Reputational Contagion and Optimal Regulatory Forbearance.*

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Abstract

This paper examines common regulation as a cause of interbank contagion. Studies based on the correlation of bank assets and the extent of interbank lending may underestimate the likelihood of contagion because they do not incorporate the fact that banks have a common regulator. In our model, the failure of one bank can undermine the public's confidence in the competence of the banking regulator, and hence in other banks chartered by the same regulator. Thus depositors may withdraw funds from other, unconnected, banks. The optimal regulatory response to this 'panic' behaviour can be privately to exhibit forbearance to a failing bank in the hope that it - and hence other vulnerable banks - survives. In contrast, public bailouts are ineffective in preventing panics and must be bolstered by other measures such as increased deposit insurance coverage. Regulatory transparency improves confidence ex ante but impedes regulators' ability to stem panics ex post.

JEL Classification: G21, G28

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1. Introduction

In this paper we show that regulator reputation can be a conduit for financial contagion. In our model the failure of one bank can cause depositors to withdraw from another, even when the returns on the assets in which the banks invest are uncorrelated and there is no interbank lending. The reason for this is that, if the regulator has a poor initial reputation, a bank failure may cause depositors to lose confidence altogether in its ability to discriminate between good and bad banks. When depositors rely upon the regulator to screen out unsound banks, they respond to a loss of confidence in the regulatory system by abandoning the banking sector. Hence, banks in our model can suffer contagious failure even if their observable "fundamentals" are unchanged.

We show that this effect can justify regulatory forbearance on unsound banks. The reason is that, for informational reasons, banks creditors (uninsured depositors in our model) do not capture all of the social value generated the bank in which they invest, and so as perceived bank quality drops, they withdraw their deposits from the bank at a quality threshold which is too high from a social point of view. Regulatory corrective action to close a weak bank reveals that the regulator has less skill in screening banks than previously expected. This reduces confidence in other banks screened by the same regulator, and in some circumstances triggers financial contagion and the closure of these banks, even though their intermediation remains socially valuable. Regulators can attempt to forestall this effect by secretly forbearing on the weak bank; this generates immediate social costs arising from resource misallocation but, in turn, it allows the regulator to manage its reputation so that the banking sector survives into the future.

This story is in contrast to the existing literature on the causes of financial contagion, which focusses on the effects of interbank lending and of correlation of bank asset portfolios. Nevertheless, we believe that it generates some insights into the financial crisis of 2007-08. One could argue that, in part, this crisis was triggered by a loss of faith in both US and EU regulators. For example, the introduction of the Basel II Accord significantly increased the importance that regulators ascribed to ratings information when assessing capital requirements. Emerging evidence of unreliable ratings for the structured finance assets that many banks hold on- and off-balance sheet (Coval, Jurek & Stafford (2009)) led to a loss of faith in regulatory assessments of banks.

We would further argue that the numerous recent bank rescues in the US and the EU can be understood in light as being at least partly designed to maintain depositor confidence in the banking system as a whole. Why else, for example, did the UK government rescue the Northern Rock Bank in September 2007? Or the German government rescue Hypo Real Estate? While interbank linkages are not public information, these banks did not appear to be “systemically important” in the traditional sense: in neither case did regulators, politicians, or the press argued that rescue was necessary because these banks were too connected” to be allowed to fail (in contrast to the bailout of AIG, for example). Nor were the asset holdings of these banks necessarily particularly representative of other banks in the system. Instead, government officials stressed the importance of maintaining depositor confidence in the financial system, and of avoiding contagion. This argument is consistent with our finding that, at least ex post, it may be socially optimal to forbear on fragile banks rather than to acknowledge a failure of regulation.[1]

[1] According to http://news.bbc.co.uk/1/hi/7653868.stm, the German government argued that it had acted to stop Hypo Real Estate’s collapse in order to avoid "incalculably large" damage to Germany and financial services providers in Europe; after an emergency meeting with the central bank, German Chancellor Angela Merkel said: "We tell all savings account holders that your deposits are safe. The federal government assures it." UK Chancellor of the Exchequer Alisdair Darling said that the decision to guarantee all deposits at Northern Rock (not just the amounts covered by the UK deposit insurance scheme) came because he wanted "to put the matter beyond doubt" and "because of the importance I place on maintaining a stable banking system and public confidence in it". The Financial Services Authority chairman Callum McCarthy welcomed the move, commenting, "The purpose

Our paper also explains why the UK bank Northern Rock suffered a depositor run when the Bank of England made a public announcement that it would provide emergency funding to Northern Rock as part of its lender of last resort function, while two other substantial UK commercial banks, HBOS and RBS, which it later emerged received secret bailouts, suffered no such run. When the evidence has emerged since the crisis that the UK authorities had provided these secret loans, some UK commentators expressed concern that the failure to reveal information about this loans might be perceived as dishonest;[2] whereas our work suggests that, on the contrary, the secrecy was welfare-enhancing, and was necessary to ensure the stability of the banking sector. In a nutshell, when regulators can be trusted to act in a welfare-maximising way, secret rescues allow a regulator to manage its reputation appropriately, whereas public rescues will inevitably result in reputational damage to the regulator and may force the regulator to adopt other costly measures to shore up the banking system such as increased capital requirements or enhanced deposit insurance coverage in order to maintain depositor confidence.

Thus, our paper demonstrates that it can be socially desirable that regulators engage in ex post "reputation management." However, such reputation management is not without costs: when the public anticipates such management it is less willing to deposit in the banking system ex ante. In some circumstances we conclude that it is socially better to design institutional arrangements so as to commit regulators not to forbear upon weak banks. Nevertheless, we are left with a parameter region within which it is ex ante optimal to allow regulators to manage their reputations so as to perpetuate the banking system.

This conclusion is in contrast to work by Boot & Thakor (1993), who examine a model of regulator reputation in which the regulator's reputational concern is purely selfish, so that regulatory forbearance is never an optimal policy. In our model forbearance is suboptimal for regulators with very strong reputations, because the banking system can survive a downward shock to regulatory reputation, and for those with very weak reputations, because they are so incompetent that a continuing banking sector generates no social benefit. However, regulators with intermediate reputations will forbear for non self-interested reasons in our model.

As noted above, the prior literature focusses on two sources of financial contagion: interbank lending and correlated bank portfolio returns. This work is complementary to our own in that it highlights other sources of contagion which may also have been important in the recent crisis. In the first class of models, starting

of this is not to save Northern Rock per se... It's to make sure that there's not a negative effect on the banking system overall," see http://news.bbc.co.uk/1/hi/business/6999615.stm.

[2]For example, Vince Cable, Treasury spokesman for the Liberal Democrats, described the secrecy as evidence of a "shocking cover-up." See http://news.bbc.co.uk/1/hi/8375969.stm

with Allen & Gale (2000), banks hold interbank deposits so as to insure themselves against idiosyncratic liquidity shocks. Banks that are ex post illiquid meet depositors' short-term liquidity demands by drawing down their deposits in ex post liquid banks. In this set-up, an aggregate liquidity shock to the banking sector results in a general attempt to liquidate interbank deposits; this causes system-wide contagion that would be absent if banks were prevented from holding interbank deposits. This suggests that, if the threat of an aggregate liquidity shock is large enough, large interbank deposits should be discouraged, because they threaten the stability of the system. Nevertheless, Leitner (2005) shows that interbank lending can commit banks to help other ailing banks ex post when ex ante it is desirable but impossible that they commit to do so. Hence, Leitner is able to show that interbank lending can be welfare-enhancing even if aggregate shocks are the only type of shock to hit the system. In Leitner's model the regulator's role is to coordinate private sector bailouts; such bailouts are feasible precisely when banks face the threat of contagion in the absence of an organised bailout.

Several more recent papers examine liquidity shocks and interbank lending in greater detail. Heider, Hoerova & Holthausen (2009) argue that liquidity crises arise when adverse selection problems between banks become acute. In their paper, the interbank market breaks down when risk levels are heightened and the quality of individual banks is unknown, so that sound banks elect to hoard liquidity rather than to lend it in the interbank market. Indeed, the 2007-09 financial crisis was characterised by heightened uncertainty regarding counterparty risk (see Gorton (2009) for a discussion of counterparty uncertainty in the market for mortgage-backed securities). In Diamond & Rajan (2009), liquidity shocks arise because households withdraw from banks; this results in high real interest rates, which in turn diminish investment. Diamond and Rajan show that any subsidy to correct this problem should be paid for by taxes on non-depositors, so as to ensure that it is not immediately reversed by further withdrawals. Freixas, Martin & Skeie (2009) argue that the optimal regulatory response to aggregate liquidity shocks involves monetary policy. They show that interest rates should be lowered during a crisis so as as to discourage liquidity hoarding, and they argue that short term rates in normal times should be high, so as to ensure that there are adequate levels of liquidity in the banking system. In related work, Allen, Carletti & Gale (2009) show that the price volatility caused by uncertain aggregate liquidity requirements is welfare reductive, and argue that this problem can be resolved through appropriate Open Market operations.

Rochet & Tirole (1996) have a different explanation for the regulator's acceptance of extensive interbank lending when such lending seems to increase the risk of a systemic failure. They argue that banks have superior ability to monitor one anothers' soundness, but that they will have incentives to do so only if they are engaged in significant lending to one another. Interbank lending thus has the advantage that each bank is forced to behave well or else it will not be able to borrow from other banks. In their model banks are arranged in a circle, within which each bank monitors its neighbours. As a result, the failure of one bank indicates that it was inadequately monitored, and hence that the monitor was itself inadequately monitored, and so on; the consequence is a systemic meltdown.

Our model is in contrast to this first class of models, since we make the simplifying assumption that there is no interbank lending or monitoring. Instead, the regulator should be monitoring the banks. Contagion can occur in our model even in the absence of interbank lending, because the failure of one bank may reflect poor regulatory monitoring, and hence casts doubt upon the soundness of other banks in the same regualtory system.

