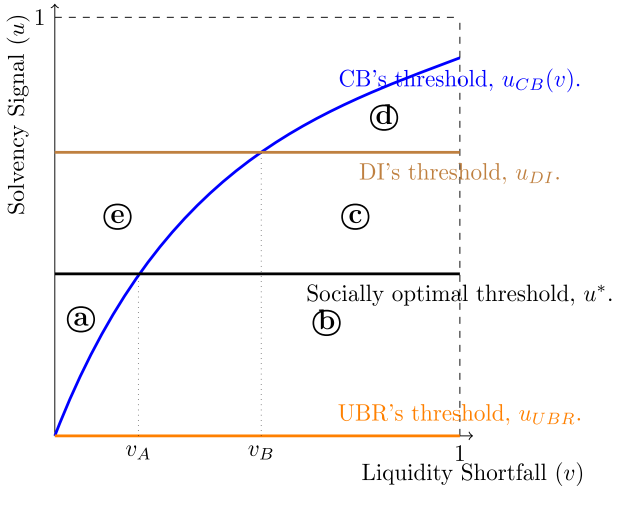

Fig. 1. Lending decisions. It is socially optimal to lend to banks with solvency signals above u^*. In region ⓐ the central banker (CB) provides socially non-desirable emergency loans; in regions ⓒ and ⓓ she does not provide socially desirable emergency loans. In regions ⓒ and ⓔ the deposit insurer (DI) does not provide socially desirable emergency loans. In regions ⓐ and ⓑ, socially non-desirable emergency loans are provided by following the unconditional bailout rule (UBR). Let $v_A \equiv \frac{\alpha cL}{R-L+c}$ be the value for v such that $u_{\text{CB}}(v) = u^*$ and $v_B \equiv \frac{\alpha cL}{1-L+\beta c}$ the value for v such that $u_{\text{CB}}(v) = u_{\text{DI}}$. It is immediate that $0 < v_A < v_B$. Moreover, $c < \frac{1-L}{L}$ implies that $v_B < 1$.

3.1.4. The unconditional bailout rule

If the policy maker instructs the central bank to always provide emergency loans to illiquid banks, then banks will be bailed out regardless of their solvency signal u. That is

$$u \geqslant 0 \equiv u_{\mathrm{UBR}}. \tag{6}$$

Fig. 1 shows these lending decision thresholds in the (v, u) plane. (Recall that v denotes the liquidity shortfall and u the solvency signal.) The lending decisions of the central banker and the deposit insurer, as well as the unconditional bailout rule, do not coincide with the socially optimal lending decision. On the one hand, the central banker 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 emergency loans will be provided.

The deposit insurance agency has to compensate depositors if the bank fails, while the central bank does not have such liability, and only the deposit insurance agency receives the liquidation value of the bank's assets, L, when the bank is liquidated at date 1. So, the same emergency loan may have different impacts on the expected net income of these two agencies. In addition, the political costs that bank regulators incur when a bank fails may be different because their compensation schemes (characterized by the relative weights α and β) may be different. These are the main reasons why the central banker and the deposit insurer can 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 loan, the central banker will be softer than the deposit insurer when liquidity shortfalls are small and tougher when they are large.

3.1.5. Normalized expected social welfare

Given the definition of the socially optimal lending decision threshold, $u^* \equiv \frac{L}{R+c}$, expected social welfare (2) can be expressed as

$$W = E\{\mathbb{1}_{\{\mathrm{LLR}\}}[u(R+c) - L]\} + (L - c) = E\big[\mathbb{1}_{\{\mathrm{LLR}\}}(u - u^*)\big](R+c) + (L - c). \tag{7}$$

So, maximizing (7) is analogous to maximizing the normalized expected social welfare

