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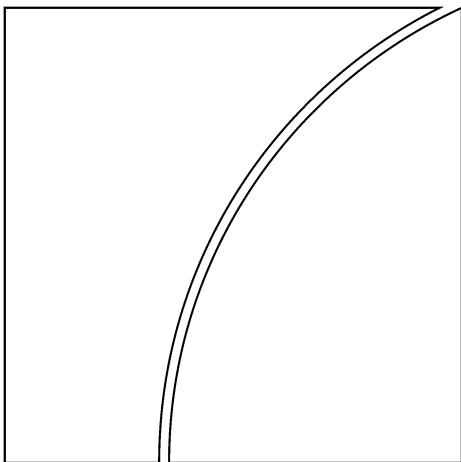
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Optimal supervisory policies and depositor-preference laws

by Henri Pagès* and João A C Santos**

Monetary and Economic Department

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* Bank of France

** Federal Reserve Bank of New York

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Abstract

When supervisors have imperfect information about the soundness of banks, they may be unaware of insolvency problems that develop in the interval between on-site examinations. Supervising banks more often will alleviate this problem but will increase the costs of supervision. This paper analyzes the trade-offs that supervisors face between the cost of supervision and their need to monitor banks effectively. We first characterize the optimal supervisory policy, in terms of the time between examinations and the closure rule at examinations, and compare it with the policy of an independent supervisor. We then show that making this supervisor accountable for deposit insurance losses in general reduces the excessive forbearance of the independent supervisor and may also improve on the time between examinations. Finally, we extend our analysis to the impact of depositor-preference laws on supervisors' monitoring incentives and show that these laws may lead to conflicting effects on the time between examinations and closure policy vis-à-vis the social optimum.

Keywords: Deposit Insurance, Depositor Preference, Supervision

JEL classification: G21, G28

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1 Introduction

A key function of bank supervisors is to monitor banks.¹ This requires them to gather timely and reliable information, which they do through regulatory reports and on-site examinations. Examinations are pivotal because they enable supervisors to confirm the accuracy of the information disclosed by banks and give them access to confidential information. In addition, they give supervisors an opportunity to enforce regulations in a timely manner. On-site examinations are, however, costly. As a result, supervisors with budgetary concerns face a trade-off between their ability to monitor banks effectively and the cost of supervision. Solving this trade-off entails choosing the “quality” of supervision.

In this paper, we develop a model where the ‘quality’ of supervision is determined by two policies: the time interval between on-site examinations and the decision on whether to close the bank at the time of examination. Supervisors’ choice of these policies will, of course, depend on their mandate as defined by governments. We evaluate the importance of supervisors’ mandate by comparing the policies of an independent supervisor with those of a supervisor who is also accountable for deposit insurance. Finally, we extend the latter arrangement to study the impact of depositor-preference laws on the quality of supervision.²

To begin with, it is useful to understand the general rationale for supervision. This rationale is directly linked to the functions performed by banks. The information asymmetries that make banks’ provision of liquidity insurance to depositors and monitoring services to investors advantageous also make it difficult for them to borrow in the market in the event of a liquidity shock.³ Consequently, a liquidity shock may generate an insolvency problem which culminates in system failure. This systemic risk forms the support of the classical argument proposing mechanisms to protect banks from liquidity shocks.

Bagehot (1873), for example, suggested the central bank commits to lending to any solvent bank with liquidity problems. Such a bank, however, would be able to borrow from the market. It is when

¹Throughout the paper we use interchangeably the terms monitoring and supervision. We also use interchangeably the terms on-site examinations and audits.

²Under a depositor-preference law, depositors, and by extension the deposit insurance provider, have a senior claim over the other claimants of the bank. Thus, in the event of bankruptcy, they have to be fully reimbursed before the other claims can be honored. The United States, Switzerland, Hong-Kong, Malaysia and Argentina are examples of jurisdictions that have some form of depositor preference.

³Calomiris and Kahn (1991), Flannery (1994) and Diamond and Rajan (1998) explain the advantages of combining these two functions in a single intermediary.

there is uncertainty about the bank's financial condition that the bank will have problems borrowing from the market.⁴ This market failure provides a rationale for supervising banks in order to be able to evaluate their financial condition more accurately than the market. Diamond and Dybvig (1983) proposed instead to protect banks through deposit insurance. This mechanism is effective against runs by depositors but by charging banks a flat premium it gives rise to moral hazard.⁵ This provides a rationale for supervising banks to control for their risk-shifting incentives.

Given these rationales for supervision, it becomes apparent that if supervision were costless it would be desirable to monitor banks continuously. Supervision, however, is costly. As a result, supervisors with budgetary responsibilities face important trade-offs.⁶

The traditional trade-off put forth in the literature is one between closing early to save on audit costs and closing late to put off meeting the costs of bankruptcy. This trade-off builds on the assumption that continuous auditing is not prohibitively costly. We deviate from this literature by assuming that audit costs prevent continuous auditing. If on-site examinations at discrete intervals are the only possibility, then the trade-off supervisors face has a new important component — the time interval between examinations. In addition to this choice, supervisors in our model also select their actions at the time of on-site examinations. We limit these actions to either closing the bank or letting it continue in operation.

We motivate the need for a bank supervisor by assuming that a bank failure is costly, and that bankruptcy costs are lower when the bank is closed by the supervisor rather than by its shareholders. Because the supervisor cannot audit the bank continuously and bank shareholders may find it advantageous to close the bank between on-site examinations, a cost-minimizing supervisor who accounts for bankruptcy costs faces the following problem: increasing the time interval between examinations and letting the bank continue in operation saves on audit and bankruptcy costs respectively, but it increases the chances of shareholders closing the bank between on-site examinations with the corresponding higher bankruptcy costs.

⁴Flannery (1996) and Freixas, Parigi and Rochet (2000) provide a rationale for a lender of last resort based on interbank market failures arising from asymmetry of information.

⁵Asymmetry of information makes it impossible, or undesirable from a welfare viewpoint, to charge banks fairly priced premiums, according to Chan, Greenbaum and Thakor (1992) and Freixas and Rochet (1997), respectively.

⁶A determinant of these trade-offs is the time decay of the value of the examination information. Hirtle and Lopez (1999) study this issue based on US data and find that the private component of examination information ceases to provide useful information about the current condition of a bank after one and a half to three years.

Even though the supervisor in our model accounts for the social costs of bankruptcy, his policies differ from those of a social planner because we assume he also incurs a political cost of bankruptcy. This difference between the supervisor’s policies and the social optimum gives us an opportunity to study the impact of different mandates of the supervisory agency on the “quality” of bank supervision. We focus on two alternative mandates: the case of an independent supervisor who accounts only for the costs of supervision and bankruptcy costs, and the case of a supervisor who also accounts for the costs a bank failure imposes on the deposit insurance provider.

Finally, the analysis of the latter mandate when the bank borrows from creditors other than depositors also leads us to study a novel impact of depositor-preference laws. The literature on these laws has focused on the cost of funds to banks and the cost a bank failure imposes on the deposit insurance provider. We focus instead on their impact on the monitoring incentives of the supervisor and show that they may have conflicting effects on the policies of a supervisor vis-à-vis the social optimum. The reason is that, as researchers have pointed out, a lender’s incentives to monitor a borrower vary both with the priority of the lender’s claim and with the borrower’s financial condition at the time monitoring is performed. In our model, the conflicting effects arise because the supervisor cannot monitor the bank continuously and the bank’s financial condition changes between on-site examinations. As a result, depositor preference may improve supervisor’s incentives to close a bank at the time of an on-site examination, but it can also lead him to wait a long time between examinations, thereby increasing the opportunities for bank shareholders to close the bank voluntarily with the corresponding higher costs of bankruptcy.

The remainder of the paper is organized as follows. The next section reviews the related literature. Section 3 presents our model and the solution of the social planner. Section 4 analyzes the policy choices of an independent supervisor and those of a supervisor who accounts for the losses a bank failure imposes on the depositor insurance provider. Section 5 studies how the policies of the latter supervisor change when the bank also borrows from non-depositor creditors and a depositor-preference law is introduced. Section 6 concludes.

2 Related literature

Our paper is close to the literature that examines the optimal closure time of ailing banks. Acharya and Dreyfus (1989), for example, derive the fair deposit insurance premium and the optimal closure rule for a pure cost-minimizing deposit insurer. Fries, Mella-Barral and Perraudin (1997) derive the optimal

closure rule and bailout policy taking into account equityholders' incentives to recapitalize banks and regulators' objective of minimizing bankruptcy costs. Ronn and Verma (1986), Pennacchi (1987) and Allen and Saunders (1993) also consider the issue of different closure rules but they focus on the impact of these rules on the fair insurance premium.

Like these papers, we use a dynamic contingent claims model to examine supervisors' optimal policies. In contrast with them, however, we assume that the cost of on-site examinations prevents continuous auditing. This difference is important because it introduces a true information asymmetry between banks and supervisors and gives us the opportunity to address the question of how often supervisors should examine banks. Bhattacharya, Plank, Strobl and Zechner (2000) also derive the optimal closure rule in a dynamic contingent claims model where there is asymmetry of information between the bank and its supervisor, but they assume auditing is stochastic with constant intensity.

Our paper is also related to the literature on the institutional allocation of bank regulatory powers.⁷ This literature, however, has focused on the optimal institutional allocation of the lender of last resort function. The recent debate on the institutional allocation of bank supervision in turn has focused on the issues arising from placing this function in either the central bank or an independent agency.⁸ Our model considers instead the optimal allocation of supervision between an independent supervisor and a supervisor with deposit insurance responsibilities.⁹

Finally, our paper is related to the literature on the role of debt priorities. There has been a great deal of interest in the seniority of debt claims in connection with the funding of non-financial firms.¹⁰ In the context of banks, there has been less attention to this issue and much of the focus has been on the potential effects of requiring banks to fund themselves with subordinated debt.¹¹ The literature on depositor-preference laws, in turn, has focused on the impact of these laws on the cost of funds to banks and the liabilities of the deposit insurance provider in case of a bank failure.¹² An

⁷See, for example, Repullo (2000) and Kahn and Santos (2000, 2002).

⁸See Haubrich (1996), Goodhart and Shoenmaker (1998) and Vives (2001) for a review of the arguments put forward in this debate.

⁹Kahn and Santos (2000) also study the optimal allocation of supervision between the central bank and the deposit insurance provider, but in their model there is no role for an independent supervisory agency.

¹⁰ See, for example, Diamond (1993), Repullo and Suarez (1998), Park (2000), Welch (1997) and Longhofer and Santos (2000, 2002).