The second class of models of systemic banking failures focuses on the idea that the assets in bank porfolios are correlated, for example because banks within a country or region all invest in particular industries or regions. Crises occur when these assets have low returns; one could therefore argue that this type of crisis driven not by contagion across banks, but rather by fundamental shocks that hit all banks at the same time. For an example of such a model, see Acharya (2001). Other models that recognise the agency problem that exists between asset managers and their employers (e.g. Scharfstein & Stein (1990)) can also be applied to the banking industry to show that, in the face of yardstick type performance evaluation by bank investors, bank managers may have incentives to invest in assets that are too correlated from a social point of view. Contagion can occur in this type of environment if depositors are aware that bank assets are correlated and are unable to distinguish idiosyncratic from system-wide shocks. In Chari & Jagannathan (1988), for example, some depositors are informed about the true state of a bank's assets, and others are uninformed. When an uninformed depositor observes another depositor queueing to withdraw his deposits in a bank early, he is concerned that this may be for informational rather than personal liquidity reasons, and is inclined to join the queue himself. This can lead to a contagion effect across depositors and, in some circumstances, to an inefficient bank run. It is easy to see how the same type of effect could occur across banks if investors believe that bank assets are correlated, so that queues at one bank could signal that investors have bad news about the value of the fundamental asset held by both banks.

Acharya, Shin & Yorulmazer (2009) explain co-movement in asset prices as a consequence of restricted levels of arbitrage capital. In their work, capital moves slowly into impaired assets because its investment is limited by the level of investor expertise. This causes asset fire sales in crises, as a result of which the returns to investment in impaired assets increase, and so reduce the equilibrium prices of other investments.

Our model can be seen as endogenising the correlation of returns on bank assets not through slow-moving arbitrage capital, herding or other strategic behaviour on the part of banks, nor through the assumption of common investment opportunities or information. We abstract from all of these effects, yet depositors rationally anticipate that returns on bank deposits are correlated each bank's performance depends upon the regulator's ability, and the banks share a common regulator.

An extensive empirical literature attempts to quantify and compare the two sources of systemic risk mentioned above. The extent of contagion that might arise from inter-bank lending is usually assessed by taking actual or conjectured data on interbank exposures and "stress testing" it, by assuming that one or several banks' assets are impaired, and investigating the knock-on impact of this on other banks (see, for example, Mistrulli (2007) or Degryse & Nguyen (2007)). However, our model suggests that the risk of contagion may be underestimated by these studies, because they fail to account for the effect of a bank failure on *depositor confidence* in the regulator.

An alternative approach uses stock price information on banks. Hartmann, Straetmans & de Vries (2005) perform a detailed analysis of domestic and cross-border contagion among US and European banks 1992-2004, using techniques from multivariate extreme value theory to assess the probability of a crash in one bank's stock price conditional on other bank stocks or the market crashing. They find greater contagion risk among US than European banks, even though interbank exposures are typically higher in Europe, mainly because the risk of contagion between European banks in different countries is relatively low. According to our model, one might also explain this finding by the fact that banks in different European countries have different regulators. They also find that contagion risk seems to increase over time, perhaps because of greater financial integration. More recently, Gropp, Lo Duca & Vesala (2009) assess European banks' exposure to cross-border contagion by estimating the probability of a large change in a bank's distance to default as a function of large changes in foreign banks' distance to default using data from 1994-2003. They find evidence of cross-border contagion between large European banks, but not between small ones, and they find some evidence that contagion was increased by the introduction of the euro. The strength of these studies is that in using stock price data rather than data on interbank lending, they can in principle capture all the sources of contagion which affect equity holders. Gropp et al note that a weakness of their estimations is that they are performed over relatively calm periods, so that the risk of contagion from under-represented shocks could be understated.

As they stand, these studies also do not make a strong distinction between the different sources of contagion affecting banks, although in principle, with sufficient data, their method might allow this. For example, if interbank lending drives contagion, then the extent of contagion between two banks should be related to the extent of interbank exposure between them. Similary, since in both Europe and in the US, some banks have different regulators to others (e.g., in Europe, bank regulation takes place at a national level whereas in the US, some banks are regulated by the Federal Reserve and others are regulated by the OCC) it should be possible to consider whether two banks with a common regulator have a greater correlation of shocks, ceteris paribus.

Like us, Kane (1989*b*) emphasises the importance of maintaining depositor confidence in the regulatory system, although he does so in a different context. Kane discusses the State's decision to bail out the Ohio Deposit Insurance Fund event. Contrary to popular belief at the time, the State was not a guarantor of this fund. Nevertheless, Kane argues that the State stepped in because, in light of its regulatory failure, the public deemed it responsible for the losses.[3]

The remainder of the paper is set out as follows. Section 2 presents our basic model. Section 3 shows how bank regulator reputation can serve as a conduit for financial contagion. Section 4 derives our basic results for regulatory forbearance. In section 5 we analyze an extension to our basic model in which the regulator can acquire a reputation for competent auditing of extant banks, and we show that concern for this reputation can in some circumstances override the regulator's concern for its ex ante screening reputation. Section 6 concludes.

2. The Model

We develop our argument in a simple two period model of a world populated by two types of risk-neutral agent: *bankers* and *depositors*. Period 1 runs from time 0 to time 1; period 2 runs from time 1 to time 2.

Each depositor starts each period with an endowment of \$1, which he can invest in one of two ways. First, he can place it in a riskless storage technology which yields a certain return of r. Second, he can invest it in a bank.

Banks are run by bankers, each of whom is endowed with a constant returns to scale project which occurs in either period 1 or period 2. Bankers in this model have no capital endowment. Projects return R per dollar invested if they succeed, and they otherwise return 0. A fraction σ of bankers are endowed with a monitoring technology: we refer to these bankers as *sound*, and to the remaining $(1-\sigma)$ as *unsound*. The

[3] In hindsight, the Savings and Loans crisis was the consequence of an enormously expensive failed gamble. Kane (1989*a*) and Rom (1996) also argue that this gamble was more a consequence of poor incentives hard-wired into the system than of the actions of individuals. Nevertheless, Kane also argues that individuals have a moral duty not to succumb to perverse systemic incentives.

effect of the monitoring technology is to increase the success probability of the project: one can think of monitoring as including activities such as advising the (unmodelled) project manager, eradicating agency problems, and so on. The success probability of projects is p_L if they are not monitored by the banker, and it is $p_H = p_L + \Delta p > p_L$ if they are monitored. The cost of monitoring a project is C per dollar invested in it, and monitoring is unobservable.

The relationship between the depositors and their bank is governed by a *deposit contract*, under the terms of which the banker pays the depositor a *deposit rate* of $R-Q$ if the project succeeds and 0 otherwise. The banker therefore earns a fee Q in the event that his bank succeeds. Bankers in our model have no capital and hence payments to depositors are impossible in case their projects fail.[4] There is no deposit insurance.

We assume that

$$Rp_H > r > Rp_L, \tag{1}$$

so depositors prefer investing in a sound bank to investing in the storage technology, and in turn prefer the storage technology to an unsound bank.

Suppose that depositors select a bank at random. If sound banks monitor, depositors' expected return from depositing in a randomly-selected bank will be $(R-Q)(p_L + \sigma\Delta p)$: they will choose not to deposit if this is less than their outside option, r. We assume that this is the case even when the fee Q for depositing is equal to zero:

$$\sigma < \frac{r - Rp_L}{R\Delta p}. \tag{2}$$

Equation (2) implies that in the absence of additional intervention, depositing is on average less socially productive than investment in the storage technology, and hence that all depositors will place their endowments in the storage technology.

We now introduce a *regulator*. In this simple model the regulator's only tool is an imperfect screening technology which allows it to distinguish between sound and unsound bankers.[5] Equation (2) implies that without regulation of this sort, there can be no banking sector. Note that, in the absence of any other regulatory activity, the regulator's role could be performed by a private screening body such as a ratings agency. However, when in section 4 we consider regulatory forbearance, the regulator is given the power to audit and to close failing banks. As we argue in the conclusion, this role is harder to delegate to a third party.

[4] We consider the impact of capital requirements in Morrison & White (2005).

[5] We examine the use of capital requirements and deposit insurance in related work: see Morrison & White (2005) and Morrison & White (2004).

The regulator uses its technology to allocate banking licences. Since we wish to show that it may in some circumstances be socially optimal for the regulator to forbear on failing banks, we assume that it has no selfish career-type concerns. We simply assume that the regulator aims to maximize social welfare, as measured by the total expected output from the economy. If the screening technology is sufficiently good, the expected gross return from bank investment will exceed that from investment in the storage technology and so the socially first-best outcome will be for all funds to be invested in the banking system. On the other hand, if the screening technology is poor, the banking system has no social value and value is maximised by potential depositors using the storage technology instead.

Although the regulator has no career concerns, our results are driven by its socially optimal concern for its reputation. We therefore assume that the same regulator is appointed for both periods of our model. For simplicity, we assume that it allocates a total of two bank licences. Bank 1 receives its licence at time 0, when it collects deposits and invests. Bank 1 operates for one period: it closes and pays returns to its depositors at time 1. Bank 2 operates from time 1 to time 2. Our substantive results would be unchanged if both banks operated throughout periods 1 and 2, but the algebra would be significantly more complex.

The licences are awarded in the following way. The regulator examines bankers one at a time and awards a licence to the first one for whom its technology returns a positive signal. Regulatory technologies are of two types: *good* regulators have a technology which sends the wrong signal with probability $\gamma \in \left(0, \frac{1}{2}\right)$; *bad* regulators have a technology which sends the wrong signal with probability $\frac{1}{2}$. At time 0 no one, including the regulator, knows which type of technology it has. All agents assign a common prior probability α that it is good. We refer to α as the regulator's *reputation*.