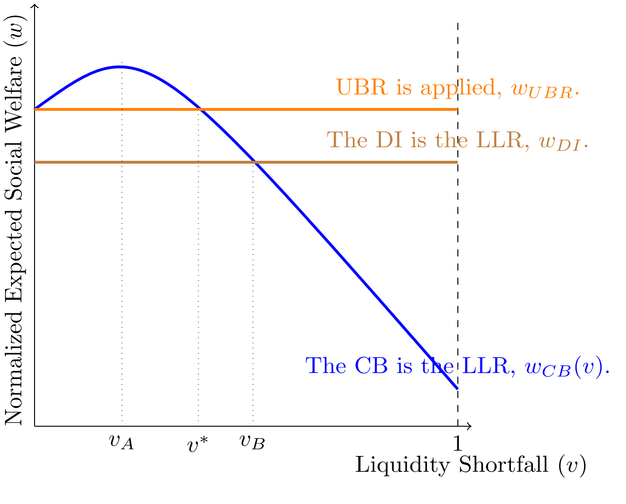

Fig. 2. Normalized expected social welfare. The optimal allocation of the lender of last resort activity follows the upper envelope of these functions: for $v < v^*$ the central banker's decision maximizes w; for $v \geqslant v^*$ the unconditional bailout rule maximizes w.

$$w \equiv E\left[\mathbb{1}_{\{\mathrm{LLR}\}}(u - u^*)\right]. \tag{8}$$

Normalized expected social welfare is equal to

$$w_{\mathrm{CB}}(v) = \int_{u_{\mathrm{CB}}(v)}^{1} (u - u^*)dF(u), \tag{9}$$

$$w_{\mathrm{DI}} = \int_{u_{\mathrm{DI}}}^{1} (u - u^*)dF(u), \tag{10}$$

$$w_{\mathrm{UBR}} = \int_{0}^{1} (u - u^*)dF(u), \tag{11}$$

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

Lemma 1. *Assume $E(\tilde{u}|u \leqslant u_{\mathrm{DI}}) > u^*$. Then, (1) $w_{\mathrm{CB}}(v)$ is increasing in v if $v < v_A \equiv \frac{\alpha cL}{R-L+c}$, decreasing if $v > v_A$, and has a global maximum at $v = v_A$; (2) $w_{\mathrm{CB}}(0) = w_{\mathrm{UBR}} > w_{\mathrm{DI}}$; (3) if $v < v_B \equiv \frac{\alpha cL}{1-L+\beta c}$, then $w_{\mathrm{DI}} < w_{\mathrm{CB}}(v)$, otherwise $w_{\mathrm{DI}} \geqslant w_{\mathrm{CB}}(v)$; and (4) $w_{\mathrm{DI}} > w_{\mathrm{CB}}(1) > 0$.*

Proof. See Appendix A. □

The policy maker will allocate policy instruments in order 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 $E(\tilde{u}|u \leqslant u_{\mathrm{DI}}) > u^*$. 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 $E(\tilde{u}|u \leqslant u_{\mathrm{DI}}) > u^*$ implies that, choosing a bank at random, it is more probable that its assets would be of average quality (i.e., $u \in [u^*, u_{\mathrm{DI}}]$) than of low quality (i.e., $u \in [0, u^*)$). So, it is more probable that the deposit insurer does not provide socially desirable emergency loans than those banks with low quality assets benefit from an unconditional bailout. Consequently, the policy maker prefers to bail out illiquid banks over the alternative of giving the deposit insurer the authority to decide whether to lend to them.

To always support illiquid banks is not optimal in all situations, however. On the one hand, when liquidity shortfalls are large the central banker 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 banker is the closest to the socially optimal one; so, to give the central banker the authority to decide whether to lend to illiquid is (second-best) optimal.[14]

3.2. Date 1/2: liquidity manipulation

Now, I analyze the banker's behavior.

3.2.1. Benchmark

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

[14] These results differ from Repullo's (2000) (i.e., to allocate the lender of last resort responsibilities to the central bank if liquidity shortfalls are small and to transfer such responsibilities to the deposit insurer if liquidity shortfalls are large), because I have extended his model by introducing the unconditional bailout rule.

$$E(w) = \int_0^{v^*} w_{CB}(v)dG(v) + \int_{v^*}^1 w_{UBR}\, dG(v) = G(v^*)\{E[w_{CB}(v)|v < v^*] - w_{UBR}\} + w_{UBR}. \tag{12}$$

The term in brackets is positive because $w_{CB}(v) \geqslant w_{UBR}$ 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 cumulative distribution function of the liquidity shortfall under manipulation) dominates G_b (the baseline cumulative distribution function) in the sense of first-order stochastic dominance, it follows that $G_b(v) \geqslant G_m(v)$ for all v. Consequently, it is socially optimal for the banker not to manipulate her bank's liquidity needs.