¹¹See Board of Governors (1999) for a review of the literature on subordinated debt.

¹²See Hirschhorn and Zervos (1990), Osterberg (1996) and Osterberg and Thomson (1999).

exception is Birchler (2000), who considers the role of debt priorities in the optimization of monitoring efforts when investors differ with respect to (privately known) information costs. He finds that the large number of depositors a bank has to interact with calls for a standardization of contracts it offers them. In order to keep small depositors from wasteful monitoring it might be efficient to offer them seniority over larger depositors who will then have more incentives to monitor the bank. Our paper differs from Birchler’s in that we assume all depositors are identical. In addition, our interest in the priority of depositors’ claims is not because of its impact on the bank’s funding costs but instead because of its impact on supervisors’ incentives to monitor banks.

3 The model

Our model has similarities with Fries, Mella-Barral and Perraudin (1997), but it differs from theirs in an important way. In contrast with them, we assume that examining banks continuously is not cost-effective. This difference is important because, among other things, it requires supervisors to determine the optimal time interval between on-site examinations. The full extent of the implications of this difference will become clear in Section 3.2.

We take the “bank” to be a portfolio of risky activities, including those of making illiquid loans. These activities generate a stochastic cash flow of g_t per dollar of deposits and per unit of time. The amount of total deposits could be any process of bounded variation, but we impose homogeneity by scaling all quantities per dollar of deposits. The only source of uncertainty comes from the cash flow, which is modeled as

$$\frac{dg_t}{g_t} = \mu dt + \sigma d\tilde{w}_t, \tag{1}$$

where μ and σ are constant parameters and $d\tilde{w}_t$ the increment to a standard Brownian motion under the empirical probability. The drift μ must be less than the short rate of interest r for an equilibrium to exist.¹³ To rule out the possibility of infinitely-lived banks, we also assume that $\mu < \sigma^2/2$. This implies that the bank’s cash flow grows in expectation at rate μ but falls almost surely (path by path) to zero. In other words, the bank is doomed, although its lifetime is arbitrarily large.

¹³The bank’s fair equity value satisfies the fundamental equation of finance which requires that the return on bank equity equal the flow of income to equityholders plus expected capital gains.

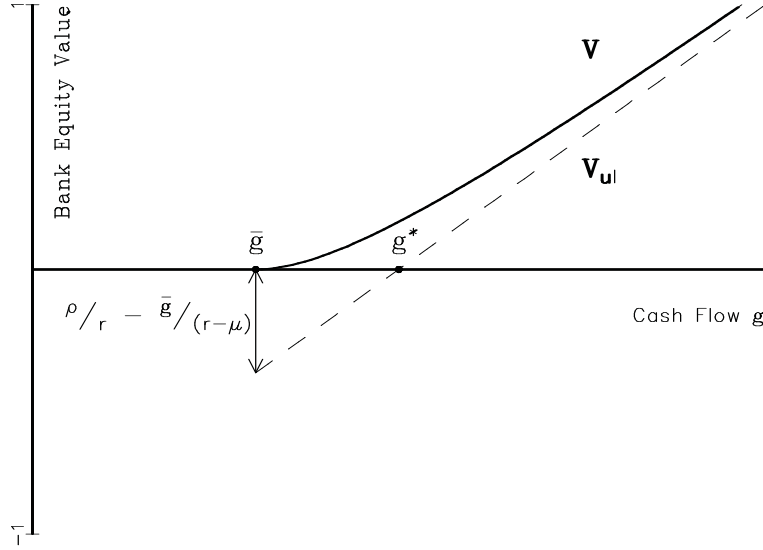


Figure 1: Full and unlimited value of bank equity

3.1 Bank shareholders' problem

Net cash flows available to bank shareholders are $g_t - \rho$, where ρ denotes the average rate paid per dollar of deposits, including the interests earned by depositors and the premium levied by the deposit insurance agency. We assume that all deposits are insured and that $\rho = r + \gamma$, where γ is the (constant) premium on insured deposits.¹⁴ Negative net cash flows imply that shareholders inject capital in some states of the world to maintain the bank as a going concern.¹⁵ If they stop making disbursements at some point τ , the bank is closed. Thus, under limited liability, bank shareholders' *participation constraint* can be viewed as the solution to the following optimal stopping time problem

$$V(g) = \sup_{\tau \geq 0} \mathbf{E} \left[\int_0^{\tau} e^{-rt} (g_t - \rho) dt \right]_{g(0)=g},$$

where g denotes the initial income level, V the corresponding (normalized) equity value and r the risk-free rate of interest.

The unlimited liability value of bank equity, $V_{ul}(g) = g/(r - \mu) - \rho/r$, is the difference between

¹⁴Throughout the paper we assume, for simplification reasons, that the deposit insurance premium is exogenous, and that there is no repricing of risk as new information on the bank's financial condition is gathered. We accordingly set $\gamma = 0$ in simulations.

¹⁵We implicitly assume that bank shareholders have unlimited resources to keep the bank in operation. This, however, does not imply that they would choose to finance the bank entirely with equity.

the expected discounted value of the bank's risky cash flow and the value of the annuity ρ . We call g^* , the value for which V_{ul} is zero, the *insolvency level*. When $g_t \in (g^*, \rho)$, the bank is illiquid but solvent. The following proposition shows that when g_t is less than g^* , shareholders choose to maintain the bank in operation by injecting funds as long as cash flows remain above an endogenously determined level \bar{g} , which defines the participation constraint of shareholders.

Proposition 1 *Bank shareholders let the bank continue in operation as long as cash flows are greater than the participation constraint $\bar{g} = [-\lambda/(1-\lambda)]g^*$, where λ is the negative root of $(\sigma^2/2)\lambda^2 + (\mu - \sigma^2/2)\lambda - r = 0$. The corresponding value of the bank's equity is*

$$V(g) = \frac{g}{r-\mu} - \frac{\rho}{r} + \left(\frac{g}{\bar{g}}\right)^\lambda \left(\frac{\rho}{r} - \frac{\bar{g}}{r-\mu}\right).$$

The bank fails at time $\tau = \inf \{t : g_t = \bar{g}\}$.

Proofs of propositions are given in the Appendix. Figure 1 displays the value of the bank equity as a function of the state variable g for a particular choice of parameter values.¹⁶ It is the sum of two terms. The first is the bank's net present value under unlimited liability, $V_{ul}(g)$. The second is the value of the "down-and-in" barrier option of abandoning the bank when g_t hits the lower boundary \bar{g} . The option payoff is the liability transferred to the bank claimants upon failure, $\rho/r - \bar{g}/(r-\mu)$, which is known with certainty. The remaining term in the formula is the discount factor

$$E [e^{-r\tau}]_{g(0)=g} = (g/\bar{g})^\lambda, \quad (2)$$

where τ is the knock-in time.

The present value of the bank's assets at the time of default is $\bar{g}/(r-\mu) = -[\lambda/(1-\lambda)]\rho/r$. Proposition 1 shows that the negative parameter λ depends only on μ , r and σ and reflects the value to shareholders of the option to abandon the bank. A higher volatility σ , a lower interest rate r or a lower drift μ all contribute towards lowering \bar{g} by making the option more valuable.

3.2 The social planner problem

Consider a social planner who takes into account the value of the bank, that of the deposit insurance agency, as well as audit and social bankruptcy costs. The latter are intended to capture the administrative costs of closing the bank and paying back depositors (excluding the costs of reimbursing them) as

¹⁶ All parameter values are per dollar of deposits. Our benchmark case has $r = 2\%$, $\gamma = 0$, $\sigma = 20\%$, $\mu = 0$ and $\xi = 0.2\%$. This implies an insolvency level and a participation constraint of $g^* = 2\%$ and $\bar{g} = 0.76\%$, respectively.

well as the negative externalities associated with a bank failure. Given that there is no moral hazard in our model, we give our social planner a useful role by assuming that social bankruptcy costs are lower when she closes the bank than when shareholders do so. These social costs are noted c_s (s for social planner) and c_b (b for bank), respectively, with $c_s < c_b$.

There are some reasons to believe that the “preventive” cost c_s should be lower than the “curative” cost c_b . An orderly workout is likely to lead to lower costs than a resolution process where the bank unexpectedly declares bankruptcy, as the bank’s economic value may be better preserved. In addition, the externalities associated with a bank failure, such as disruptions in financial markets or interruptions in payment, clearing and settlement systems, are likely to be less extensive if they are managed in conjunction with the decision to close the bank rather than after the bankruptcy announcement. Finally, the social planner is concerned about the risk of contagion, which will be heightened if the bank failure is imposed abruptly on the financial system as a *fait accompli*.

The basic question we ask in this section is whether the social planner can improve on the simple *laissez-faire* policy under which the bank is allowed to fail when shareholders’ participation constraint is met. As we shall see, the optimal policy depends on the information set available to the social planner. We start by assuming that there is no asymmetry of information, i.e., that the social planner is able to observe the bank’s cash flow at no cost. We then examine the case of a social planner who incurs an audit cost whenever she needs to ascertain the bank’s financial condition.

3.2.1 Perfect information

Under the *laissez-faire* policy, we know from Proposition 1 that bank shareholders will close the bank at time τ when $g_\tau = \bar{g}$. As a result, the value of the bank and that of the deposit insurance provider are respectively

$$\begin{aligned} V_b(g) &= E \left[\int_0^\tau e^{-rt} (g_t - \rho) dt \right] \\ V_d(g) &= E \left[\int_0^\tau e^{-rt} \gamma dt + e^{-r\tau} \left(\frac{\bar{g}}{r - \mu} - 1 \right) \right], \end{aligned}$$

Adding up these two functions, and subtracting the discounted bankruptcy costs, we find the social welfare

$$\mathcal{W}_{LF} = \frac{g}{r - \mu} - 1 - c_b \left(\frac{g}{\bar{g}} \right)^\lambda,$$

where the initials *LF* stand for *laissez-faire*.

Given that the social planner continuously observes the bank cash flow g_t , she can implement any threshold above the participation constraint \bar{g} with the relevant bankruptcy cost c_s . However, liquidation is costly and it is optimal to put off meeting the costs of bankruptcy until $g_t = \bar{g}$. As the social planner is more efficient at closing the bank than bank shareholders, her optimal policy is to wait and apply her special skills just before bank shareholders “pull the plug.” The corresponding social welfare is

$$\mathcal{W}_{PI} = \frac{g}{r - \mu} - 1 - c_s \left(\frac{g}{\bar{g}} \right)^\lambda,$$

where the initials *PI* refer to the perfect information optimum. With perfect information and costly liquidation, the participation constraint is always binding, which results in a degenerate optimal closure policy.