The regulator's reputation is updated in response to any signals that the depositors receive about bank 1's performance and the updated reputation will inform their attitude towards bank 2. We examine the updating process and its impact upon the period 2 bank in the following sections. In section 3 we assume that the regulator has no advance warning of impending bank 1 failure, and hence that it cannot act to prevent it. We demonstrate that in this case, the failure of bank 1 can result in the contagious failure of bank 2, even when such a run is socially undesirable. I

3. Contagious Bank Failures

We start by considering the contract that a bank will offer its depositors. Recall from equation (1) that depositors will invest in a bank only if it elects to monitor its investments. Since monitoring is unobservable, it will occur only if the return $Q(p_L + \Delta p) - C$ from monitoring exceeds the return Qp_L from not doing so: in other words, if the following monitoring incentive compatibility constraint is satisfied:

$$Q \geq \frac{C}{\Delta p}. \tag{3}$$

It is convenient to define $w(\alpha)$ to be the probability which the regulator and the depositors assign to the event that a reputation α regulator's screening technology yields the wrong signal: in other words, that it selects an unsound rather than a sound bank. Then

$$w(\alpha) \equiv \alpha\gamma + \frac{1}{2}(1-\alpha). \tag{4}$$

Note that $\frac{1}{2} \geq w(\alpha) \geq \gamma$, and $w'(\alpha) = \gamma - 1/2 < 0$.

When the regulator is wrong with probability w we write $\pi(w)$ for the probability that the regulator and the depositors place upon the bank being sound. Then, using Bayes' rule,

$$\begin{aligned} \pi(w) &= P\{\text{Sound bank} \mid \text{Sound signal from screening technology}\} \\ &= \frac{\sigma(1-w)}{(1-w)\sigma + w(1-\sigma)} = \frac{\sigma(1-w)}{\sigma - 2\sigma w + w}. \end{aligned} \tag{5}$$

Finally, let $U_D(w_t)$ and $U_R(w_t)$ be the respective per-period utilities which the depositors and the regulator derive from the time t bank:

$$U_D(w) = (R-Q)(p_L + \pi(w)\Delta p); \tag{6}$$

$$U_R(w) = R(p_L + \pi(w)\Delta p) - \pi(w)C. \tag{7}$$

Lemma 1 establishes some simple but useful facts about $U_D(w)$ and $U_R(w)$:

LEMMA 1. *Both $U_D(w)$ and $U_R(w)$ are monotonically decreasing in w, with $U_D(w) < U_R(w)$ and $U_R'(w) < U_D'(w)$.*

We assume that banking is socially desirable when $\alpha = 1$ and that it is not when $\alpha = 0$: in other words, $U_R(w(0)) < r < U_R(w(1))$, or

$$\sigma < \frac{r - Rp_L}{R\Delta p - C} < \frac{\sigma(1-\gamma)}{\gamma + \sigma - 2\gamma\sigma}. \tag{8}$$

Since $U_D(w) < U_R(w)$, there can be too little depositing, but there can never be too much. Equation (8) implies that depositing will never occur when $\alpha = 0$. We assume in addition that $U_D(\gamma) > r$, so that conditional upon sound bank monitoring, depositing will occur for sufficiently high regulator reputation. This

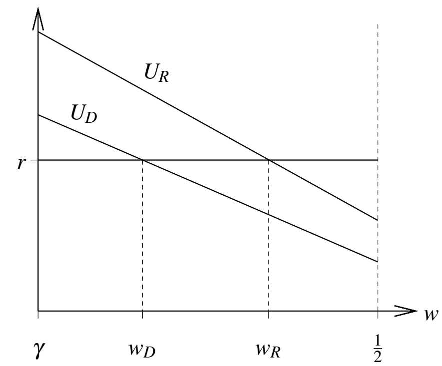

Figure 1: U_D and U_R are the utilities of depositors and regulators, respectively. If regulator reputation falls between w_D and w_R then banking is socially valuable, but depositors withhold their funds from the banks.

reduces to equation (9):

$$Q \leq R - r\frac{(1-\gamma)\,\sigma + \gamma(1-\sigma)}{p_H\sigma\,(1-\gamma) + p_L\gamma(1-\sigma)}. \tag{9}$$

Banking is possible for some regulator reputation precisely when equations (3) and (9) can be satisfied simultaneously: in other words, when

$$C \leq \Delta p\left(R - \frac{r\,(\gamma - 2\sigma\gamma + \sigma)}{(1-\gamma)\,\sigma p_H + \gamma(1-\sigma)\,p_L}\right). \tag{10}$$

We adopt equation (10) as an assumption.

Figure 1 plots the respective regulator and depositor welfares U_R and U_D as a function of the probability w of regulator error. We know from Lemma 1 that both functions are monotone decreasing with U_R dropping faster than U_D, and we know from equations (8) and (9) that both exceed r for $w = \gamma$ and both are less than r for $w = \frac{1}{2}$. Hence each curve has a unique intersection with r: we denote the intersection point of U_D by w_D, and the intersection point of U_R by w_R. Throughout the paper, terms that represent indifference points for depositors and for the regulator are represented with D and R subscripts, respectively.

For $w_D < w \leq w_R$ banking is socially valuable ($U_R > r$), but depositors are unwilling to deposit ($U_D < r$) and hence there is no banking sector. This is because depositors receive only a fraction $Q < R$ of the returns on successful bank investments and so fail fully to internalise their social benefits. We write α_D and α_R for the regulator reputations that correspond to the error probabilities w_D and w_R. Figure 2 illustrates α_R and α_D; the intermediate reputation range $\alpha_R < \alpha \leq \alpha_D$ in which banking is socially desirable but depositors are unwilling to deposit corresponds to the error probability range $w_D < w \leq w_R$. Expressions for w_D, w_R, α_D and α_R are derived in the appendix.

We now show that when first period reputation $\alpha > \alpha_D$, so that first period banking is possible, updating

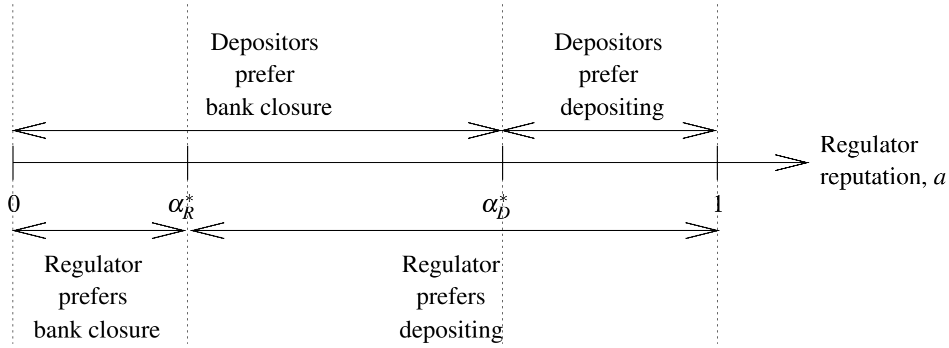

Figure 2: α_R and α_D are threshholds for the regulator's reputation, α. When $\alpha < \alpha_R$, the regulator and the depositor would both prefer the banking sector to close; when $\alpha \geq \alpha_D$, the regulator and the depositor would both prefer the banking sector to remain open. For reputation levels between α_R and α_D, the depositor would prefer not to depositor, even though it is socially optimal for depositing to occur.

regulatory reputation in the wake of first period bank failure may result in second period bank failure, even when this is socially suboptimal. We start by describing the process by which reputations are updated in the wake of bank failure: Lemma 2 provides expressions for the updated reputation.

LEMMA 2. *Suppose that in either period, the regulator's reputation is α when bank licences are allocated. Then the posterior reputation $\alpha_F(\alpha)$ after bank failure is given by equation (11):*

$$\alpha_F(\alpha) = \frac{\alpha\phi_G}{\alpha\phi_G + (1-\alpha)\phi_B}, \tag{11}$$

where

$$\phi_G = \frac{(1-p_H)\,\sigma\,(1-\gamma) + (1-p_L)\,\gamma(1-\sigma)}{\sigma - 2\sigma\gamma + \gamma} \tag{12}$$

is the probability that the bank fails conditional upon the regulator being good, and

$$\phi_B = (1-p_H)\,\sigma + (1-p_L)(1-\sigma) \tag{13}$$

is the probability that the bank fails conditional upon the regulator being bad. Moreover, $\alpha_F'(\alpha) > 0$: as the prior reputation drops, so does the posterior reputation after failure.

Clearly, if $\alpha_F(\alpha) < \alpha_D$ then first period bank failure will result in second period closure of the banking sector. This closure occurs not because the depositors have made a direct observation of some property of the second period banks, but because they have learned something about the regulator, and hence about the average quality of the second period banks. Hence, regulatory reputation serves in this model as a conduit for financial contagion. We summarise these remarks in Proposition 1.

PROPOSITION 1. *Let*

$$\alpha_C = \frac{\phi_B \alpha_D}{\phi_G (1-\alpha_D) + \phi_B \alpha_D}.$$

Then $\alpha_F(\alpha_C) = \alpha_D$. *Let* α *denote the first period regulator reputation. If* $\alpha_D < \alpha < \alpha_C$ *then first period banking will occur, but first period bank failure will cause a contagious closure of the second period banking sector. Moreover, if* $\alpha_F(\alpha) > \alpha_R$*, this contagion is socially damaging.*

Proof: Only the statement about α_C requires proof. It is derived by setting $\alpha_F(\alpha)$ equal to α_D, and solving for α. □

We have derived our results in this section in a simple model in which regulators cannot intervene in the banking sector after they have allocated banking licences. In the next section we extend our model to incorporate an ex post role for regulatory auditing.

4. Regulatory Forbearance

In the previous section, the regulator could only screen bank licence applicants, but could do nothing once a bank was chartered and its investments were in place. In this section, we introduce an auditing role for the regulator. We assume that at an interim date, after bank investments have been made, it is able to audit the bank to determine for sure whether it is sound or unsound. In addition, we endow the regulator with the power to close the bank at this stage it if this is socially optimal (for example, if it learns that the bank is unsound). The contagion effects highlighted in proposition 1 carry through to the richer model of this section. In addition, we can show that, although closing an unsound bank has a positive net present value, the regulator may in some cases neglect to do so because of concern regarding the impact on its reputation.