3.2.2. Liquidity manipulation

The banker may prefer, however, to engage in manipulation. Consider a liquidity shortfall in the region in which the central banker should decide on emergency liquidity assistance. 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 attempt to increase the likelihood of ending up in 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 residual value of the bank, $u(R-1)$, if the bank receives an emergency 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 receive an emergency loan at date 1 is

$$\int_0^{v_{CB}(u)} dG(v) + \int_{v^*}^1 dG(v) = G(v_{CB}(u)) + 1 - G(v^*), \tag{13}$$

where $v_{CB}(u) \equiv \frac{u\alpha c}{1-u}$ is the central banker's lending decision threshold, $u_{CB}(v)$, expressed as a function of the solvency signal u. The first integral is the probability with which the bank receives an emergency 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

$$\max_{G\in\{G_b,G_m\}} u(R-1)[G(v_{CB}(u)) + 1 - G(v^*)]. \tag{14}$$

Equivalently,

$$\max_{G\in\{G_b,G_m\}} G(v_{CB}(u)) + 1 - G(v^*). \tag{15}$$

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

The policy maker faces a trade-off. On the one hand, given a sufficiently large liquidity shortfall at date 1 it is 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 penalize the banker when a large liquidity shortfall occurs (i.e., if the unconditional bailout rule is applied) the policy maker destroys 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., $v \leqslant v^*$), the unconditional bailout rule should be applied for shortfalls larger than v^* (i.e., the optimal allocation characterized in Proposition 1), and the banker should be penalized (e.g., demoted) each time the unconditional bailout rule is applied.*

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

$$\max_{G\in\{G_b,G_m\}} u(R-1)\int_0^{v_{\mathrm{CB}}(u)} dG(v) + u(R-1)(1-d)\int_{v^*}^1 dG(v), \tag{16}$$

where $d \in (0,1]$ measures the severity of the punishment. This problem is equivalent to

$$\max_{G\in\{G_b,G_m\}} G(v_{\mathrm{CB}}(u)) + (1-d)(1-G(v^*)). \tag{17}$$

Consequently, it is sufficient to apply some punishment $d \geqslant \underline{d}(u)$ so that the banker prefers not to manipulate.[15] $\underline{d}(u) \equiv 1 - \frac{G_b(v_{\mathrm{CB}}(u)) - G_m(v_{\mathrm{CB}}(u))}{G_b(v^*) - G_m(v^*)}$ denotes the minimum severity of the punishment that is required to align the banker's incentives. □

The optimality of the policy stated in Proposition 3 stems from two factors. First, given a small liquidity shortfall, society is better off if the central bank has the authority to decide on emergency liquidity assistance. Second, the threat of punishing the banker 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 banker's lending decision.

4. The optimal compensation scheme, punitive actions and policy implications

4.1. Optimal compensation scheme for the central banker

The results in Section 3 hold for all feasible compensation schemes for bank regulators. This section shows how the policy maker should design the bank regulators' compensation schemes in order to maximize the efficiency of banking regulation.

The problem of the policy maker is to determine the relative weight α in the central banker's compensation scheme that leads to maximum expected social welfare. Equivalently, it should find a weight such that the lending decision of the central banker, $u_{\mathrm{CB}}(v)$, is as close as possible to the optimal (first-best) lending decision u^*. Since $u_{\mathrm{CB}}(v) = u^*$ implies $\alpha(v) = v\frac{R+c-L}{Lc}$, and taking into account the central banker's participation constraint (i.e., $\alpha \leqslant 1$), the optimal weight is equal to $\alpha^*(v) \equiv \begin{cases} v\frac{R+c-L}{Lc} & \text{if } 0 \leqslant v < \frac{Lc}{R+c-L}, \\ 1 & \text{if } \frac{Lc}{R+c-L} \leqslant v. \end{cases}$

Consequently, I have proved the following result.