3.2.2 Asymmetric information

We now assume that the social planner does not observe the bank’s cashflow g_t unless she incurs the audit cost ξ . A key implication of this asymmetry of information is that the time when the participation constraint of bank shareholders is reached comes as a complete surprise. As a result, the social planner can no longer intervene right before the bank files for bankruptcy to minimize bankruptcy costs. However, because the social planner has specific skills at liquidating the bank, she is able to improve on the benchmark of no intervention if auditing the bank is not too expensive. Under these circumstances, the optimal policy is determined by both the frequency of bank examinations and the closure rule at the time of examination.

Consider what happens if the social planner decides to close the bank right away. In this case, social welfare is $g/(r - \mu) - 1 - c_s$. The social planner can thus improve on \mathcal{W}_{LF} by generating a cost relief of $\Gamma_0^+(g) = \max \{ \Gamma_0(g), 0 \}$, where

$$\Gamma_0(g) = c_b \left(\frac{g}{\bar{g}} \right)^\lambda - c_s. \quad (3)$$

We call $\Gamma_0(g)$ the *immediate closure gain*. It is positive as long as the observed cash flow g is lower than the threshold $\hat{g} = \bar{g}(c_s/c_b)^{1/\lambda}$. The cut-off point \hat{g} is a rough metaphor for the stiffness of intervention, because the interval $[\bar{g}, \hat{g}]$ is the closure region that the social planner would implement if she had only one opportunity to intervene. For this reason, we call \hat{g} the *stopgap closure rule*.

More generally, let $\Gamma(g)$ be the *intervention gain*, relative to the benchmark of no intervention, that the social planner can obtain by optimally adjusting her closure decision and the frequency of

bank examinations. The function Γ does not take into account the audit cost that the social planner has just paid to learn about the true cash flow, but it captures all future gains originating from the possible recurrence of the optimal closure policy. Conditioning on the knowledge of g , we can derive social welfare from the definition of Γ as

$$\mathcal{W}_{AI}(g) = \frac{g}{r - \mu} - 1 - c_b \left(\frac{g}{\bar{g}} \right)^\lambda + \Gamma(g),$$

where the initials *AI* refer to asymmetric information. Since the stopgap policy is available anyway, we have $\Gamma(g) \geq \Gamma_0^+(g)$, with equality holding when immediate closure is chosen. We get the following result.

Proposition 2 *Let $\xi < c_b - c_s$. Under asymmetric information, the optimal social policy upon examination is characterized by a partition of $\{g > \bar{g}\}$ and a stationary time-to-examination function $\theta(g)$ such that if:*

- (a) $\Gamma(g) = \Gamma_0^+(g) > 0$: *the social planner closes the bank right away;*
- (b) $\Gamma(g) > \Gamma_0^+(g) \geq 0$: *the social planner examines the bank after time $\theta(g)$;*
- (c) $\Gamma(g) = \Gamma_0^+(g) = 0$: *the social planner lets the bank continue in operation and decides not to examine it again.*

The function $\Gamma(g)$ captures the social gain of intervention. It is decreasing and satisfies the Bellman equation

$$\Gamma(g) = \max \left\{ \Gamma_0^+(g), \sup_{\theta > 0} e^{-r\theta} E \left[\Gamma(g_\theta) - \xi; \tau > \theta \right] \right\}, \quad (4)$$

where the supremum is attained at $\theta(g)$.

The interpretation of Proposition 2 is straightforward. For low initial cash flow g , bank shareholders' participation constraint is going to be hit soon. To save on bankruptcy costs, the social planner forecloses that possibility by winding up the bank immediately. For intermediate g , social welfare is increased if the social planner defers closure. The *deferred closure gain*

$$G(\theta, g) = e^{-r\theta} E \left[\Gamma(g_\theta) - \xi; \tau \geq \theta \right] \quad (5)$$

can be interpreted as the price of a “down-and-out” barrier option maturing at θ and paying off $\Gamma(g) - \xi$ if the barrier $g = \bar{g}$ has not been reached. The social planner maximizes the value of this option over all

possible times to expiry for given g . This yields the time-to-examination function $\theta(g)$ and corresponding optimal intervention gain $\Gamma(g) = G(\theta(g), g)$. Finally, when g is sufficiently high, the expected audit costs may outrun the benefits of closing preventively. In this case, the social planner cannot improve on the benchmark social welfare \mathcal{W}_{LF} .

3.3 The two-examination problem

The optimal control problem (4) is difficult to solve explicitly. The deferred closure gain G in (5) can be derived from a partial differential equation with boundary conditions depending on Γ . Conversely, the intervention gain function Γ in (4) is obtained as the maximum of G over θ in the free-boundary deferred closure region. To simplify the analysis, we make the final assumption that the audit technology available to the social planner can be used at most twice.¹⁷ At time 0, the social planner observes the bank's cash flow and decides whether the bank can be left open and, if it is, for how long. At the second examination, if there is one, the social planner either closes the bank or leaves it open, in which case the bank remains in operation until its shareholders eventually choose to pull out.

Under these conditions, the optimal social policy is defined by: (a) the three regions defining the type of intervention to be performed at the time of the first examination (either close the bank right away, or examine it again within a given period of time, or never examine it), (b) the time-to-last-examination function in the intermediate region, and (c) the stopgap closure rule following the last examination, in case there is one (that is, in case bank shareholders did not close the bank before this examination).

The continuous line in the upper panel of Figure 2 illustrates the immediate closure gain $\Gamma_0^+(g)$ applicable to social welfare at the time of the last examination.¹⁸ The stopgap closure rule is \hat{g} . Because the social planner has a cost advantage in closing banks, the welfare gain is all the higher, the closer cash flows are to the bank participation constraint \bar{g} . The maximum cost relief is $c_b - c_s$.

Solving backwards, we write the deferred closure gain at the time of the first examination as

$$G_1(\theta, g) = e^{-r\theta} E \left[\Gamma_0^+(g_\theta); \tau \geq \theta \right] - e^{-r\theta} \xi Q(\tau \geq \theta), \quad (6)$$

¹⁷We have obtained the general stationary solution using numerical simulations. The stationary solution yields a broader deferred closure region and a higher frequency of examinations than under the restricted two-examination setup. Details are available from the authors upon request.

¹⁸ Parameter values are set as in Footnote 16 with $c_b = 0.5$ and $c_s = 0.4$.

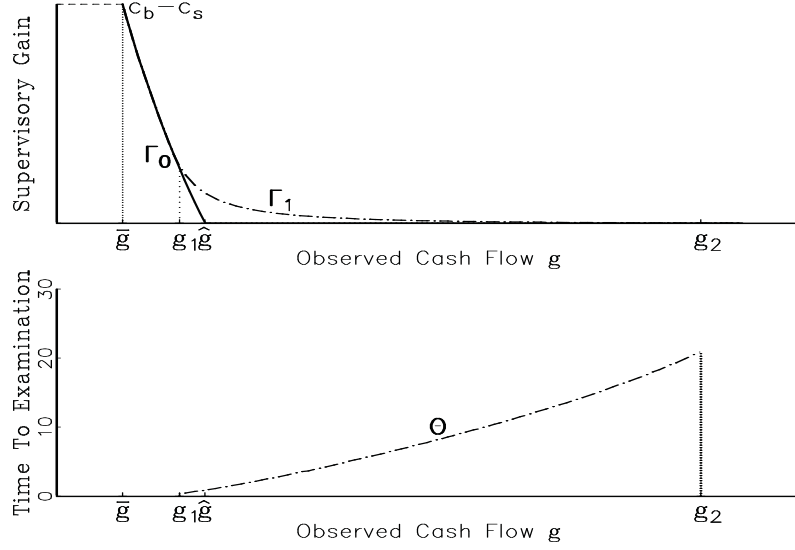


Figure 2: Two-examination optimal social policy

where Q denotes the empirical probability. The first term is the reward from intervening at time θ . It is positive under two circumstances: the bank must be still alive ($\tau \geq \theta$) and its cash flow must lie in the critical region (\bar{g}, \hat{g}) . The second term is the expected cost of auditing if the bank has not defaulted. Obviously, the social planner closes the bank if the expected audit costs outrun the deferred closure gain. For example, if $c_b - c_s < \xi$, the first term on the right-hand side of (6) falls short of the second at all points in time, implying that $G_1(\theta, g)$ is negative. We must assume that $\xi < c_b - c_s$ to allow for non-degenerate intervention policies.

In maximizing (6) over θ , the social planner attempts to find out the time it takes for future cash flows to reach the critical region (\bar{g}, \hat{g}) . If successful, she reaps the benefits of declaring the bank insolvent before bank equityholders pull out. This is when the payoff is the largest. Setting θ to a larger value implies that current information about the bank's cash flow will have decayed at the time of the last examination. Choosing a smaller θ implies on the contrary that this information will still be valuable. We summarize these results in the following proposition.

Proposition 3 *Let $\xi > c_b - c_s$. With only two examinations available, the optimal social policy is defined by:*

- (a) *A partition of g indicating the type of intervention to be performed at the time of the first examination. The bank is closed if $g < g_1$, is examined at time $\theta(g)$ if $g_1 \leq g \leq g_2$ and is no longer*

examined if $g > g_2$. The intervention gain on $[g_1, g_2]$ at time 0 is

$$\Gamma_1(g) = \max \left\{ \Gamma_0^+(g), \sup_{\theta > 0} G_1(\theta, g) \right\}, \quad (7)$$

where $G_1(\theta, g)$ is given by (6). The boundaries g_1 and g_2 solve

$$G_1(\theta(g_1), g_1) = \Gamma_0(g_1) \quad (8)$$

$$G_1(\theta(g_2), g_2) = 0 \quad (9)$$

and the time-to-examination function is

$$\theta(g) = \arg \max_{\theta} G_1(\theta, g); \quad (10)$$

(b) A closer rule, the stopgap rule, to be implemented at the time of the last examination, in case there is one. At that time the bank is closed if $g \leq \hat{g}$, where $\hat{g} = \bar{g}(c_s/c_b)^{1/\lambda}$, and left open otherwise.