Regulatory auditing consists of such activities as scrutinising the books of the bank and examining its risk management systems. For the purposes of our model, we assume that the auditing technology each type of regulator possesses yields with probability λ a perfect signal of banker type.[6] The signal is accompanied by hard and verifiable data if the banker is unsound, but not if he is sound. This data allows the regulator to close down the bank, in which case a return L is realised per dollar invested, and is distributed amongst the bank's depositors. We assume that closure of banks is impossible without hard evidence, and hence that

[6] Thus the auditing technology is independent of the regulator's type. Relaxing this assumption would have little qualitative effect upon our results, but it would significantly complicate the analysis. In section 5 we allow the regulator to have a reputation for auditing as well as screening, so that some regulators are believed to be more competent auditors than others.

closure will never occur unless the audit has returned a poor signal. We assume that

$$r > L > Rp_L. \tag{14}$$

Hence the regulator will never wish to close down a sound bank (which is expected to return $Rp_H > r$), and *ceteris paribus* would prefer to close down an unsound bank (which is expected to return $Rp_L < r$ if it remains open).

We start by considering the second period. Since the game ends at the end of this period, the regulator has no reputational concerns and hence closes bank 2 precisely when their interim audit returns a bad signal. Analogous to equations (6) and (7), we can write $W_D(w)$ and $W_R(w)$ for the respective expected time 1 utilities of the depositor and the regulator when the regulator's screening is wrong with probability w:

$$\begin{aligned} W_D(w) &= U_D(w) + (1-\pi(w))\,\lambda\,(L-(R-Q)\,p_L)\,; \qquad (15)\\ W_R(w) &= U_R(w) + (1-\pi(w))\,\lambda\,(L-Rp_L)\,. \qquad (16) \end{aligned}$$

The following results are analogous to those of Lemma 1.

LEMMA 3. *Both $W_D(w)$ and $W_R(w)$ are monotonically decreasing in w, with $W_D(w) < W_R(w)$ and $W_R'(w) < W_D'(w)$.*

Note in addition that $W_D(w) > U_D(w)$ and $U_R(w) > W_R(w)$: the ability to audit renders depositing more attractive, and it raises aggregate welfare. It follows from equation (8) that there will always be a second period banking sector for sufficiently high time 1 reputation, α. We assume in addition that second period depositing will be unattractive even with auditing when α is sufficiently low: in other words, $W_R\left(\frac{1}{2}\right) < r$, or

$$(1-\sigma)\,(r-L+(1-\lambda)\,(L-Rp_L)) > \sigma\,(Rp_H - C - r)\,. \tag{17}$$

In this section, we denote indifference points for regulators and depositors with subscripts *LR* and *LD* respectively, where we use the *L* prefix to indicate that early liquidation is possible. Again by analogy to Section 3, there exist regulator reputations α_{LR} and α_{LD}, with $\alpha_{LR} < \alpha_{LD}$, such that the regulator prefers not to open a banking sector when its time 1 reputation is lower than α_{LR}, and the depositors refuse to deposit when the time 1 regulator reputation is lower than α_{LD}. α_{LR} and α_{LD} correspond to the values α_L and α_D that are illustrated in figure 2. Since $W_R > U_R$ and $W_D > U_D$ it is clear that $\alpha_{LR} < \alpha_R$ and $\alpha_{LD} < \alpha_D$: in other words, when there is a chance that unsound banks will be liquidated after they are audited, the expected returns from the banking sector are higher, and both the depositors and the regulator accept a banking system with a lower regulator reputation. We denote the error probabilities that correspond to α_{LR} and α_{LD} by w_{LR} and w_{LD}, respectively: expressions for w_{LR}, α_{LR}, w_{LD} and α_{LD} appear in the Appendix.

We now consider the effect of a closure upon regulator reputation. Recall from equation (11) that $\alpha_F(\alpha)$ is the regulator's posterior reputation after a bank failure. We write $\alpha_L(\alpha)$ for the regulator's posterior reputation after it liquidates a bank. Lemma 4 describes α_F and α_L.

LEMMA 4. *Suppose that the regulator has a prior reputation of α. Then its posterior reputation after it liquidates a bank is given by $\alpha_L(\alpha)$:*

$$\alpha_L(\alpha) = \frac{\gamma\alpha}{\gamma\alpha + \frac{1}{2}(1-\alpha)}.$$

Moreover, $\alpha_L(\alpha) < \alpha_F(\alpha)$.

The second part of this result says that the regulator's posterior reputation α_L after a liquidation is worse than its posterior reputation α_F after a failure. The intuition for this result is simple. When closure occurs, the depositors learn that the regulator knows for certain that the bank was unsound: this is a worse signal than a bank failure, which could occur with a sound bank. Hence $\alpha_L(\alpha) < \alpha_F(\alpha)$.

We are now examine the circumstances under which our social maximising regulator chooses to forbear on unsound period 1 banks.

4.1. Forbearance Equilibria

Define α^*_{CD} and α^*_{CR} as follows:

$$\begin{aligned} \alpha_L(\alpha^*_{CD}) &= \alpha_{LD}; \\ \alpha_L(\alpha^*_{CR}) &= \alpha_{LR}. \end{aligned} \tag{18}$$

Expressions for these terms appear in the Appendix. The asterix superscript coupled with the C subscript indicates a reputation that is updated to an indifference point; the agent to whom the indifference point applies is indicated by the second term in the subscript.

Whenever $\alpha < \alpha^*_{CD}$, second period banking will be impossible if the regulator decides to close bank 1 at the interim date. This is because α^*_{CD} is the period 1 reputation from which interim bank closure causes depositors to update their assessment of the regulator's reputation to a level at which they are just indifferent between investing in a period 2 bank and investing in the outside option. Depositors are unwilling to invest in bank 2 after bank 1 is closed for lower initial regulator reputations.

Note that when the interim period 1 audit demonstrates that the period 1 bank was unsound, the regulator updates its prior over its own reputation to $\alpha_L(\alpha)$ irrespective of whether it actually closes the bank. α^*_{CR} is the prior reputation after which this update will leave the regulator indifferent between maintaining a period 2 banking sector, and closing it down. Hence, the regulator will prefer to close down the period 2 banking sector after learning that the period 1 bank was unsound whenever $\alpha < \alpha^*_{CR}$.

Since $\alpha^*_{LD} > \alpha^*_{LR}$ and $\alpha'_L(\alpha) > 0$, we have that $\alpha^*_{CD} > \alpha^*_{CR}$. If the initial reputation α is such that $\alpha^*_{CD} > \alpha > \alpha^*_{CR}$, the closure of an unsound period 1 bank will result in closure of the period 2 banking sector, even though this is a socially undesirable outcome. To avoid this, the regulator could instead forbear on an unsound period 1 bank: in other words, it could elect not to close the period 1 bank, even though closure is positive NPV from the perspective of the first period bank. In exchange for giving up the value $L - Rp_L$ of early liquidation payoff, the regulator may manage to maintain a second period banking sector. For convenience, we refer to an economy in which this is the regulator's best action as exhibiting a *forbearance equilibrium*.

Note that in a forbearance equilibrium, depositors will extract no information from a regulator's failure to close the period 1 bank at the interim date. If the first period bank fails they will therefore update their priors over the regulator's reputation as in section 3, to $\alpha_F(\alpha)$. Define α^*_{FD} as follows:

$$\alpha_F(\alpha^*_{FD}) = \alpha_{LD}.$$

Once again, the asterix supercript on α^*_{FD} indicates that it is a prior reputation that is updated to an indifference point; the F subscript indicates that the relevant update is in the wake of a period 1 bank failure in a forbearance equilibrium. In other words, α^*_{FD} is the prior reputation at which period 1 bank failure in a forbearance equilibrium leaves depositors indifferent between investing in a period 2 bank, and taking their outside option. Period 1 bank failure therefore results in closure of the second period banking sector precisely when $\alpha < \alpha^*_{FD}$. It follows from Lemma 4 that $\alpha^*_{FD} < \alpha^*_{CD}$.

The updating process is illustrated in Figure 3. Recall that α_{LR} and α_{LD} are the respective time 1 regulatory reputations below which the regulator and the depositors regard bank 2 as untenable. The regulator updates its own reputation after learning from an audit that the period 1 bank is unsound; if the regulator's prior reputation is α^*_{CR} then it will be α_{LR} after updating. The depositors update their assessment of the regulator's reputation after observing a liquidation; they will be indifferent between depositing and not depositing after updating if their prior assessment of the regulator's reputation is α^*_{CD}. In the region $\alpha^*_{CD} > \alpha > \alpha^*_{CR}$, the regulator would prefer not to close the banking system after observing an unsound

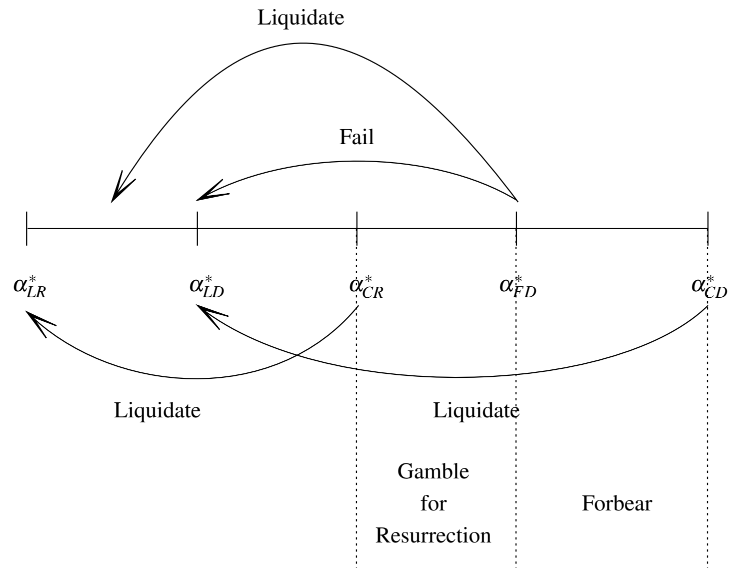

Figure 3: **Reputational updating when regulators can audit.** It is socially optimal to close banks after an audit reveals low type when the posterior regulator reputation is less than α^*_{LR}; depositors will withdraw their funds when the posterior reputation is less than $\alpha_{LD} > \alpha_{LR}$. Hence, when the posterior reputation is between α_{LR} and α_{LD} it may be socially optimal to forbeat on a low quality first period bank.

banker and updating its own assessment of its reputation, but it knows that liquidating the unsound bank 1 would result in the failure of bank 2. Hence, as discussed above, the regulator may elect to forbear on the first period unsound banker in order to maintain a second period banking sector.