Proposition 4. *Assume that the lending of last resort activity is organized according to Proposition 3 and that the policy maker implements the weight $\alpha^*(v)$ in the compensation scheme of the central banker. Then, the first-best optimal lender of last resort policy will be implemented for small liquidity shortfalls (i.e., $v < \frac{Lc}{R+c-L}$).*

Since the failure of a bank may have destabilizing effects on other banks (e.g., contagion effects), the optimal compensation scheme (characterized by $\alpha^*(v)$) implies that the central banker has to increase her concern about the stability of the banking system as the size of the liquidity problems in individual banks increases.

4.2. Punitive actions

Proposition 3 shows that the use of the unconditional bailout rule should be complemented by the application of punitive actions against the banker. This section characterizes these actions.

Punitive actions should be severe enough to reduce the banker's expected income by a proportion $\underline{d}(u) \equiv 1 - \frac{G_b(v_{\mathrm{CB}}(u)) - G_m(v_{\mathrm{CB}}(u))}{G_b(v^*) - G_m(v^*)}$ (see the Proof of Proposition 3). The following Lemma proves two properties of $\underline{d}(u)$.

[15] Any sort of punishment would work as long as its severity is larger than $\underline{d}(u)$ (e.g., bankers' prison). However, to make the punishment too harsh may imply important perverse incentives on bankers (e.g., gambling on the resurrection of the bank).

Lemma 2. *If the solvency signal u tends to zero, then $\underline{d}(u)$ (1) is decreasing in u; and (2) tends to 1.*

Proof. See Appendix A. □

Lemma 2 implies that punitive actions should be more stringent as the quality of the bank's assets decreases (recall that the solvency signal u denotes the probability of success of the bank's assets). For example, bank regulators may impose the suspension of the distribution of dividends for banks with (relatively) good solvency signals, and successively add to this provision the suspension of management fees and restrictions to the officers' payments for banks with lower asset quality. Moreover, if the quality of a bank's assets is too low, bank regulators should apply the most severe punishment to the banker (e.g., demotion of managers and expropriation of shareholders).

However, bank regulators may find it hard to punish faulty bankers. This was the main reason supporting the enactment of the Federal Deposit Insurance Corporation Improvement Act (FDICIA) in the United States in 1991. The FDICIA defines a series of quantitative triggers and a comprehensive package of norms (mandatory and discretionary provisions) that have to be applied by bank regulators when a trigger is reached. According to Benston and Kaufman (1997), FDICIA has proved to be an efficient commitment device; since it was enacted, bank regulators began to act in a more timely fashion to penalize poorly performing institutions. Consequently, the optimal lender of last resort policy characterized in Proposition 3 may be implemented if an unconditional bailout by the central bank triggers the application of mandatory, punitive actions against the bank that receives it.

4.3. Policy implications

This section offers some reflections on alternative ways to implement the optimal lender of last resort policy. It emphasizes the idea that the policy maker may improve the efficiency of banking regulation through an adequate arrangement of the regulatory system.

If the central bank's loans are collateralized (i.e., if the central bank is a senior creditor), the central banker will lend regardless of the solvency condition of the bank because she is certain to always recover the full amount of the loan and she might avoid the political cost of a bank failure. If, however, the central bank does not get priority repayment, the central banker will lend only to banks with high enough solvency signals. Consequently, if central bank's emergency loans larger than v^* are guaranteed (and punitive actions are applied against the bank), the optimal lender of last resort policy (characterized in Proposition 3) will be implemented.[16]

Who should guarantee large emergency loans granted by the central bank? Two reasons justify the choice of the deposit insurance agency, over other source of funds (e.g., the Treasury), as guarantor. First, taxpayer's money is not involved. Moreover, the way in which the costs of the policy are borne is more transparent. Deposit insurance schemes are funded by the banking industry through premiums. Consequently, banks will bear the downside risk associated with the lender of last resort policy. Second, the deposit insurer receives incentives to enhance the quality of the deposit insurance scheme. Since the deposit insurance fund will be affected when a bank fails to repay a large emergency loan, the deposit insurer will attempt to prevent large liquidity shortfalls. One way to do this is to improve depositors' protection (e.g., to increment deposits' coverage, to reduce the time necessary to make reimbursements, and to increase the quality of the information and overall services to depositors) in order to reduce the likelihood of strategic withdrawals.