For simplification reasons, we chose to disregard the role of bank capital standards in this paper. However, the three regions (\bar{g}, g_1) , (g_1, g_2) and (g_2, ∞) can be viewed as a metaphor for the specifications of capital categories which trigger the set of actions that regulators have to take under a prompt corrective action program. The first would be the “undercapitalized” category, where strict mandatory actions are taken, the second the “adequately capitalized” one, where banks are subjected to periodic scrutiny, and the last the “well capitalized” one, where no action is called for.¹⁹

Note that a rule based on cash flows g is equivalent to a rule based on the bank’s leverage ratio, since the capital/assets ratio is a monotonic transformation of the value of assets per unit of deposits $g/(r - \mu)$. In our model, however, capital categories are not defined according to predetermined leverage ratios. Rather, they come out as bank-specific rules that the social planner is willing to adopt to spare the financial system part of the costs associated with unexpected panics and banking runs.

4 The supervisory agency problem

Ideally, a government would like to design a supervisory authority that mimics the social planner of the previous section. However, difficulties of varying order will prevent the government from attaining this goal. Note, for example, that even if the objectives of the supervisory authority could be specified so

¹⁹The adequately capitalized threshold g_2 can be infinite if the social planner’s cost advantage $c_b - c_s$ is sufficiently large.

completely as to render them perfectly consonant with those of the government, the incentive difficulties arising from the agency problem and imperfections in monitoring this authority would still lead to conflicts between its objectives and those of the government.

In what follows, we assume that by giving the supervisory authority the “responsibility” for bank failures, the government successfully makes it accountable for the social costs of a bank failure and by giving it budgetary responsibilities the government successfully makes it a cost minimizer. We introduce a friction with the government’s objectives by assuming that the supervisor incurs a political cost of bankruptcy whenever he closes the bank. To simplify the analysis, we assume that this political cost of bankruptcy occurs only when the supervisor closes the bank, that is, he does not incur it when bank shareholders do it. A rationale for this difference is that if the bank is declared bankrupt by its shareholders, the supervisor can always diffuse some of the blame he will otherwise face when he forces the bank to close.²⁰

Like the social planner, the bank supervisor has two controls: first, the time interval between on-site examinations and, second, whether or not to close the bank at examination time. For the sake of tractability, we continue to assume that the supervisor considers making at most one further trip to the bank. Given our political cost assumption, the cost is c_b when bank shareholders declare bankruptcy, and $c'_s > c_s$ when the supervisor declares the bank closed, with $c'_s < c_b$.

In what follows, we determine the optimal policy of this supervisory agency and compare it to the social optimum of the previous section. We then investigate the implications for the optimal supervisory policy of a change in the mandate of the supervisory agency, when it is made accountable for the losses the deposit insurance provider incurs when the bank goes bankrupt.

4.1 A stand-alone supervisory agency

We start by considering a stand-alone supervisor, that is, a supervisor who is accountable for bank failures but does not take into account the cost these failures impose on the provider of deposit insurance. Let $C^{\text{sa}}(g)$ be his cost function conditional on knowing g . The stand-alone supervisor minimizes expected bankruptcy and audit costs. For the moment we write $c'_s = c_s$.

If at time zero the supervisor considers leaving the bank open and examining it at time θ , the

²⁰It is worth noting that the results of this section hold if we assume that the supervisor also incurs a political cost of bankruptcy when bank shareholders close the bank but that this political cost is smaller than the one he faces when he makes the closure decision.

deferred cost of monitoring is

$$C^{\text{sa}}(\theta, g) = c_b E [e^{-r\tau}; \tau < \theta] + e^{-r\theta} E \left[\xi + \min \left\{ c_s, c_b \left(\frac{g\theta}{\bar{g}} \right)^\lambda \right\}; \tau > \theta \right]$$

The first term on the right-hand side is the cost incurred if bank shareholders happen to close the bank between the current on-site examination and the next one at time θ . The second captures the cost incurred if the bank is still in operation at time θ . On that occasion, the supervisor incurs the audit cost ξ and either closes the bank at that time, in which case the cost c_s prevails, or leaves it open, in which case bank shareholders eventually close it when $g = \bar{g}$, imposing a cost c_b on the supervisory agency. After some simplifications, this expression can be rewritten as

$$\begin{aligned} C^{\text{sa}}(\theta, g) &= c_b E [e^{-r\tau}; \tau < \theta] + e^{-r\theta} E \left[\xi + c_b \left(\frac{g\theta}{\bar{g}} \right)^\lambda - \Gamma_0^+(g\theta); \tau > \theta \right] \\ &= c_b \left(\frac{g}{\bar{g}} \right)^\lambda - G_1(\theta, g), \end{aligned}$$

where G_1 is the deferred closure gain in (6).

The supervisor also has the alternative of the stopgap policy at time 0, which costs $\min \{c_b(g/\bar{g})^\lambda, c_s\}$.

The stand-alone cost function is thus

$$\begin{aligned} C^{\text{sa}}(g) &= \min \left\{ c_b \left(\frac{g}{\bar{g}} \right)^\lambda, c_s, c_b \left(\frac{g}{\bar{g}} \right)^\lambda - \sup_{\theta > 0} G_1(\theta, g) \right\} \\ &= c_b \left(\frac{g}{\bar{g}} \right)^\lambda - \Gamma_1(g). \end{aligned}$$

The first term on the right-hand side is the expected cost in the absence of intervention. The second, as seen before in (7), is the cost relief brought to the supervisor by the optimal intervention policy. The only difference is that now $c'_s > c_s$. Based on this result, we can assess the “quality” of supervision by a stand-alone supervisor (that is, how his policies compare to the social optimum) through the analysis of an increase in c_s .

Proposition 4 *The stand-alone supervisor is more forbearing than the social planner in the following sense:*

- (a) *The stopgap closure rule is lower, that is, $\hat{g}^{\text{sa}} < \hat{g}$;*
- (b) *The “undercapitalized” and “adequately capitalized” thresholds are both lower, that is, $g_1^{\text{sa}} < g_1$ and $g_2^{\text{sa}} < g_2$.*

Also, the stand-alone supervisor chooses a time interval between on-site examinations which is longer than that of the social planner, that is, $\theta^{\text{sa}}(g) > \theta(g)$, provided μ is sufficiently high.

There are three possible indicators of forbearance in our model. One is the cutoff point \hat{g} determining whether or not the bank is closed following the last examination. The other two are the g_1 and g_2 boundaries marking the three regimes at the time of the first examination. Based on these classifications and Proposition 4, we conclude that the stand-alone supervisor is too forbearing.

The final determinant of the “quality” of supervision is the time interval between on-site examinations. As the $(g_1^{\text{sa}}, g_2^{\text{sa}})$ region shifts to the left of (g_1, g_2) , this time interval is also affected. To the right of g_1^{sa} the supervisor leaves the bank open in situations where the social planner would otherwise close it, so $\theta^{\text{sa}}(g)$ is larger than $\theta(g)$. To the right of g_2^{sa} the supervisor relinquishes his right to monitor (the time interval is infinite) when the social planner would otherwise exercise it, so again $\theta^{\text{sa}}(g)$ is larger than $\theta(g)$. In between the result is less clear-cut. However, when μ is sufficiently high the stand-alone supervisor sets a longer time interval between on-site examinations.²¹ The rationale is as follows. Due to the political costs of bankruptcy, closing the bank preventively is less advantageous. Looking at it from time zero, the supervisor will save on audit costs and plan the second examination only when his cost advantage is the largest, i.e., when the bank is expected to be in a weak financial position, and this requires waiting longer.

4.2 Supervisory agency with deposit insurance responsibilities

As we saw above, the “quality” of supervision of a stand-alone supervisor differs from the social optimum in two important ways: there is excess forbearance and on-site examinations are too far apart. A problem with the stand-alone supervisor is that he does not account for the costs his policies might impose on the provider of deposit insurance. This suggests that mixing these two regulatory functions may improve supervision. One way of accomplishing this is to have a single agency with both supervision and deposit insurance responsibilities. An alternative would be to maintain the two agencies separated but make the first accountable for the losses that bank failures impose on the second.

In a few countries, deposit insurance agencies can intervene in a bank or take legal action against its managers, but this is a rare occurrence. In a recent survey, Barth, Caprio and Levine (2001) find out that, of the 60 countries which responded on this account, more than half do not in fact have such power. But even when no supervisory power is devolved to the deposit insurance system, supervisors may implicitly take into account the cost that bank failures impose on it. For example, Mishkin (1997)

²¹More precisely, there exists a function $\mu_c(\sigma, c_b/c_s, g/\bar{g})$ such that $\partial\theta/\partial c_s$ is positive whenever $\mu \geq \mu_c$. At $g = \hat{g}$, the critical value μ_c is negative except when both c_b/c_s and σ are large.

points out that the FDICIA requires that a report be produced by the supervisory agencies if a bank failure imposes costs on the FDIC. A key aspect of this institutional arrangement is that it improves supervisors' incentives to lean more on the standing of the deposit insurance system.

We next examine the policy of a supervisor entrusted with deposit insurance responsibilities and compare it with that of the stand-alone supervisor.²² The important difference between the two institutional arrangements is that under the new arrangement when the bank is closed, the supervisor has to reimburse one unit to depositors and is entitled to the asset liquidation value $g/(r - \mu)$, up to the outstanding claims held by insured depositors.

Consider first the stopgap policy at the time of the last examination. If the decision to close is made by the supervisor, the "preventive" cost is

$$C_s^{\text{di}}(g) = c'_s + \max \left\{ 1 - \frac{g}{r - \mu}, 0 \right\},$$

where g is the observed cash flow upon examination. Alternatively, if it is presented by bank shareholders, the expected "curative" cost is

$$C_b^{\text{di}}(g) = \left(c_b + 1 - \frac{\bar{g}}{r - \mu} \right) \left(\frac{g}{\bar{g}} \right)^\lambda,$$

where we have used the fact that the liquidation value of assets is less than deposits at $g = \bar{g}$. The stopgap policy is accordingly

$$\min \left\{ C_s^{\text{di}}(g), C_b^{\text{di}}(g) \right\} = C_b^{\text{di}}(g) - \Gamma_0^{\text{di},+}(g),$$

with $\Gamma_0^{\text{di},+}(g) = \max \left\{ \Gamma_0^{\text{di}}(g), 0 \right\}$ and corresponding immediate closure gain

$$\Gamma_0^{\text{di}}(g) = C_b^{\text{di}}(g) - C_s^{\text{di}}(g).$$

The stopgap policy rule \widehat{g}^{di} is given by the solution to $\Gamma_0^{\text{di}}(g) = 0$.