The region in which forbearance might potentially occur can be divided into two parts. First, there is the region where the prior reputation α is less than α^*_{FD}, so that *failure* of a first period banker causes the regulator's reputation to be updated to a level below α_{LD}, and the banking system closes in the second period. Hence, if the regulator forbears when $\alpha < \alpha^*_{FD}$, it is relying upon the *success* of an unsound bank to ensure the survival of the banking sector. We refer to this behaviour as *gambling for resurrection*. It transpires that gambling for resurrection is never socially optimal:

LEMMA 5. *The socially optimal policy when $\alpha < \alpha^*_{FD}$ is to liquidate every bank that is revealed by an audit to be unsound.*

Proof: If the regulator forbears on a period 1 bank the expected return from that bank is Rp_L. When $\alpha < \alpha^*_{FD}$, there will be a second period banking sector precisely when the first period bank succeeds: this occurs with probability p_L. If there is a second period banking sector, the regulator uses the updated reputation

$\alpha_L(\alpha)$ to assess it, since it has observed that the period 1 bank is unsound. The expected social surplus generated by the second period banking sector is therefore $p_L W_R(w(\alpha_L(\alpha)))$. Forbearance is therefore optimal precisely when condition (19) below is satisfied. Since we know that $p_L W_R < p_L R < L < r$, this is never the case. To see the first of these inequalities, note that from the definition of W_R, $p_L W_R < p_L R$ reduces to $\pi(w)(\Delta p R - C) > R$, which is impossible.

$$\{R + W_R(w(\alpha_L(\alpha)))\}\, p_L > L + r. \tag{19}$$

□

The second potential forbearance region is the one to the right of α^*_{FD} in Figure 3. In this region, the prior reputation α is sufficiently low for time 1 liquidation to cause second period closure of the banking sector, and not so low that time 1 bank failure causes contagious failure of the second period bank. Since in this case time 1 forbearance cannot cause period 2 bank closure (because failure does not do so), the expected social return from forbearance increases to $Rp_L + W_R(w(\alpha_L(\alpha)))$; the social welfare from closure is $L + r$. Hence forbearance is optimal for $\alpha^*_{FD} \le \alpha \le \alpha^*_{CD}$ precisely when condition (20) is satisfied:

$$Rp_L + W_R(w(\alpha_L(\alpha))) > L + r. \tag{20}$$

Note that, as in the proof of Lemma 5, the regulator uses the updated reputation $\alpha_L(\alpha)$ to make the forbearance decision even though the depositors will not update in the forbearance equilibrium. The regulator makes the same inferences as the depositors, but has more (negative) information. Its decision to forbear arises because it internalises all of the benefits from monitoring, and the depositors do not.

Note that by definition, $Rp_L + W_R(w(\alpha_L(\alpha^*_{CR}))) = Rp_L + r < L + r$, so condition (20) fails for some $\alpha_{FBR} > \alpha^*_{CR}$. α_{FBR} is less than α^*_{FD}, so that forbearance occurs throughout the region $\alpha^*_{FD} \le \alpha \le \alpha^*_{CD}$ precisely when condition (20) is satisfied for $\alpha = \alpha^*_{FD}$. We prove in the Appendix that this is true precisely when condition (21) is satisfied:

$$\begin{aligned}(Rp_H - C - L)(1-\sigma)(r - L\lambda - (R-Q)(1-\lambda)p_L)& \\ -(r - Rp_L)(1-\sigma)((R-Q)(\Delta p + \lambda p_L) - L\lambda) -& \\ ((R-Q)p_H - r)(L - Rp_L)(1-\lambda)(1-\sigma) > 0.&\end{aligned} \tag{21}$$

It is clear from inspection of this condition that it is satisfied whenever $(r - L)$ and $(L - Rp_L)$ are sufficiently small.

Proposition 2 summarises the analysis of this section.

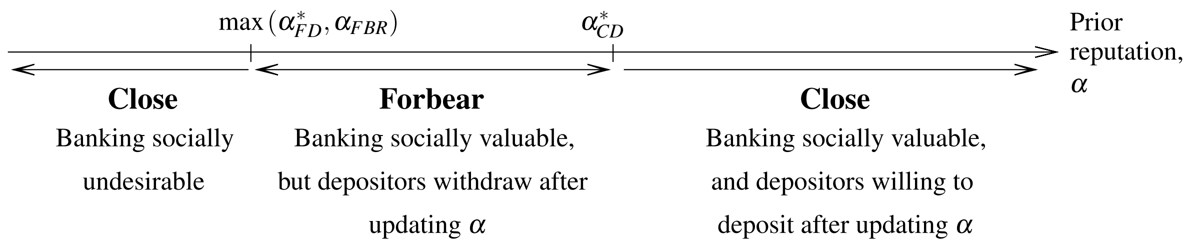

Figure 4: **Forbearance policy as a function of reputation.** If the regulator observes a bad bank then it lowers its own assessment of its ability α; if it closes the bank then depositors also lower their assessment of α, and as a result, they may refuse to deposit in the second period. If the prior α is low then, after observing a bad bank, the regulator no longer wants to run a banking sector, and it therefore closes the bank. It the prior α is high then the regulator's posterior reputation is still high enough to satisfy depositors, so, once again, it closes the bank. For intermediate α, the banking is valuable at the posterior reputation, but depositors are unwilling to deposit; the regulator therefore forbears upon bad banks so as to protect its reputation.

PROPOSITION 2. *Let α be the regulator's interim period 1 public reputation and suppose that that the regulator learns from the interim audit that the period 1 bank is unsound. Then there exists an α_{FBR} such that:*

1. *If $\alpha \geq \alpha^*_{CD}$ then the regulator closes down the bank and there is a second period banking sector;*
2. *If $\alpha^*_{CD} > \alpha \geq \max(\alpha^*_{FD}, \alpha_{FBR})$ then the regulator forbears and there is a second period banking sector;*
3. *If $\max(\alpha^*_{FD}, \alpha_{FBR}) > \alpha$ then the regulator closes down the bank and there is no second period banking sector.*

The Proposition is illustrated in Figure 4, which shows optimal ex post forbearance policy as a function of the regulator's reputation, α. The left hand side of this figure corresponds to part 1 of the proposition. The regulator does not exhibit forbearance in this region because, although closing the bad bank will will cause a contagious failure of the second period banking sector, the regulator no longer believes after updating its priors that a second period banking sector is socially worthwhile. The right hand side of the Figure corresponds to part 3 of the Proposition. In this region, the regulator's reputation is so strong that depositors remain willing to participate in the second period banking sector even after updatin their priors. The regulator therefore loses nothing in the second period by capturing the value $L - Rp_L$ of closing a first period unsound bank. Part 2 of the Proposition corresponds to the central region of the Figure. In this region, the regulator belives that a second period banking sector is worthwhile but depositors will not if the first period bank is closed and depositors update their priors accordingly. The regulator therefore chooses the sacrifice the immediate gain of $L - Rp_L$ from closing the first period bank, in order to ensure the survival of the second period banking sector.

In our model, the regulator does not have to supply any funds when it forbears on a bank: the regulator merely has to allow the bank to continue its operations when depositors would be better served by closing it. However, our model is isomorphic to one where closure yields zero, but the regulator would have to provide a loan of L at the interim date in order for bank 1 to remain open. This loan would make a loss of $L - Rp_L$ in expectation.

4.2. Numerical Example

We have constructed a numerical example of the phenomenon at the center of our analysis in Mathematica. When $R = 2$, $p_L = 0.3$, $p_H = 0.8$, $L = 0.61$, $r = 0.85$, $\sigma = 0.2$, $c = 0.3$, $\gamma = 0.1$, and $\lambda = 0.25$, all of the parameter restrictions that we consider are satisfied, and we have $\alpha^*_{CD} = 0.9722$, $\alpha_{FD} = 0.9222$, $\alpha^*_{CR} = 0.8152$, $\alpha^*_{LD} = 0.875$ and $\alpha^*_{LR} = 0.4688$. Moreover, $Rp_L + W_R(w(\alpha_L(\alpha^*_{FD}))) = 0.0717 > 0$ for these parameters. Hence, the forbearance region in this case extends all the way from α^*_{FD} to α^*_{CD}.

4.3. Policy Implications

(i) Public versus Private Bailouts

When National Westminster Bank was caught up in the UK secondary banking crisis of 1973, the Bank of England arranged a secret loan to tide the bank through its difficulties. The crisis passed, bank profits recovered and only a few insiders were ever aware of the extent of the banking sector's difficulties. In contrast, the Bank of England's support of Northern Rock in September 2007 was all too public. In comments to the UK Parliament, Mervyn King remarked that, although he believed it to be desirable, he was unable to arrange secret support for Northern Rock for fear of falling foul of EU rules on State Aid. These episodes suggest that there may be some benefits to allowing regulators the scope to effect secret forbearance. Our model allows us to compare the efficacy of such a regime with one where legislation forces the regulator's actions and information to be completely transparent.

In a transparent regime, if the regulator is forced to publicise any bad information that it receives, its reputation cannot be saved by forbearing on an unsound bank: the reputational damage was sustained as soon as depositors learned that an unsound bank was chartered. Therefore, the best the regulator can do is to maximise depositors' returns by promptly closing the bank and generating L rather than Rp_L. Since the regulator who has the power to secretly forbear could have chosen this action but choses not to do so for reputational values $\alpha \in [\max(\alpha^*_{FD}, \alpha_{FBR}), \alpha^*_{CD}]$, enforcing transparency is clearly strictly worse ex post than allowing secret bailouts.