Similar reasoning suggests that the deposit insurer should act as bank supervisor (i.e., she should have the authority to gather private information from banks and to apply regulatory rules and policies to them). Since the deposit insurance agency will be economically liable when a large liquidity shortfall occurs (in its role as guarantor of large emergency loans), the deposit insurer will have incentives to act promptly in order to avoid its occurrence (in its role as bank supervisor).

[16] The guarantee of large central bank's loans gives the central banker incentives to provide larger than v^* emergency loans. However, the central banker will be unable to convince bankers with liquidity needs smaller than v^* to accept larger than v^* loans because, under the optimal policy, bankers will be punished in the latter case. Moreover, the central banker is indifferent in lending any amount above v^*; so, she will have no incentive to overstate banks' liquidity needs in this region.

The following proposition summarizes.

Proposition 5. *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 (i.e., the central banker decides whether to lend to illiquid banks and the central bank funds the operation); the deposit insurance agency acts as bank supervisor and guarantees central bank's emergency loans that are larger than the threshold v^*; and the provision of such loans triggers the application of punitive actions against the bank.*

5. Banking supervision

5.1. Information sharing

In the basic model it is assumed that both bank regulators (the central banker and the deposit insurer) observe the solvency signal u. This section analyzes the incentives of bank regulators to share supervisory information when only one of them gathers such information from the bank.

Information sharing between bank regulators is not frictionless. Kahn and Santos (2006) show that the central banker does not have an incentive to share its supervisory information with the deposit insurer. The following proposition shows that the same reasons that make the deposit insurer's lending decision different form the central banker's may imply that the former does not truthfully reveal supervisory information to the latter.[17]

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 observes the bank's solvency signal u. Then, the deposit insurer will not truthfully reveal such information to the central banker (except possibly in the implausible case in which the lending decisions of both agencies coincide under perfect information).*

Proof. See Appendix A. □

5.2. Discussion

As a corollary to Proposition 6, the central banker will be able to meet her responsibilities as lender of last resort only if she has the authority to gather private information from banks. This gives a rational to allocate banking supervision to the central bank. However, allocating bank supervision to the deposit insurance agency increases the efficiency of banking regulation because the deposit insurer has a strong incentive to act promptly in order to avoid the occurrence of large liquidity problems (see Section 4.3).[18] Consequently, the optimal allocation of banking supervision should solve the trade-off between duplicating the information gathering activity and having more forbearing bank regulators.

Other arguments for and against giving supervisory responsibilities to the central bank have been proposed and should be taken into account.[19] The main argument in favor is to preserve the stability of the financial system. The main opposition is that banking supervision could conflict with monetary policy and reduce its efficiency.[20] Additionally, the increasing complexity of financial systems provides another reason to allocate financial surveillance (including banking supervision) to specialized agencies outside the central bank.

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[17] Evidence supporting 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).

[18] The central banker does not have this incentive because large emergency loans granted by the central bank are guaranteed by the deposit insurance agency.

[19] See Goodhart and Schoenmaker (1995) for a detailed analysis.

[20] However, 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.

The discussion in the previous paragraphs suggests that in modern economies with complex financial systems (e.g., the United Kingdom) it may be optimal to allocate banking supervision to an agency other than the central bank. It also suggests that the central bank should have the authority to gather private information from banks in order to meet its responsibilities as lender of last resort.

6. Extensions

6.1. Costly punitive actions

Until now I have assumed that taking punitive actions against the bank is costless. However, these actions may be costly, because bankers may have specific knowledge about the activity of their banks and managerial expertise that contribute to the success of their banks only if they are not demoted. I model this cost as a reduction in the probability of success of the bank. The solvency signal u measures this probability conditional on the fact that the incumbent banker is not demoted. Thus, if she is demoted, the probability of success will be lower than u. More precisely, I assume that the probability of success of the bank is equal to $(1-\delta)u$, with $\delta \in [0,1]$, when punitive actions are applied. The larger δ, the higher the cost of applying punitive actions. δ is assumed to be observable and verifiable, then contractible, at date 1. Proposition 7 characterizes the optimal lender of last resort policy in this setting.