Next, consider the supervisor's cost function conditional on knowing g at the time of the first examination. The interpretation is the same as before and is skipped for brevity. We find

$$C^{\text{di}}(g) = C_b^{\text{di}}(g) \left(\frac{g}{\bar{g}} \right)^\lambda - \Gamma_1^{\text{di}}(g),$$

where the intervention gain is

$$\Gamma_1^{\text{di}}(g) = \max \left\{ \Gamma_0^{\text{di},+}(g), \sup_{\theta > 0} e^{-\tau\theta} E \left[\Gamma_0^{\text{di},+}(g\theta) - \xi; \tau \geq \theta \right] \right\}.$$

²²Since we have set $\gamma = 0$, we neglect the deposit insurance premium. Recall that throughout the paper the insurance premium is assumed to be exogenous.

The argument where the supremum is attained is noted $\theta^{\text{di}}(g)$.

If the supervisor closes the bank following the second examination, his immediate closure gain, $\Gamma_0^{\text{di}}(g)$, is now affected by an opportunity gain equal to the difference between the losses to be expected if the bank is closed later by shareholders and the actual losses if it is closed today. An important property of our model is that this amount, which we define as $\psi(g)$ with

$$\psi(g) = \left(1 - \frac{\bar{g}}{r - \mu}\right) \left(\frac{g}{\bar{g}}\right)^\lambda - \max\left\{1 - \frac{g}{r - \mu}, 0\right\}, \quad (11)$$

is positive for all levels of cash flow g . That is, supervisory intervention at the time of the second examination always brings relief to the deposit insurance agency. The following proposition shows that this provides the supervisor with insurance responsibilities with an incentive to be less forbearing than the stand-alone supervisor, at least when the bank is adequately capitalized.

Proposition 5 *Assume $C_b^{\text{di}}(g)|_{g=r-\mu} < c'_s$. Compared to a stand-alone supervisor, the policy of a supervisor vested with deposit insurance responsibilities is such that:*

- (a) *The stopgap closure rule is higher, that is, $\hat{g}^{\text{di}} > \hat{g}^{\text{sa}}$;*
- (b) *The “adequately capitalized” threshold is higher, that is, $g_2^{\text{di}} > g_2^{\text{sa}}$.*

The condition $C_b^{\text{di}}(g)|_{g=r-\mu} < c'_s$ implies that even with deposit insurance responsibilities the supervisor still does not close the bank at the time of the second examination when the value of its assets equals that of its deposits, that is, when $g/r - \mu = 1$. Allowing $C_b^{\text{di}}(g)|_{g=r-\mu}$ to be larger than c'_s will in general lead the supervisor to allow the bank to operate over *two* regions (g_a, g_b) and (g_c, g_d) and close it in between, preventing any meaningful comparison with the stand-alone case.²³

The results of Proposition 5 can be interpreted as follows. Adding one dollar to cash flows at the time of the second examination dilutes the prospect of the bank closing voluntarily, inducing supervisors to relax the stopgap closure rule. With deposit insurance responsibilities, however, the same unit increase also lowers deposit insurance losses, restoring part of supervisors’ incentives to close. Thus, the second-examination closure rule \hat{g}^{di} must lie to the right of the stand-alone supervisor’s \hat{g}^{sa} .

Consider next what happens at the time of the first examination. The supervisor has to compare the expected deposit insurance relief that will be obtained if he allows the bank to operate and happens

²³The issue arises because when the relief in deposit insurance losses is sufficiently large around $g = r - \mu$ the supervisor chooses to close the bank, even though he may “gamble for resurrection” on a range (g_a, g_b) to the left of $r - \mu$. This behavior will be examined in more detail in the next section.

to close it at the second examination with the current one. When $g = g_2$, the deposit insurance agency is currently fully protected and its standing can only deteriorate as time goes by. Therefore, entrusting the supervisor with a stake in deposit insurance liabilities gives him a good reason to be able to improve its standing in the future, i.e., to keep the bank under scrutiny by raising the adequately capitalized boundary g_2 .

The implications of making the supervisor accountable for deposit insurance losses for the other two endogenous variables of our model, g_1 and $\theta(g)$, are less clear, however. If g_1 is large, the current standing of the deposit insurance is still very good and provides the supervisor with one more reason to close immediately, i.e., to raise the undercapitalized threshold g_1 . If on the contrary g_1 is low, the deposit insurance agency is hardly entitled to any relief when the bank is closed. In this situation, the supervisor would rather gamble on the upside potential for good performance of the bank to alleviate deposit insurance losses, and this requires lowering g_1 . Naturally, the indeterminacy about g_1 funnels into the time to examination. It can be shown that if a marginal stake in deposit insurance losses increases the undercapitalized threshold, it also shortens the interval between examinations at that point. The indeterminacy about θ^{di} thus reflects that of g_1^{di} .

On the basis of Proposition 5, we conclude our welfare analysis by noting that vesting supervisors with deposit insurance responsibilities falls short of reversing all the effects produced by the assumed political cost of bankruptcy. Nevertheless, it unambiguously restores two of the three forbearance indicators. Supervisors are given improved incentives to monitor adequately capitalized banks following the first examination and to close them at the second examination.

5 The role of depositor-preference laws

In the beginning of the 1990s, deposit insurance in the United States went through several important changes in an attempt to reduce FDIC losses. In 1991, the FDICIA required that a least-cost resolution strategy be put in place, unless a systemic risk exemption could be invoked. As a result, the adopted resolution strategies have moved away from the traditional payoff method in order to shift the burden of losses on uninsured depositors. In 1993, the Omnibus Budget Reconciliation Act instituted depositor preference for all insured depository institutions. As a result, domestic depositors, and by extension the FDIC, became senior vis-à-vis foreign uninsured depositors and interbank suppliers of federal funds. These changes in the priority of bank claims had the effect of altering not only the relative costs of banks' funding sources and their stakeholders' discipline, but also the monitoring incentives of bank

supervisors. Yet, most of the literature on depositor-preference laws has turned its attention to the former effects. This section tries to bridge this gap by focusing on the impact of depositor preference on the monitoring incentives of a supervisor who is also accountable for the costs a bank failure may impose on the provider of deposit insurance.

In order to analyze the aforementioned impact of depositor preference, it is necessary for the bank to raise funding from creditors other than depositors. The presence of other creditors' claims in the bank's capital structure, however, opens up a vast array of issues.²⁴ For example, what will happen if the supervisor, in addition to taking into account the costs a bank failure imposes on deposit insurance, also considers the costs incurred by other creditors? If the supervisor only takes into account the impact of bankruptcy costs on deposit insurance, his monitoring incentives will be affected by, for example, the monitoring exercised by the other creditors.

In what follows, and to simplify the analysis, we consider only the case where the bank supervisor accounts for the costs a bank failure imposes on deposit insurance. Remember that the social costs c_s and c_b exclude the cost of reimbursing depositors. Moreover, given our interest in the impact of depositor preference on the supervisor's monitoring incentives, and given that the impact of this law on the cost of bank funding has been widely researched, we make the simplifying assumption that bank creditors charge the bank an exogenous interest rate.²⁵ We continue to assume that bank liabilities are equal to one unit, but now half of them are insured deposits, and the other half is comprised of uninsured deposits or interbank claims. We ensure comparability with the previous sections by normalizing all variables in terms of total liabilities instead of deposits. Under these conditions, the optimal social policy defined in Section 2 still applies.²⁶

These assumptions allow us to focus on the impact of depositor preference on the supervisor's monitoring incentives without having to take into account the impact of repricing that will also occur

²⁴There has been a great deal of interest focused on the proposals to require banks to issue subordinated debt. The focus of this literature, however, has been on the monitoring exercised by subordinated debtholders rather on the potential impact of their presence on the monitoring incentives of bank supervisors (see Board of Governors (1999) for a review of this literature).

²⁵See Hirschhorn and Zervos (1990), Osterberg (1996) and Osterberg and Thomson (1999) for an analysis of the impact of depositor preference on the cost of a bank's funding sources.

²⁶Implicit here is our assumption that the social planner takes into account the value of the bank, that of the deposit insurance agency, that of the bank's other creditors as well as audit and social bankruptcy costs.

as the non-deposit creditors, for example, switch from being senior to being junior.²⁷ Note that even in the absence of repricing, the simple presence of non-deposit claims will influence the monitoring incentives of a supervisor who accounts for deposit insurance losses, as the priority of deposit claims in bankruptcy is altered. A reason is that, as has been shown in the literature (see, for example, references in Footnote 10), creditors' incentives to monitor a borrower depend not only on the seniority of their claim but also on the financial condition of the borrower at the time they are able to exercise monitoring. A junior creditor, for example, has "good" incentives to monitor a financially sound borrower but has "poor" incentives to monitor a financially distressed borrower. When the financial condition of the borrower deteriorates beyond a certain point, the incentives of a junior creditor become aligned with those of the borrower.

This result seems to suggest that a depositor-preference law is detrimental to supervisors' incentives to monitor banks. For, if depositors had a junior claim, a supervisor with deposit insurance responsibilities would have a strong incentive to monitor a financially sound bank and he would not let the bank's financial condition deteriorate beyond a certain point. This arrangement complemented, for example, with a regulation requiring banks to be financially sound at the beginning of their operations would rule out those states where the supervisor has "poor" monitoring incentives. Implicit in this reasoning, however, is the assumption that the supervisor is able to monitor the bank's financial condition continuously. When, as in our model, continuous auditing is not feasible and the bank's financial condition changes between on-site examinations, a depositor-preference law may have conflicting effects on the monitoring that occurs at each examination vis-a-vis the social optimum.

The conflicts we want to illustrate can be put as follows. We use as short cuts the expressions "senior supervisor" and "junior supervisor" to refer to a situation where either insured depositors or other creditors are given preference, respectively. Suppose it is possible to require banks that start operations to have such a sound financial condition that a junior supervisor would choose at the first examination the optimal time to the next examination. Banks' financial condition, however, may deteriorate to a point where at the next examination the junior supervisor will decide to let them operate, although the social optimum would command that they should be closed and a senior supervisor would choose to do so. Similarly, for a different set of initial conditions, the senior supervisor can take the right decision at the first examination although, if the bank is allowed to operate and its situation

²⁷Note that under these conditions, if our supervisor were also to account for the losses that a bankruptcy imposes on the bank's creditors (other than the depositors) we would be back to the setting of Subsection 4.2.

improves, the junior supervisor would do better at the second examination. In what follows, and to simplify the analysis, we limit our study of depositor-preference laws to the illustration of these conflicts by contrasting the actions taken by the supervisor when depositors have opposite priority rights.