Requiring transparency does have an ex ante benefit, however. When the regulator is allowed to undertake secret bailouts, bank 1 can be opened for any value of $\alpha > \alpha_D$. Whereas if secret bailouts are impossible, bank 1 can be opened for any value of $\alpha > \alpha_{LD}$, where $\alpha_D > \alpha_{LD}$. This is because when secret bailouts are impossible, depositors know that if bank 1 is unsound they will receive L rather than only Rp_L. Therefore they are more willing to invest, particularly when they have low confidence in the regulator's screening ability. This suggests that transparency is important in economies where there is little public trust in the regulator's ability, whereas secrecy may be preferable in economies where the regulator is perceived to be strong.

(ii) Capital Requirements and Deposit insurance

As remarked above, the episodes of "forbearance" that occurred in the 2007-08 financial crisis were played out in a glare of publicity. In our model, such publicity can make it impossible for bank 2 to open. In reality, it may be intolerable for an economy to suffer such a catastrophic loss of its banking system. Our model suggests that if the cause of a banking crisis is the reputational loss of the regulator, this damage cannot be undone overnight but will need to be rebuilt over a number of years. In the meantime, what measures can be put in place to shore up the banking system?

Morrison & White (2004) show that deposit insurance can be a useful instrument in this setting. In particular, they demonstrate that when - as here - the banking sector is socially too small, it is beneficial for the government to provide a subsidised deposit insurance scheme funded out of general taxation to encourage agents to deposit in banks.[7] They also show that deposit insurance should become more generous as the regulator's reputation deteriorates. Whilst for simplicity we do not incorporate deposit insurance explicitly into the current model, it is easy to see that in the present model it would be appropriate for the regulator to put in place a subsidised deposit insurance scheme as advocated by Morrison & White (2004), and further, that if the regulator is forced to publicise bad news at the interim date, then it would be

[7]Since everyone is risk neutral, subsidised recapitalisations are an equivalent remedy in their model. Unsubsidised measures, by contrast, are ineffective.

appropriate to increase the subsidy to the deposit insurance scheme to prevent the collapse of bank 2. This is the path that most developed country regulators have been following as the current crisis has progressed.

US and UK regulators have also responded to the crisis by instructing the banks under their supervision to raise more capital. In a static but more complex version of the present model Morrison & White (2005) demonstrate how tightening capital requirements can be an optimal response to a loss of confidence in regulatory screening or auditing ability. Introducing capital into the current model would be very involved because of the need to alter capital requirements in response to changes to the regulator's reputation. However, Morrison and White's (2005 analysis suggests that tighter period 2 capital requirements could be used to screen out unsound applicants. It would therefore be possible to run a small banking system when depositors have very little confidence in the regualtor.

Notwithstanding the above discussion, both capital requirements and general taxation in support of subsidised deposit insurance are costly instruments. Hence, neither instrument removes the need for reputation management by the regulator. Forbearing on a given bank (bank 1) may be less costly than raising deposit insurance or capital requirements for another (bank 2) after the first bank has been publicly liquidated.

(iii) Term Limits and the Separation of Regulatory Powers

We have already seen that preventing secret bailouts can be an optimal policy when the regulator's starting reputation is below α_D but above α_{LD}. One way to ensure that such reputation management does not occur is to separate the regulatory powers of screening and auditing on the one hand and bank closure on the other. For example, in the US, many banks are audited by the Federal Reserve or the OCC, but closure is undertaken by the FDIC. If the FDIC is unconcerned by the Federal Reserve reputation, this would make it more likely that bank closure will occur when this is socially optimal for depositors, and reduce forbearance (see Kahn & Santos (2005)). In the United Kingdom, regulatory powers are shared between the Financial Services Authority, which is responsible for the auditing and licence-granting of our model, the Bank of England, which has general responsibility for financial stability, and the Treasury. This so-called "Tripartite" system of regulation was criticised in the wake of the 2007 failure of the Northern Rock bank, because it was apparently unable sufficiently rapidly to commit to recapitalise and to bail out the Northern Rock bank. There criticisms may be valid for a number of reasons, but our analysis suggests that the tripartite arrangement's inability to accomodate rapid reponses may be optimal if the regulator's reputation falls in the range $\alpha_{LD} \leq \alpha < \alpha_D$.

In a similar vein, imposing term limits for regulators would reduce the scope for reputation management. In our model, replacing the regulator every period would remove the need for reputation management altogether. However, in a more complex model where the regulator has tacit knowledge and learns by doing, this effect would come at a cost. In any case, public confidence in developed country financial regulation has at least as much to do with the systems used to monitor banks as with the personnel that deploy them. Term limits for regulators may therefore be ineffective, and forcing frequent changes to regulatory systems is unlikely to be a practical proposition.

5. Auditing Reputation

In Section 4, early closure of a weak bank sends a worse signal about the regulator's competence than would be transmitted by the subsequent failure of a bank that was not closed. This allows us to make a clear point about regulatory forbearance, but it is intuitively hard to believe that a regulator that closed a failing bank would necessarily fare worse in the court of public opinion than a regulator that identified a problem early, and then moved to resolve it. In this section, we introduce a second dimension of regulator reputation, which is strengthened by the early closure of a bank. We demonstrate that gains to this dimension of reputation can outweigh the costs of the regulator's screening ability, and, hence, can ensure that the regulator adopts the optimal closure policy at time 1. This benefit comes at a cost, though: because failure sends a poor signal about auditing competence as well as screening ability, the region within which failure causes financial contagion expands.

We now assume that, in addition to its reputation for *ex ante* screening of banking licence applicants, the regulator has a reputation for interim auditing of bankers. Regulators can be *strong auditors*, in which case they receive a perfect signal of banker type with probability 1, or *weak auditors*, in which case their auditing never yields a signal of banker type. The regulator's auditing skill is independent of its screening skill.[8] The regulator's auditing type is unknown to regulators and to depositors at time 0, when all agents assess a common probability λ that the regulator is a strong auditor.

We start by considering the second period. Since the game ends at the end of this period, the regulator has no reputational concerns and hence closes banks precisely when their interim audit returns a bad signal. Suppose that the regulator's screening is wrong with probability w and that depositors assign a posterior probability λ' that the regulator is a strong auditor. In line with equations (15) and (16), the expected time 1

[8] We do not believe that relaxing this assumption would affect our qualitative conclusions, but it would render the algebra intractible.

utilities of the depositor and the regulator are given by equations (22) and (23):

$$W_D(w,\lambda') = U_D(w) + (1-\pi(w))\lambda(L-(R-Q)p_L); \tag{22}$$

$$W_R(w,\lambda') = U_R(w) + (1-\pi(w))\lambda(L-Rp_L). \tag{23}$$

As in Lemma 3, $W_D(w,\lambda')$ and $W_R(w,\lambda')$ are monotonically decreasing in w, with $W_D(w,\lambda') < W_R(w,\lambda')$ and $W_R'(w,\lambda') < W_D'(w,\lambda')$; moreover, $W_D(w,\lambda')$ and $W_R(w,\lambda')$ are both increasing in the regulator's posterior reputation λ' for auditing.

As in Section 4, we search for a Bayesian Nash equilibrium of the audit game. Assume for now that strong auditors close down weak banks in the first period; we exhibit below conditions under which this assumption is true in equilibrium. Then depositors update their prior that the regulator is a strong auditor after bank failure as follows:

$$\begin{aligned}
\lambda_f &\equiv \mathbb{P}[\text{Strong auditor}|\text{Failed bank}] \\
&= .\frac{\mathbb{P}[\text{Failed bank}|\text{strong auditor}]\,\mathbb{P}[\text{strong auditor}]}{\mathbb{P}[\text{Failed bank}|\text{strong auditor}]\,\mathbb{P}[\text{strong auditor}]+\mathbb{P}[\text{Failed bank}|\text{weak auditor}]\,\mathbb{P}[\text{weak auditor}]} \\
&= \frac{\lambda\pi(w)(1-p_H)}{\lambda\pi(w)(1-p_H)+(1-\lambda)(1-p_L-\pi(w)\Delta p)} \\
&= \frac{\lambda\pi(w)(1-p_H)}{(1-p_L)(1-\lambda(1-\pi(w)))+\pi\Delta p}.
\end{aligned}$$

To understand this expression, note that strong auditors never allow a weak bank to fail, and hence the probability of a failed bank when the auditor is strong is the probability $\pi(w)$ of a strong bank, multiplied by the probability $(1-p_H)$ that it fails.

The updated prior that the regulator is a strong auditor after bank success is calculated in an analogous fashion:

$$\lambda_s \equiv \frac{p_H\pi\lambda}{p_L\pi(w)\lambda+\pi\Delta} + (1-\lambda)p_L.$$

If the depositors observe a liquidation then they conclude that the regulator is a strong auditor, and their posterior assessment of λ' is 1 .

Simultaneous updating of the ex ante screening reputation α and the ex post auditing reputation λ introduces some complications into our analysis, which we illustrate in Figure 5. The figure is a two-dimensional analogue of Figure 3, illustrating α and λ'. The reputations α^*_{CD} and α_{LD} appear in Proposition 2. Recall that, when there is no updating of the prior λ, depositors are indifferent between depositing and not depositing for $\alpha = \alpha_{LD}$, that $\alpha_L(\alpha^*_{CD}) = \alpha_{LD}$, and that, in equilibrium without λ updating, the regulator liquidates banks when $\alpha < \alpha_{FBR}$, that it forbears for $\alpha_{FBR} > \alpha \geq \alpha^*_{CD}$, and that it liquidates for $\alpha \geq \alpha^*_{CD}$.