Proposition 7. *There exists a threshold value δ^* for the cost of applying punitive actions such that the optimal lender of last resort policy is characterized as follows:*

- *If the cost of applying punitive actions is small (i.e., $\delta \leqslant \delta^*$), there exists a threshold value $v^*(\delta)$ for the liquidity shortfalls such that for small ones (i.e., $v \leqslant v^*(\delta)$) 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 punitive actions should be applied against the bank.*
- *If the cost of applying punitive 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., $v \leqslant v_B$) the central bank should act as lender of last resort, and for large liquidity shortfalls (i.e., $v > v_B$) the deposit insurance agency should act as lender of last resort.*

Proof. See Appendix A. □

Let us first analyze the case in which a large liquidity shortfall occurs (i.e., $v > v_B$). If applying punitive actions were costless, Proposition 3 implies that it will be optimal to use the unconditional bailout rule and to apply punitive actions. The expected social welfare associated with this policy decreases in δ. Moreover, it will be equal to zero if applying punitive actions were prohibitive (i.e., if $\delta = 1$). However, if the deposit insurance agency acts as lender of last resort, no punishment will be necessary; the banker does not have an incentive to manipulate the liquidity shortfall because the deposit insurer's lending decision is not contingent on it. Consequently, if the cost of applying punitive actions is large enough (i.e., $\delta > \delta^*$), the deposit insurance agency 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 punitive actions.

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

6.2. Bank capital

In the basic model it is assumed that the bank has no capital. In this section, I 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 follows in two steps. First, neither the first-best lending decision nor the lending decisions of the central banker 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, it follows that the central banker's lending decisions is the same as before (i.e., the central banker prefers to lend to the bank if $u \geqslant u_{\mathrm{CB}}(v)$). Second, the deposit insurer is tougher than before. Her utility from supporting the illiquid bank is $U_{\mathrm{DI}}^{\mathrm{YES}} = (1-u)(k-1-\beta c)$, while her utility from liquidating the bank is $U_{\mathrm{DI}}^{\mathrm{NO}} = L + k - 1 - \beta c$, because the deposit insurer's liability with depositors is now $1-k$ (instead of 1) when the bank fails. The deposit insurer prefers to lend to the bank if $u \geqslant u_{\mathrm{DI}}^{k} \equiv \frac{L}{1+\beta c-k} \geqslant \frac{L}{1+\beta c} = u_{\mathrm{DI}}$. Consequently, the policy maker still prefer not to allocate the lender of last resort responsibilities to the deposit insurance agency and the optimal lender of last resort policy is characterized by Proposition 3.

6.3. Positive deposit insurance premium

In this section, I discuss a variation of the model in which the flat-rate deposit insurance premium is positive rather than zero as 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 lend to an illiquid bank if $u \geqslant u^*$). The central banker is now tougher than in the basic model because her utility from supporting the bank, $U_{\mathrm{CB}}^{\mathrm{YES}} = -(1-u)[v + (1-p)\alpha c]$, increases by $(1-u)p\alpha c$, while her utility from liquidating the bank, $U_{\mathrm{CB}}^{\mathrm{NO}} = -(1-p)\alpha c$, increases by $p\alpha c$. The central banker prefers to lend to the illiquid bank if $u \geqslant \frac{v}{v+(1-p)\alpha c} \equiv u_{\mathrm{CB}}^{p}(v)$. The deposit insurer is softer than before. She prefers to lend to the illiquid bank if $1 + (1-p)\beta c - (1-p)L \geqslant (1-u)[1+(1-p)\beta c]$. This implies: $u \geqslant \frac{(1-p)L}{1+(1-p)\beta c} \equiv u_{\mathrm{DI}}^{p}$. 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 greater.

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., $w_{\mathrm{DI}}^{p} = \int_{u_{\mathrm{DI}}^{p}}^{1} (u-u^*)\,dF(u) \geqslant \int_{0}^{1} (u-u^*)\,dF(u) = w_{\mathrm{UBR}}$). However, since the response of u_{DI}^{p} to changes in p is less than proportional (i.e., $\left|\frac{\partial u_{\mathrm{DI}}^{p}}{\partial p}\right| = \frac{L}{[1+(1-p)\beta c]^2} < 1$), it follows that p has to be too large for the allocation of the lender of last resort responsibilities to the deposit insurance agency to be optimal. A simple example illustrates 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% for the intervention of the deposit insurance agency 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% and that the most frequent premiums are smaller than 1%.