To facilitate the analysis, we introduce the indicator variable δ , which takes the value one when insured depositors have a senior claim vis-a-vis the other creditors over the bank's assets and zero when they have a junior claim. Taking these priority rules into account and building on the terminology introduced in the previous section, we reset the "preventive" and "curative" cost functions as

$$C_s(g, \delta) = c'_s + \min \left\{ \max \left(\frac{1}{2} - \delta \frac{g}{r - \mu}, 0 \right), \max \left(1 - \frac{g}{r - \mu}, 0 \right) \right\} \quad (12)$$

$$C_b(g, \delta) = \left(\Delta + C_s(\bar{g}, \delta) \right) (g/\bar{g})^\lambda, \quad (13)$$

respectively, where $\Delta = c_b - c'_s$ is the maximum cost reduction following early resolution and $(g/\bar{g})^\lambda$ is the discount factor. The immediate closure gain²⁸ is now

$$\Gamma_0^{di}(g, \delta) = C_b(g, \delta) - C_s(g, \delta).$$

5.1 Impact on the second-examination closure rule

Figure 3 displays the preventive and curative cost functions for $\delta = 0$ (junior supervisor) and $\delta = 1$ (senior supervisor) for a particular configuration of parameters.²⁹ The difference $C_b - C_s$, when positive, is the cost relief that can be obtained by supervisors when they close the bank at the time of the second examination.

The junior supervisor closes the bank if g is in the range $(\tilde{g}^j, \check{g}^j)$ and, in particular, when the bank just meets its debt obligations at $g = r - \mu$. He leaves the bank open when $g > \check{g}^j$. Important to note, however, is that when the bank financial condition is worse, that is, when g is in the range (\hat{g}^j, \tilde{g}^j) , the junior supervisor chooses to let the bank continue in operation. For even lower values of g , that is in the region (\bar{g}, \hat{g}^j) , the supervisor closes preventively in order to save on bankruptcy costs, as bank shareholders are about to pull out themselves.

In contrast, the senior supervisor winds up the bank in the range (\bar{g}, \hat{g}^s) and, in particular, when it is in financial distress at $g = (r - \mu)/2$. Note that, and this is the important result, when g is

²⁸The expressions for the corresponding deferred closure gain and related functions are omitted for the sake of brevity. They involve an additional term noted T , the expression of which is displayed in the proof of Proposition 3.

²⁹Parameters are set as in Section 3.1 with $c_s = 0.1$, $c'_s = 0.45$ and $c_b = 0.5$. For $c_s = 0.1$ the adequately capitalized threshold g_2 of the social planner is infinite.

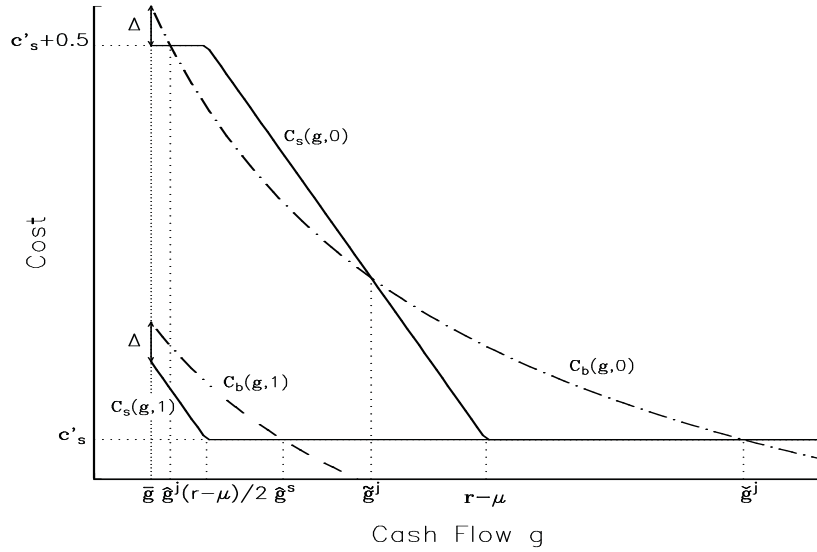


Figure 3: Bankruptcy costs with junior and senior rights.

in the range (\hat{g}^j, \hat{g}^s) , the bank is insolvent, the social planner would close the bank as would the senior supervisor, but the junior supervisor chooses instead to let the bank operate. The proposition below gives a sufficient condition for this to follow.

Proposition 6 *Assume $\sigma^2 > r + \mu$, $\gamma = 0$, $2c_s \leq c_b \leq 1/2$ and c'_s sufficiently close to c_b . Then, at the time of the second examination:*

- (a) *The socially optimum closure rule is higher than the insolvency level, that is, $\hat{g} > g^* = r - \mu$;*
- (b) *The junior supervisor's stopgap closure rule is as follows: He closes the bank in the ranges (\bar{g}, \hat{g}^j) and $(\tilde{g}^j, \check{g}^j)$, but leaves it open in the range (\hat{g}^j, \tilde{g}^j) and when $g > \check{g}^j$, with $\bar{g} < \hat{g}^j < g^*/2 < \tilde{g}^j < g^* < \check{g}^j \geq \hat{g}$;*
- (c) *The senior supervisor's stopgap rule is as follows: He closes the bank in the range (\bar{g}, \hat{g}^s) , and leaves it open when $g > \hat{g}^s$ with $g^*/2 < \hat{g}^s \geq \hat{g}$;*
- (d) *If $\hat{g}^s < \hat{g}$, there exists a range (\hat{g}^j, \hat{g}^s) where it is socially optimal to close the bank, the senior supervisor closes it and the junior supervisor opts to let it continue in operation.*

Our assumptions in the proposition above have the following interpretation. The first two have the effect of lowering the liquidation value $\bar{g}/(r - \mu)$ below one half, so that even senior creditors do

not get full protection. As shown in Section 3.1, such a low participation constraint obtains whenever shareholders attach a significant value to the option of abandoning the bank. The third assumption, $c_s \leq c_b/2$, is normative and ensures that the social planner will not allow insolvent banks to remain in operation at the time of the last examination. (Recall from Section 3.1 that the bank is insolvent when $g < g^*$ and that shareholders are always willing to maintain an insolvent bank as long as $g > \bar{g}$.) Finally, the condition $c_b \leq 1/2$ requires that insured deposits be at least as large as bankruptcy costs, so that supervisors lean significantly on the standing of the deposit insurance system.

Proposition 6 shows how a depositor-preference law can affect supervisors' incentives at the time of the second examination. The social planner would close banks forever in the range (\bar{g}, \hat{g}) . By comparison, the junior supervisor is too lenient with high-risk banks, that is in the range (\bar{g}, \tilde{g}^j) , although he makes the right decision in the insolvency region around $g = r - \mu$. In contrast, the senior supervisor makes the right decision concerning all high-risk banks, but can be much too forbearing regarding insolvent banks. For example, if deposit insurance losses do not outrun bankruptcy costs when the bank fails voluntarily,³⁰ one can show that $\hat{g}^s < \hat{g}$. Thus, neither supervisor can correctly implement the socially optimal "stopgap" policy when the preference legislation successfully contains the senior supervisor's exposure to deposit insurance losses.

5.2 Impact on the time to the next examination

Solving the model backwards, we now consider supervisors' decision regarding the time to the next examination when they first examine the bank. The time-to-examination functions are exhibited in Figure 4.

The supervisory policy of the senior supervisor conforms to the usual pattern. The bank is closed when its cash flow is less than g_1^s . The undercapitalized level is lower than the social optimum g_1 , and the time-to-examination function θ^s is uniformly higher than the socially optimal θ .

The situation is different for the junior supervisor. The undercapitalized level is now $g_1^j < g_1^s$. The time-to-next-examination function jumps abruptly and then decreases until g_2^j . Between g_2^j and g_3^j the bank is closed. At $g = g_1^j$, the junior supervisor weighs the downside risk of bad performance against the upside potential for good performance. The bank's financial position can improve. If it is declared insolvent at the time of the second examination, he will partake in the recoveries. There is more to gain from the upside potential than to lose from the downside risk. The junior supervisor chooses to wait a

³⁰The exact condition is $1/2 - \bar{g}/(r - \mu) \leq c_b$.

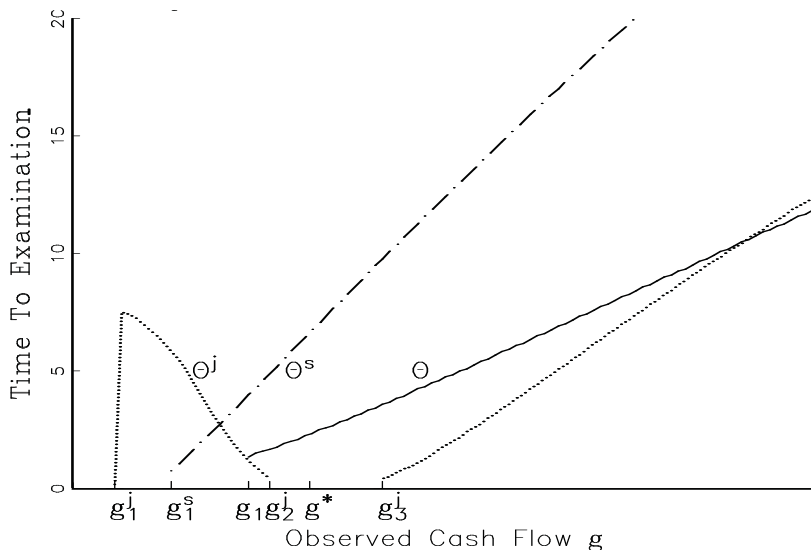


Figure 4: Junior vs. senior time to examination

long time.

Putting together the results of the last two subsections, we see that if we use the first-period $\theta(g)$ and the second-period \hat{g} as proxies for the frequency and stiffness of supervision, respectively, the senior supervisor is a relatively poor monitor for sound banks and the junior supervisor a relatively poor monitor for problem banks. Here, the qualification “poor” refers to the distance between the actual controls and the optimal values that a social planner would set. The thrust of our model is that neither supervisor can perform the best monitoring when the bank’s financial condition cannot be observed continuously.

6 Final remarks

We have identified the role of some key determinants of a trade-off that bank supervisors face when they have less information than banks: balancing the costs of supervision against their ability to monitor banks effectively. In doing that, we have focused on the impact of these determinants on the actions that supervisors can undertake, namely the time interval between on-site examinations and the corrective policies they apply at the time of examinations.