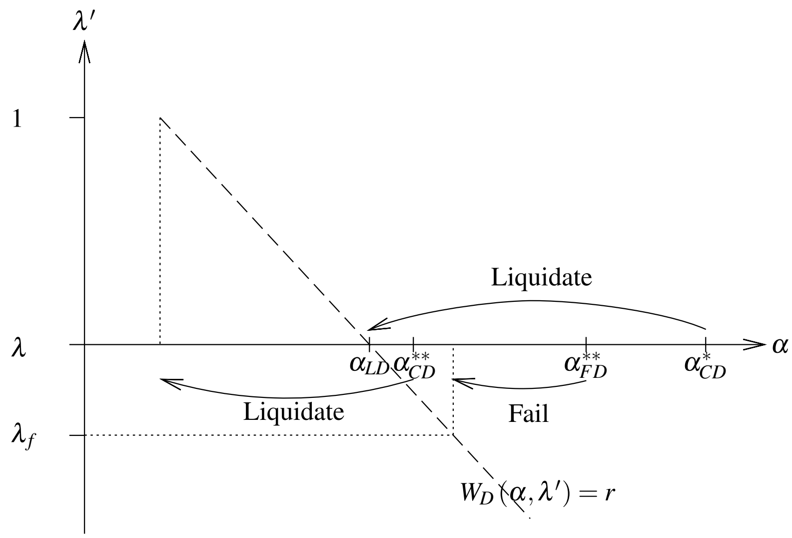

Figure 5: **Updating of screening and auditing abilities.** The regulator's screening reputation is denoted α; the prior auditing reputation is λ, and the posterior is λ'. The dashed line represents (α, λ') pairs for which the depositors are indifferent between depositing and their outside option; the line has a negative slope because, from the depositors' point of view, auditing and screening are substitutes.

The dashed line on the Figure illustrates the locus of (α, λ') values for which $W_D(\alpha, \lambda') = r$; that is, the locus of points at which the depositors are indifferent between depositing and their outside option. Note that this line passes through the point (α_{LD}, λ).

We define α_{CD}^{**} to be the prior screening reputation for which

$$W_D\left(\alpha_L\left(\alpha_{CD}^{**}\right), 1\right) = r.$$

That is, when there is updating of the regulator's auditing ability, α_{CD}^{**} is the prior screening ability for which the depositors are indifferent between depositing and their outside option after they have updated both their prior over the screening reputation and the regulator's auditing ability λ in the wake of liquidation. Note that, because the dashed line in Figure 5 slopes downwards, $\alpha_{CD}^{**} < \alpha_{CD}^{*}$.

When the interim audit uncovers bad news, liquidation is always the optimal strategy for the regulator when it does not result in second period closure of the banking sector. Moreover, the regulator cannot credibly commit not to act upon information that the audit uncovers. Lemma 6 therefore follows immediately.

LEMMA 6. *When the first period audit reveals that the bank is unsound, the regulator always liquidates when the prior screening reputation α is greater than or equal to α_{CD}^{**}.*

We define α_{FD}^{**} to be the prior screening reputation for which

$$W_D\left(\alpha_F\left(\alpha_{FD}^{**}\right), \lambda_f\right) = r.$$

Hence, α_{FD}^{**} is the prior screening reputation at which failure renders the depositors indifferent between depositing and their outside option, after updating their prior over screening ability and the regulator's outside ability. Note that, because $W_D(\alpha, \lambda)$ is increasing in α, we have $\alpha_{FD}^{**} > \alpha_{FD}^{*}$.

When $\alpha \geq \alpha_{CD}^{**}$, the regulator always liquidates after an audit reveals that the bank is unsound. Hence bank failure for these α causes the prior auditing reputation λ to be updated to λ_f, and Lemma 7 follows immediately.

LEMMA 7. *When $\alpha_{CD}^{**} < \alpha \leq \alpha_{FD}^{**}$, first period bank failure causes contagious failure of the the second period banking system.*

Lemma 7 identifies a cost of audit reputation updating: because $\alpha_{FD}^{**} > \alpha_{FD}^{*}$, the range of prior α values for which a first period bank failure results in the second period failure of the banking sector is greater than it is when the regulator's auditing reputation is not updated. On the other hand, because a strong auditing reputation substitutes for a weak screening reputation, the range of α values for which liquidation occurs in the wake of a bad first period audit is greater.

When $\alpha < \alpha_{CD}^{**}$, liquidation of the first period bank results in contagious failure of the second period banking system. The regulator therefore forbears in the circumstances under which it would have done so in Section 4, and there is no updating of λ.

Proposition summarizes the discussion of this section.

PROPOSITION 3. *Let α and λ be the regulator's period 1 reputations for auditing and screening respectively. There exist α_{CD}^{**} and α_{FD}^{**} with $\alpha_{CD}^{**} < \alpha_{CD}^{*}$ and $\alpha_{FD}^{**} > \alpha_{FD}^{*}$ such that:*

1. *If the regulator learns from the first period audit that the period 1 bank is unsound then:*
   (a) *If $\alpha \geq \alpha_{CD}^{**}$ then the period 1 bank is closed and there is a second period banking sector;*
      i. *If $\alpha_{FBR} \leq \alpha < \alpha_{CD}^{*}$ then the regulator forbears and there is a second period banking sector;*
      ii. *If $\alpha < \alpha_{FBR}$ then the regulator closes down the bank and there is no second period banking sector.*
2. *If the first period bank is not closed down then:*

(a) *If* $\max(\alpha_F^*, \alpha_{CD}^{**}) \leq \alpha < \alpha_{FD}^{**}$ *then there is a second period banking sector if the first period bank succeeds, but first period bank failure causes a contagious failure of the second period banking sector;*

(b) *If* $\alpha_F^* \leq \alpha < \alpha_{CD}^{**}$ *then there is a second period banking sector whether or not the first period bank succeeds;*

(c) *If* $\alpha < \alpha_F^*$ *then there is a second period banking sector if the first period bank succeeds, but first period bank failure causes a contagious failure of the second period banking sector.*

(d) *If* $\alpha \geq \alpha_F^*$ *then there is a second period banking sector whether or not the first period bank succeeds;*

The introduction of regulator reputations for auditing has two effects. First, it renders the regulator more willing to liquidate a bank that is revealed by an interim audit to be of low quality. The reason is that such a liquidation generates a positive signal of auditing ability, which serves to counteract the negative effect upon screening reputation of a bank closure. Hence the region covered by part 1(a) of Proposition 3 is larger than the region covered by part 1 of Proposition 2.

The second effect is that the set of α values for which first period bank failure causes contagious failure of the second period banking sector is greater. The reason is that first period bank failure is more likely to be evidence of an unsound bank, and hence to be evidence that the regulator is a poor auditor. When the first period bank fails for an α value at which a poor auditing signal would result in bank closure the regulator's reputations for both screening *and* auditing are impaired, and so contagious bank failure occurs for α values that would not experience it without an auditing reputation. This effect occurs in the region identified in part 2(b) of Proposition 3.

6. Conclusion

We have built a model in which investors are unable to reap all the rewards from their investment because moral hazard and adverse selection create a need for rents and incentive pay in the financial sector. The role of the bank regulator is to try to mitigate these problems suffiiciently to make investment in the banking sector attractive. The regulator's repuation - or perceived ability - to solve these problems is therefore an important asset: the size of the financial sector depends upon it. If the regulator's reputation declines too far, there will be a financial crisis as investors' trust in the system declines and they seek to withdraw their funds. We show that under these circumstances, it may be valuable for the regulator to be allowed secretly to exercise forbearance towards failing banks in order to conserve its reputation. Private rescues were not uncommon in the past but are difficult to achieve when regulation forces transparency and/or required bailouts are very large.

The need for private bailouts can be contrasted with the regulatory response to the recent crisis, when forbearance was very public. Public forbearance does not conserve the regulator's reputation ex post and so does not have the same benefits. Therefore, when forbearance is public, it may need to be supplemented by additional measures such as a tightening of capital requirements or an expansion of deposit insurance if the financial system is to be preserved. These additional measures are costly. Enforcing transparency on regulators does have an offsetting benefit, however, since it improves investors' confidence in the system ex ante as they know that all banks are sound and none are being privately supported by the regulator. Whether transparency or privacy is optimal ex ante depends on the regulator's initial reputation and the likely size of shocks to its reputation. Transparency is essential if the regulator's reputation is initially very low; otherwise, privacy and discretion may be socially preferable. In economies where transparency is difficult to achieve, term limits for regulators may be valuable in order to reduce the need for reputation management. A separation of powers between the body chartering an auditing banks and the body responsible for closing or liquidating them may achieve the same end.

The recent trend in finanial regulation has been towards a levelling of international playing fields by implementing common regulation in many different economies (Basle I and Basle II). Whilst common regulation has many benefits (Acharya 2003, Morrison and White 2009), our model shows that it also has a cost. Since contagion can occur between banks subject to common regulation (even if those banks have no interbank linkages and dissimilar assets), there is an argument to be made for maintaining regulatory diversity, so that not all banks in the financial system are subject to the same regulatory shocks.

In reality, the regulator's incentive to exhibit forbearance is clearly dependent on the systemic implications of a bank's failure, including the bank's size and interconnectedness. Our model is deliberately stark in order to show that the potential for contagion in our model is independent of these factors. Yet it is easy to imagine how the model might be extended to incorporate such features. Suppose that the failure of a large or highly connected bank would cause more disruption to the financial system. Then, other things being equal, the social welfare-maximising regulator of our model should devote more resources to monitoring such a bank. The failure of such a bank therefore sends a stronger signal about regulatory competence than the failure of a small unconnected bank, to which the regulator has devoted less time and attention; large bank failure hence has greater systemic implications than small bank failure. If so, it is rational for the regulator to follow a too big to fail policy of forbearing towards large institutions and being tough on small ones. Similarly, the regulator should forbear more with regard to institutions that it has a long history of monitoring, and less with regard to relatively young, or foreign, institutions that the regulator has monitored less and in which it has a smaller reputational stake. This would result in a policy of "too old to fail", and of more "tolerant" treatment of domestic banks than foreign subsidiaries.