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

7. Concluding remarks

The implications from the formal analysis in this paper contribute to the current policy debate in the United Kingdom. First, the Bank of England should be responsible for conducting the lender of last resort policy. It should be able to decide whether or not an illiquid bank receives emergency liquidity assistance, and it should fund the operation. The Banking Act 2009, however, allocates the responsibility for declaring a bank insolvent to the Financial Services Authority, and then gives responsibility for managing the restructuring to the Bank of England. The Governor of the Bank of England has stated explicitly in several interviews and speeches that he believes that the Bank should have the right to close banks and to decide whether they are bailed out or closed.

Second, the development and the complexity of the financial system in the United Kingdom provide a rationale for maintaining supervisory responsibilities to the Financial Services Authority. Consequently, the discussion in Section 5 implies that the Bank of England should have the authority to gather private information from individual banks in order to perform the lender of last resort activity. This would increase the cost of financial supervision. However, the possibility that bank supervision should be returned to the Bank of England (where it was prior to the FSMA Act 2000), which was adopted as Conservative party policy (see The Conservative Party, 2009), would damage the incentives of the bank supervisor to act promptly in order to prevent the occurrence of problems of large magnitude at individual banks (see Section 5.2). Other reform proposals (see HM Treasury, 2008a,b) suggest legislation in order to facilitate the Financial Services Authority sharing information with the Bank of England. While this is a sensible proposal, it is not clear how that legislation would curb the Financial Services Authority's incentive not to provide supervisory information to the Bank of England.

Third, the Financial Services Authority should manage the deposit insurance scheme and guarantee large emergency loans granted by the Bank of England. The Banking Act 2009 attempts to increase the efficiency of depositors' protection (e.g., by introducing a bank resolution procedure to facilitate fast and orderly payment of depositors' claims). However, it does not give to the Financial Services Authority the responsibility of managing the Financial Services Compensation Scheme. Moreover, none of the current reform proposals consider the possibility of guaranteeing large emergency loans granted by the Bank of England.

Finally, a fourth group of reforms should introduce the legal and regulatory framework for mandatory, punitive actions against bankers. These actions should be triggered by the provision of large emergency loans. The use of quantitative triggers (in the spirit of the United States' FDICIA) to improve the efficiency of banking regulation has been proposed by House of Commons (2008).

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Appendix A.

Proof of Lemma 1.

(1) The first derivative of $w_{\mathrm{CB}}(v)$ is: $\dot{w_{\mathrm{CB}}}(v) = -\dot{u_{\mathrm{CB}}}(v)[u_{\mathrm{CB}}(v) - u^*]f(u)$, where f is the density function of the random variable $\tilde{u}$. Since $\dot{u_{\mathrm{CB}}}(v)$ and $f(u)$ are positive for all v and u, $w_{\mathrm{CB}}(v)$ is increasing in v if $u_{\mathrm{CB}}(v) < u^*$, decreasing if $u_{\mathrm{CB}}(v) > u^*$, and has a global maximum for $u_{\mathrm{CB}}(v) = u^*$. Since $\dot{u_{\mathrm{CB}}}(v) > 0$ and v_A is such that $u_{\mathrm{CB}}(v_A) = u^*$ (see Fig. 1), the result follows.

(2) (a) Since $u_{CB}(0) = 0 = u_{UBR}$, then $w_{CB}(0) = w_{UBR}$. (b) Assume $w_{UBR} - w_{DI} \leqslant 0$. Then $\int_0^1 (u - u^*) \, dF(u) - \int_{u_{DI}}^1 (u - u^*) \, dF(u) \leqslant 0$, $\int_0^{u_{DI}} (u - u^*) \, dF(u) \leqslant 0$, $[E(\tilde{u}|u \leqslant u_{DI}) - u^*]F(u_{DI}) \leqslant 0$, and $E(\tilde{u}|u \leqslant u_{DI}) \leqslant u^*$. A contradiction.