As one would expect, the way supervisors make these choices varies with their mandate as defined by the government. We saw, for example, that making an independent supervisor accountable

for the losses a bank failure imposes on the provider of deposit insurance in general reduces the excessive forbearance of the independent supervisor and may also improve the frequency of on-site examinations. However, when the bank is also financed with non-insured deposits a new array of issues arises. We chose to focus on the relative priority of creditors' claims. Several countries have made depositors senior vis-a-vis other creditors in an attempt to reduce the losses to the provider of deposit insurance. Researchers have already noted that these laws affect the relative cost of banks' funding sources. Our paper extends this literature by showing that they also affect the monitoring incentives of bank supervisors who are accountable for deposit insurance losses.

Our key insight in this regard is that when continuous auditing is not possible and the bank's financial condition may change between on-site examinations, depositor preference may have conflicting effects on the "quality" of bank supervision. Whatever the chosen priority rule, supervisors will apply their policies at different points in time, under possibly very different financial conditions of the bank. Therefore, the same set of conditions that motivate them to perform frequent on-site examinations at a given time may also lead them to be forbearing when the next examination comes, thereby increasing unexpected failures with the corresponding higher costs of bankruptcy.

To conclude, it is worth noting that the conflicting effects of a depositor-preference law we highlighted above in the context of bank supervision apply more broadly to a lender-borrower relationship because they derive from the general principle that a lender's monitoring incentives depend not only on the priority of his claim but also on the financial condition of the borrower at the time of monitoring. The literature on the design of bank loans often builds on this principle to explain the optimal priority of bank claims. Nonetheless, the conflicting effects we illustrated here are absent from this literature. A reason is that, in contrast to our model, this literature considers settings where the bank monitors the borrower only once during their lending relationship.

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Appendix

Proof of Proposition 1

Let \bar{g} be the closure point and $\tau = \inf \{t : g_t \leq \bar{g}\}$. The discount factor $h_1(g) = E[e^{-r\tau}]_{g(0)=g}$ solves $\mathcal{L}h_1 - rh_1 = 0$, where \mathcal{L} is the infinitesimal generator associated with the diffusion (1). The limit conditions are $h_1(\bar{g}) = 1$ and $\lim_{g \rightarrow \infty} h_1(g) = 0$. This yields $h_1(g) = (g/\bar{g})^\lambda$, where λ is the negative root of the characteristic equation $(\sigma^2/2)\lambda^2 + (\mu - \sigma^2/2)\lambda - r = 0$.

Shareholders' discounted net cash flows are

$$\begin{aligned} V(g) &= E \left[\int_0^\tau e^{-rt} (g_t - \rho) dt \right]_{g(0)=g} \\ &= \frac{g}{r - \mu} - E \left[e^{-r\tau} \int_\tau^\infty e^{-r(t-\tau)} g_t dt \right]_{g(\tau)=\bar{g}} - \frac{\rho}{r} (1 - h_1(g)) \\ &= \frac{g}{r - \mu} - \frac{\rho}{r} + \left(\frac{g}{\bar{g}} \right)^\lambda \left(\frac{\rho}{r} - \frac{\bar{g}}{r - \mu} \right), \end{aligned}$$

as desired. Finally, the optimal closure point \bar{g} follows from the smooth pasting condition $V'(\bar{g}) = 0$.

Proof of Proposition 2

Let $G(\theta, g)$ be the deferred closure gain derived from leaving the bank in operation till θ . One has

$$\begin{aligned} \frac{g}{r - \mu} - 1 - c_b \left(\frac{g}{\bar{g}} \right)^\lambda + \\ G(\theta, g) &= E \left[\int_0^\tau e^{-rt} (g_t - r) dt + e^{-r\tau} \left(\frac{\bar{g}}{r - \mu} - c_b - 1 \right); \tau < \theta \right] \\ &\quad + E \left[\int_0^\theta e^{-rt} (g_t - r) dt + e^{-r\theta} (\mathcal{W}_{AI}(g_\theta) - \xi); \tau > \theta \right], \end{aligned}$$

where ξ is the cost of auditing the bank. The first term is the social welfare obtained when the bank defaults before θ , the second the social welfare if the bank is still in existence at that time.

One can write

$$\begin{aligned} G(\theta, g) &= E \left[\int_0^\tau e^{-rt} (g_t - r) dt + e^{-r\tau} \left(\frac{\bar{g}}{r - \mu} - c_b - 1 \right) \right] \\ &\quad - e^{-r\theta} E \left[\int_\theta^\tau e^{-r(t-\theta)} (g_t - r) dt + e^{-r(\tau-\theta)} \left(\frac{\bar{g}}{r - \mu} - c_b - 1 \right); \tau > \theta \right] \\ &\quad + e^{-r\theta} E [\mathcal{W}_{AI}(g_\theta) - \xi; \tau > \theta] \\ &\quad - \left(\frac{g}{r - \mu} - 1 - c_b \left(\frac{g}{\bar{g}} \right)^\lambda \right). \end{aligned}$$

To evaluate the second expectation on the right-hand side, we condition on the information at θ

$$\begin{aligned} E & \left[\int_{\theta}^{\tau} e^{-r(t-\theta)} (g_t - r) dt + e^{-r(\tau-\theta)} \left(\frac{\bar{g}}{r-\mu} - c_b - 1 \right) \middle| \mathcal{F}_{\theta} \right] \\ &= \frac{g_{\theta}}{r-\mu} - 1 - c_b \left(\frac{g_{\theta}}{\bar{g}} \right)^{\lambda} \\ &= \mathcal{W}_{AI}(g_{\theta}) - \Gamma(g_{\theta}). \end{aligned}$$

Thus

$$G(\theta, g) = e^{-r\theta} E [\Gamma(g_{\theta}) - \xi; \tau > \theta],$$

from which the Bellman equation (4) is derived. Using (14) below, one can check that $\partial G / \partial g < 0$ at $(\theta(g), g)$. Thus $\Gamma(g) < \Gamma(\bar{g}) = c_b - c_s$. A necessary condition for G to be positive for some (θ, g) is $\xi < c_b - c_s$. This completes the proof.

Proof of Proposition 3

We compute expectations (under Q) of the form

$$K(t, g) = E [V(g_t); \tau \geq t]$$

for a given function V . Solving (1) yields $g_t = g \exp \{ (\mu - \sigma^2/2)t + \sigma \tilde{w}_t \}$. Using Girsanov's theorem, we can construct an equivalent probability P such that $w_t = \tilde{w}_t + \nu t$, where $\nu = (\mu - \sigma^2/2) / \sigma$, is a standard Brownian motion under P .

Under P , the expectation above takes the form

$$\begin{aligned} K(t, g) &= E^P [V(g_t) \eta_t; \tau \geq t] \\ &= E^P [V(g_t) \eta_t; \tau \geq t \text{ and } g_t \geq \bar{g}] \\ &= E^P [V(g_t) \eta_t; g_t \geq \bar{g}] - E^P [V(g_t) \eta_t; g_t \geq \bar{g} \text{ and } \tau < t], \end{aligned}$$

where $g_t = g \exp(\sigma w_t)$ and $\eta_t = \exp \{ \nu w_t - \nu^2 t / 2 \}$ is the density process of Q with respect to P . The first expectation on the right-hand side can be expressed as

$$\begin{aligned} H(t, g) &= E [V(g_t); g_t \geq \bar{g}] \\ &= E^P [V(g_t) \eta_t; g_t \geq \bar{g}] \\ &= \frac{e^{-\nu^2 t / 2}}{\sqrt{2\pi t}} \int_{\alpha}^{\infty} V(g e^{\sigma x}) e^{\nu x - x^2 / (2t)} dx, \end{aligned}$$

where we have put $\alpha = -\ln(g/\bar{g})/\sigma$.

The second expectation on the right-hand side can in turn be assessed by invoking the reflection principle

$$\begin{aligned} P(g_t \geq ge^{\sigma x}, \tau < t) &= P\left(w_t > x, \inf_t w < \alpha\right) \\ &= P\left(w_t < 2\alpha - x, \inf_t w < \alpha\right) \\ &= P(w_t < 2\alpha - x), \end{aligned}$$

so that $P(w_t \in dx, \tau < t) = (2\pi t)^{-1/2} \exp\left(- (2\alpha - x)^2 / (2t)\right) dx$. The change of variable $y = x - 2\alpha$ yields the formula

$$K(t, g) = H(t, g) - h(g)H\left(t, \frac{\bar{g}^2}{g}\right), \quad (14)$$

where $h(g) = (g/\bar{g})^{-2\nu/\sigma}$.

We now define the functions

$$\begin{aligned} R(t, g; \hat{g}) &= Q(\tau \geq t \text{ and } g_t \leq \hat{g}) \\ B(t, g; \hat{g}) &= e^{-rt} E\left[\left(g_t/\bar{g}\right)^\lambda; \tau \geq t \text{ and } g_t \leq \hat{g}\right] \\ \varphi(t, g) &= Q(\tau \geq t), \end{aligned}$$

and, for future reference, the function

$$T(t, g; \hat{g}) = e^{-\mu t} E\left[\frac{g_t}{g}; \tau \geq t \text{ and } g_t \leq \hat{g}\right].$$

Using the notation

$$\begin{aligned} w &= -\nu\sqrt{t} - \frac{\ln(g/\bar{g})}{\sigma\sqrt{t}}, & z &= -\nu\sqrt{t} + \frac{\ln(g/\bar{g})}{\sigma\sqrt{t}}, \\ u &= \kappa\sqrt{t} - \frac{\ln(g/\bar{g})}{\sigma\sqrt{t}}, & v &= \kappa\sqrt{t} + \frac{\ln(g/\bar{g})}{\sigma\sqrt{t}}, \end{aligned}$$

where $\kappa = \sqrt{2r + \nu^2}$, we apply repeatedly (14) with the appropriate H functions to get

$$\begin{aligned} R(t, g; \hat{g}) &= \Phi\left(w + \frac{k}{\sqrt{t}}\right) - \Phi(w) - h(g)\left[\Phi\left(z + \frac{k}{\sqrt{t}}\right) - \Phi(z)\right] \\ B(t, g; \hat{g}) &= h_1(g)\left[\Phi\left(u + \frac{k}{\sqrt{t}}\right) - \Phi(u)\right] - h_2(g)\left[\Phi\left(v + \frac{k}{\sqrt{t}}\right) - \Phi(v)\right] \\ T(t, g; \hat{g}) &= \Phi\left(w + \frac{k}{\sqrt{t}} - \sigma\sqrt{t}\right) - \Phi(w - \sigma\sqrt{t}) \\ &\quad - \left(\frac{g}{\bar{g}}\right)^{-(1+\frac{2\mu}{\sigma^2})}\left[\Phi\left(z + \frac{k}{\sqrt{t}} - \sigma\sqrt{t}\right) - \Phi(z - \sigma\sqrt{t})\right], \end{aligned}$$

where $k = \ln(\widehat{g}/\overline{g})/\sigma$, $h_2 = h/h_1$ and Φ is the cumulative normal distribution. In particular,

$$\begin{aligned}\varphi(t, g) &= R(t, g; \infty) \\ &= \Phi(-w) - h(g)\Phi(-z).\end{aligned}$$

The results of Proposition 3 follow by noting that G_1 in (6) can be written as

$$G_1(t, g) = c_b B(t, g; \widehat{g}) - e^{-rt} c_s R(t, g; \widehat{g}) - e^{-rt} \xi \varphi(t, g).$$

Proof of Proposition 4

(a) The second-period threshold is $\widehat{g} = \overline{g}(c_s/c_b)^{1/\lambda}$ and the first-period boundaries g_1 and g_2 are given in Proposition 2. In taking derivatives, we repeatedly use the fact that the partial derivatives $\partial G_1/\partial t$ and $\partial G_1/\partial \widehat{g}$ are zero at $t = \theta(g)$ and $\widehat{g} = \overline{g}(c_s/c_b)^{1/\lambda}$. It is clear that $\partial \widehat{g}/\partial c_s < 0$.