(3) Since v_B is such that $u_{CB}(v_B) = u_{DI}$, then $w_{CB}(v_B) = w_{DI}$. Properties 1 and 2 imply that $w_{DI} < w_{UBR} \leqslant w_{CB}(v)$ for $v < v_B$ and that $w_{DI} \geqslant w_{CB}(v)$ for $v \geqslant v_B$.

(4) Since $v_B < 1$, Property 3 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 $u^* = \frac{L}{R+c} < \frac{1}{1+\alpha c} = u_{CB}(1) < 1$ both factors are positive, then $w_{CB}(1) > 0$. □

Proof of Lemma 2.

(1) $\frac{\partial d}{\partial u} = -\frac{1}{G_b(v^*) - G_m(v^*)} [g_b(v_{CB}(u)) - g_m(v_{CB}(u))]\dot{v_{CB}}(u) < 0$ because the term in brackets is positive when u tends to zero.

(2) $v_{CB}(u)$ tends to zero if u tends to zero, and $G(v)$ tends to zero if v tends to zero. □

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

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

Let $u_0(v) \equiv \frac{L-v}{1-v+\beta c}$ denote the threshold value for u such that if $u < u_0(v)$, then the deposit insurer prefers that the central bank does not lend to the bank, while if $u \geqslant u_0(v)$, she prefers that the central bank lends to the bank.

Given a liquidity shortfall v the deposit insurer observes the solvency signal u and sends a message m to the central banker. The deposit insurer's strategy is a function $m(u) : [0, 1] \to [0, 1]$. The central banker observes the deposit insurer's message and lends to the bank with probability z. The central banker's strategy is a function $z(m) : [0, 1] \to [0, 1]$.

In any Nash equilibrium $u < u_0(v) \iff m \in \underline{m} \equiv \{m : z(m) = 0\}$, and $u \geqslant u_0(v) \iff \; m \in \bar{m} \equiv \{m : z(m) = 1\}$.

The message is truthful if $m(u) = u$. Thus, a necessary condition for any equilibrium to be a truthful revelation equilibrium is that $u < u_0(v) \iff u \in \{m : z(m) = 0\}$, and $u \geqslant u_0(v) \iff u \in \{m : z(m) = 1\}$, which is satisfied for all $u \in [0, 1]$ only if the lending decisions of both agencies coincide under perfect information: $u < u_0(v) \iff u \in \{u : z(u) = 0\}$, and $u \geqslant u_0(v) \iff u \in \{u : z(u) = 1\}$. □

Proof of Proposition 7. When the unconditional bailout rule is used and punitive actions are applied against the bank, normalized expected social welfare is equal to

$$w_{UBRPA}(\delta) = \int_0^1 [(1-\delta)u - u^*] dF(u), \tag{A.2}$$

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

Case 1: $\delta \leqslant \delta^*$. Since $w_{UBRPA}(\delta)$ is decreasing in δ, then $w_{UBRPA}(\delta) \geqslant w_{DI}$ and the deposit insurer's intervention is not optimal. Since $w_{CB}(0) \geqslant w_{UBRPA}(\delta)$ (because $w_{CB}(0) = w_{UBR}$ by Property 2 in Lemma 1, $w_{UBR} = w_{UBRPA}(0)$ and $w_{UBRPA}(\delta)$ is decreasing in δ) and $w_{DI} > w_{CB}(1)$ (by Property 4 in Lemma 1), then $w_{CB}(0) \geqslant w_{UBRPA}(\delta) > w_{CB}(1)$. Property 1 in Lemma 1 holds, then there exists $v^*(\delta)$ such that if $v \leqslant v^*(\delta)$ then $w_{CB}(v) \geqslant w_{UBRPA}(\delta)$, and if $v > v^*(\delta)$ then $w_{CB}(v) < w_{UBRPA}(\delta)$.

Case 2: $\delta > \delta^*$. Since $w_{UBRPA}(\delta) < w_{DI}$, it is not optimal to use the unconditional bailout rule and to apply punitive actions. Property 3 in Lemma 1 implies that if $v < v_B$ then $w_{CB}(v) > w_{DI}$, and if $v \geqslant v_B$ then $w_{CB}(v) \leqslant w_{DI}$. □

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