(b) For g_1 we have

$$\frac{\partial g_1}{\partial c_s} = \frac{1 + \partial G_1/\partial c_s}{\partial \Gamma_0/\partial g - \partial G_1/\partial g}.$$

The numerator is positive because $\partial G_1/\partial c_s = -e^{-rt} Q(\tau \geq t \text{ and } g_t \leq \widehat{g})$ is larger than -1 . Since the denominator is negative, $\partial g_1/\partial c_s < 0$. For g_2 we have

$$\frac{\partial g_2}{\partial c_s} = -\frac{\partial G_1/\partial c_s}{\partial G_1/\partial g} < 0.$$

(c) The first-order condition for θ is $\partial G_1/\partial t = 0$. Thus

$$\frac{\partial \theta}{\partial c_s} = -\frac{\partial^2 G_1/\partial t \partial c_s}{\partial^2 G_1/\partial t^2} = \frac{e^{-r\theta}(\partial R/\partial t - rR)}{\partial^2 G_1/\partial t^2}.$$

If $\partial R/\partial t$ is negative, then $\partial \theta/\partial c_s > 0$ and the proposition follows. We provide a sufficient condition under which both $\partial R/\partial t$ and $\partial B/\partial t$ are negative.

Let $k = \ln(\widehat{g}/\overline{g})/\sigma$ and $q = \ln(g/\overline{g})/\sigma$ and for any $\beta > 0$ define the function

$$F(t; \beta) = \beta t \left(1 - e^{-2kq/t}\right) + q - k + (q + k)e^{-2kq/t} - 2qe^{k\beta - kq/t + k^2/(2t)}.$$

After some manipulation, we find that B_t has the sign of $F(t; \kappa)$, where, as in the proof of Proposition 3, $\kappa = \sqrt{2r + \nu^2}$, and that R_t has the sign of $F(t; -\nu)$. Moreover, $F(t; \kappa) - F(t; -\nu)$ has the sign of $c_b B_t - e^{-rt} c_s R_t$, which is negative at θ according to the first order condition.

It can be verified that $F(t, \beta)$ is always negative when $q < k/2$, that the difference $F(t; \kappa) - F(t; -\nu)$ is first positive and eventually negative when $q > k/2$ and that, if the two curves $F(t; \kappa)$ and

$F(t; -\nu)$ intersect below the horizontal axis, both B_t and R_t are negative. The envelope of $F(t; \beta)$ as β varies is found for $\beta = \phi(t)$ with

$$\phi(t) = \frac{q - k/2}{t} + \frac{1}{k} \ln \frac{1 - e^{-2kq/t}}{2kq/t}.$$

Substituting in F , we find the envelope

$$\bar{F}(t) = 2q - \left(1 - e^{-2kq/t}\right) \left(\frac{3k}{2} + \frac{t}{k} \left(1 - \ln \frac{1 - e^{-2kq/t}}{2kq/t}\right)\right).$$

The intersection between $F(t; \kappa)$ and $F(t, -\nu)$ lies below the horizontal axis if $-\nu < \kappa < \kappa_c = \phi_c$, where $\phi_c = \theta_c(k, q)$ is the unique solution to $\bar{F}(t) = 0$. Given that $\nu = (\mu - \sigma^2/2)/\sigma$, this can be written equivalently as $\mu \geq \mu_c(\sigma, c_b/c_s, g/\bar{g})$ where the critical value is $\mu_c = \sigma^2/2 - \sigma\sqrt{\phi_c^2 - 2r}$.

Proof of Proposition 5

To carry out the comparative statics analysis, we extend Γ_0^{di} as

$$\Gamma(g, \alpha) = \left(c_b + \alpha \left(1 - \frac{\bar{g}}{r - \mu}\right)\right) \left(\frac{g}{\bar{g}}\right)^\lambda - \left(c'_s + \alpha \left[1 - \frac{g}{r - \mu}\right]^+\right),$$

so that $\Gamma_0(g) = \Gamma(g, 0)$ and $\Gamma_0^{\text{di}}(g) = \Gamma(g, 1)$. We want to show that $\partial\hat{g}^{\text{di}}/\partial\alpha$ and $\partial g_2^{\text{di}}/\partial\alpha$ are positive for all $\alpha \in [0, 1]$.

(a) Consider first the stopgap closure rule $\hat{g}^{\text{di}}(\alpha)$, which solves $\Gamma(g, \alpha) = 0$. The condition $C_b^{\text{di}}(r - \mu) < c'_s$ ensures that this equation has a unique solution below $r - \mu$. We have $\partial\hat{g}^{\text{di}}/\partial\alpha = -(\partial\Gamma/\partial\alpha)/(\partial\Gamma/\partial g)$. The numerator $\partial\Gamma/\partial\alpha$ is given by $\psi(g)$ in (11). The function ψ vanishes at $g = \bar{g}$, is convex on the interval $(\bar{g}, r - \mu)$ and positive on $g > r - \mu$. Moreover, by Proposition 1,

$$\frac{\bar{g}}{r - \mu} = \frac{-\lambda}{1 - \lambda} \frac{\rho}{r} \geq \frac{-\lambda}{1 - \lambda},$$

and this implies $\psi'(\bar{g}) \geq 0$. Thus $\psi(g)$ is positive for all $g > \bar{g}$. Since the denominator $\partial\Gamma/\partial g$ is negative at $g = \hat{g}(\alpha)$, the result follows.

(b) The threshold g_2^{di} is given by

$$G(\theta(g_2^{\text{di}}), g_2^{\text{di}}, \alpha) = 0,$$

where the deferred closure gain G is derived from Γ_0^{di} as usual by

$$G(\theta, g, \alpha) = e^{-r\theta} E [\Gamma_0^{\text{di}}(g_\theta); \tau > \theta \text{ and } g_\theta \leq \hat{g}^{\text{di}}] - e^{-r\theta} \xi\varphi(\theta, g).$$

We have $\partial g_2^{\text{di}}/\partial\alpha = -(\partial G/\partial\alpha)/(\partial G/\partial g)$. The denominator is negative and $\partial G/\partial\alpha = \Psi(\theta^{\text{di}}(g_2^{\text{di}}), g_2^{\text{di}})$ where

$$\Psi(\theta, g) = e^{-r\theta} E [\psi(g_\theta); \tau > \theta \text{ and } g_\theta < \hat{g}^{\text{di}}].$$

The integrand is positive for all $g \geq \bar{g}$. Thus $\partial g_2^{\text{di}}/\partial \alpha > 0$.

Proof of Proposition 6

(a) We have $\hat{g} > g^*$ if and only if $(-\lambda/(1-\lambda))^\lambda < c_b/c_s$. But $\lambda > -1$ when $\sigma^2 > r + \mu$ and $\gamma = 0$, so $(-\lambda/(1-\lambda))^\lambda < 2 \leq c_b/c_s$.

(b) Since $\bar{g}/(r-\mu) < 1/2$, the condition $\hat{g}^j < g^*/2$ is met when c'_s is sufficiently close to c_b . Next, the condition $C_b > C_s$ at $g = r - \mu$ and $\delta = 0$ is equivalent to $(c_b + 1/2)((r - \mu)/\bar{g})^\lambda > c'_s$. Using the definition of \bar{g} in Proposition 1, we find that the rate paid by the bank per unit of deposits must be such that

$$\frac{\rho}{r} > \frac{1-\lambda}{-\lambda} \left(\frac{c_b + 1/2}{c'_s} \right)^{1/\lambda}. \quad (15)$$

We now show that the right-hand side of (15) is less than one. Since $\rho \geq r$, this will imply that the inequality is met. The right-hand side of (15) is less than one if $c_b > c'_s(-\lambda/(1-\lambda))^\lambda - 1/2$. The function $\phi(\lambda) = (-\lambda/(1-\lambda))^\lambda$ is decreasing over $\lambda > -1$ and $\phi(\lambda) < \phi(-1) = 2$. Together with $c'_s \leq 1/2$, this implies that $(-\lambda/(1-\lambda))^\lambda c'_s < c'_s + 1/2$. It follows that $c_b > c'_s > (-\lambda/(1-\lambda))^\lambda c'_s - 1/2$, as desired. So (15) is satisfied.

(c) Similarly for the senior case, the condition $C_b > C_s$ at $g = (r - \mu)/2$ and $\delta = 1$ is equivalent to $c_b > c'_s((2\bar{g}/(r - \mu))^\lambda + \bar{g}/(r - \mu) - 1/2)$. Define the function f as $f(x) = c_s x^\lambda + (x - 1)/2$ and let $x^* < 1$ solve $f(x^*) = c_b$. The last inequality can be rewritten in terms of the rate paid by the bank as

$$\frac{\rho}{r} > \frac{1-\lambda x^*}{-\lambda} \frac{1}{2}. \quad (16)$$

Requiring the right-hand side of condition (16) to be less than one is equivalent to $c_b > f(-2\lambda/(1-\lambda))$.

Now the function

$$\phi(\lambda) = \frac{1/2 + \lambda/(1-\lambda)}{(-2\lambda/(1-\lambda))^\lambda - 1}$$

is increasing and $\phi(\lambda) > \lim_{\lambda \downarrow -1} \phi(\lambda) = 1/2$. Together with $c'_s \leq 1/2$, this implies that $c'_s < \phi(\lambda)$ or, equivalently, $f(-2\lambda/(1-\lambda)) < c'_s < c_b$ and (16) is true.

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