Appendix

Proof of Lemma 1

Straightforward calculation yields the following equations:

$$\begin{aligned}
U_D'(w) &= -\frac{(R-Q)\,\sigma(1-\sigma)\,\Delta p}{(w-2w\sigma+\sigma)^2} < 0; \\
U_R'(w) &= -\frac{\sigma(1-\sigma)(R\Delta p-C)}{(w-2w\sigma+\sigma)^2} < 0; \\
U_R(w)-U_D(w) &= \frac{(1-w)\,\sigma(C-Qp_H)+Qw(1-\sigma)\,p_L}{\sigma-2\sigma w+w} > 0; \\
U_R'(w)-U_D'(w) &= -\frac{\sigma(1-\sigma)(Q\Delta p-C)}{(w-2w\sigma+\sigma)^2} < 0,
\end{aligned}$$

where the final inequality follows from equation (3).

Expressions for w_D, w_R, α_D, and α_R

w_D is found by setting $U_D(w)$ equal to r and solving for w. α_D is found by substituting the resultant w_D into equation (4) and solving for α. This procedure yields the following:

$$\begin{aligned}
w_D &= \frac{\sigma((R-Q)\,p_H-r)}{r-(R-Q)(p_L+\sigma\Delta p)+2\sigma((R-Q)\,p_H-r)}; \\
\alpha_D &= \frac{r-(R-Q)(p_L+\sigma\Delta p)}{(1-2\gamma)(r-(R-Q)(p_L+\sigma\Delta p)+2\sigma((R-Q)\,p_H-r))}.
\end{aligned}$$

The following expressions for w_R and α_R are found in an analogous fashion:

$$\begin{aligned}
w_R &= \frac{\sigma(Rp_H-C-r)}{\sigma(Rp_H-C-r)+(1-\sigma)(r-Rp_L)}; \\
\alpha_R &= \frac{r-(Rp_L+\sigma(R\Delta p-C))}{(1-2\gamma)(\sigma(Rp_H-C-r)+(1-\sigma)(r-Rp_L))}.
\end{aligned}$$

Proof of Lemma 2

Write G and B for the respective events that the regulator is good and bad; S and U for the events that the bank is respectively sound and unsound; and F for the event that the bank fails. Then

$$\alpha_F(\alpha) = P\{G|F\} = \frac{P\{F|G\}P\{G\}}{P\{F|G\}P\{G\}+P\{F|B\}P\{B\}}, \tag{24}$$

and

$$\begin{aligned} P\{F|G\} \equiv \phi_G &= P\{F|S\}P\{S|G\}+P\{F|U\}P\{U|G\} \\ &= \frac{(1-p_H)\,\sigma(1-\gamma)+(1-p_L)\,\gamma(1-\sigma)}{\sigma-2\sigma\gamma+\gamma}, \end{aligned}$$

where the second line follows by setting $w=\gamma$ in equation (5) to obtain $P\{S|G\}$. Similarly, $P\{F|B\} \equiv \phi_B = (1-p_H)\,\sigma+(1-p_L)(1-\sigma)$. Substituting into (24) gives us the following:

$$\alpha_F(\alpha) = \frac{\alpha\phi_G}{\alpha\phi_G+(1-\alpha)\,\phi_B}.$$

Substituting for ϕ_G and ϕ_B yields, after some manipulation, the following equivalent expression:

$$\alpha_F(\alpha) = \alpha\frac{\sigma(1-p_H)(1-\gamma)+\gamma(1-p_L)(1-\sigma)}{(\gamma+\sigma-2\gamma\sigma)(1-\sigma p_H-(1-\sigma)\,p_L)-\alpha(1-2\gamma)(1-\sigma)\,\sigma\Delta p},$$

from which, after further manipulation, we can derive the following expression:

$$\alpha_F'(\alpha) = \frac{(\sigma+\gamma(1-2\sigma))(1-(p_L+\sigma\Delta p))\,(\sigma(1-p_H)(1-\gamma)+\gamma(1-\sigma)(1-p_L))}{((\gamma+\sigma-2\gamma\sigma)(1-\sigma p_H-(1-\sigma)\,p_L)-\alpha(1-2\gamma)(1-\sigma)\,\sigma\Delta p)^2}.$$

This is positive, as required.

Proof of Lemma 3

Standard calculations give us:

$$\begin{aligned} W_D'(w) &= -\frac{(1-\sigma)\,\sigma((R-Q)\,\Delta p-(L-(R-Q)\,p_L)\,\lambda)}{(w-2\sigma w+\sigma)^2}; && (25)\\ W_R'(w) &= -\frac{(1-\sigma)\,\sigma((R\Delta p-C)-(L-Rp_L)\,\lambda)}{(w-2\sigma w+\sigma)^2}; && (26)\\ W_R(w)-W_D(w) &= \frac{(1-w)\,\alpha(Qp_H-C)+Qw(1-\lambda)(1-\sigma)\,p_L}{w-2\sigma w+\sigma} && (27)\\ &\geq \frac{C}{\Delta p}p_L\frac{(1-w)\,\sigma+w(1-\lambda)(1-\sigma)}{w-2\sigma w+\sigma} > 0; && (28)\\ W_R'(w)-W_D'(w) &= \frac{(1-\sigma)\,\sigma(C-Q(\Delta p+\lambda p_L))}{(w-2\sigma w+\sigma)^2} \leq 0. && (29) \end{aligned}$$

The expression of equation (25) is negative because $(R-Q)\left(p_L+\frac{\Delta p}{\lambda}\right) > (R-Q)\,p_H > r > L$. That of equation (26) is negative because $Rp_H - C > r > L$. The step between equations (27) and (28) follows from equation (3) as does the final inequality of equation (29).

Expressions for w_{LD}, w_{LR}, α_{LD}, and α_{LR}

w_{LD} is found by setting $W_D(w)$ equal to r and solving for w. α_{LD} is found by substituting the resultant w_{LD} into equation (4) and solving for α. This procedure yields the following:

$$\begin{aligned} w_{LD} &= \frac{\sigma\left((R-Q)\,p_H-r\right)}{\sigma\left((R-Q)\,p_H-r\right)+(1-\sigma)\left(r-(R-Q)(1-\lambda)\,p_L-\lambda L\right)}; \\ \alpha_{LD} &= \frac{(1-\sigma)\left(r-(R-Q)(1-\lambda)\,p_L-\lambda L\right)-\sigma\left((R-Q)\,p_H-r\right)}{(1-2\gamma)\left((1-\sigma)\left(r-(R-Q)(1-\lambda)\,p_L-\lambda L\right)+\sigma\left((R-Q)\,p_H-r\right)\right)}. \end{aligned}$$

Similarly, we obtain

$$\begin{aligned} w_{LR} &= \frac{\sigma\left(Rp_H-C-r\right)}{\sigma\left(Rp_H-C-r\right)+(1-\sigma)\left(r-Rp_L(1-\lambda)-\lambda L\right)}; \\ \alpha_{LR} &= \frac{(1-\sigma)\left(r-Rp_L(1-\lambda)-\lambda L\right)-\sigma\left(Rp_H-C-r\right)}{(1-2\gamma)\left((1-\sigma)\left(r-Rp_L(1-\lambda)-\lambda L\right)+\sigma\left(Rp_H-C-r\right)\right)}. \end{aligned}$$

Proof of Lemma 4

Closing the bank reveals for sure that it was unsound. Using the notation of the proof of lemma 2, the regulator's reputation is updated to

$$\begin{aligned} P\{G|U\} &= \frac{P\{U|G\}P\{G\}}{P\{U|G\}P\{G\}+P\{U|B\}P\{B\}} \\ &= \frac{\gamma\alpha}{\gamma\alpha+\frac{1}{2}(1-\alpha)}, \end{aligned}$$

as required. Furthermore, it is tedious but straightforward to demonstrate by direct calculation that

$$\alpha_F(\alpha)-\alpha_C(\alpha) = \frac{\alpha(1-\alpha)(1-2\gamma)\left((\sigma+\gamma(1-2\sigma))(1-p_H)+\gamma(1-\sigma)(1-2\sigma)\Delta p\right)}{(1-\alpha(1-2\gamma))\left((\gamma+(1-2\gamma)\sigma)(1-p_H)+(1-\sigma)(\gamma+(1-\alpha)(1-2\gamma)\sigma)\Delta p\right)},$$

which is positive.

Expressions for α_{CD}^* and α_{CR}^*

α_{CD}^* is found by setting $\alpha_L(\alpha)=\alpha_{LD}$ and solving for α; α_{CR}^* is found similarly by solving $\alpha_L(\alpha)=\alpha_{LR}$ for α. The calculations are lengthy and the resultant expressions are difficult to read. To aid exposition, we define $s_{DG}(Q)$ and $s_{DB}(Q)$ to be the respective surplus which the depositors earn from investing in good and bad banks, relative to their outside option of r:

$$\begin{aligned} s_{DG}(Q) &= (R-Q)\,p_H - r; \\ s_{DB}(Q) &= (R-Q)\left(\sigma p_H + (1-\lambda)(1-\sigma)\,p_L\right) + L\lambda\,(1-\sigma) - r. \end{aligned}$$

Lengthy but elementary manipulations then yield

$$\alpha^*_{CD}(Q) = \frac{s_{DB}(Q)}{(1-2\gamma)\left((1+2\gamma)\,s_{DB}(Q) - 4\gamma\sigma s_{DG}(Q)\right)}.$$

Similarly, define s_{RG} and s_{RB} to be the surplus relative to no bank which regulators derive from an economy with a bad and a good bank, respectively:

$$\begin{aligned} s_{RG} &= Rp_H - r - C; \\ s_{RB} &= R\left(\sigma p_H + (1-\lambda)(1-\sigma)\,p_L\right) + L\lambda\,(1-\sigma) - C\sigma - r. \end{aligned}$$

Then manipulations again yield

$$\alpha^*_{CR}(Q) = \frac{s_{RB}(Q)}{(1-2\gamma)\left((1+2\gamma)\,s_{RB}(Q) - 4\gamma\sigma s_{RG}(Q)\right)}. \tag{30}$$

Derivation of Condition (21)

Forbearance is optimal at $\alpha > \alpha^*_{FD}$ whenever

$$Rp_L + W_R\left(w\left(\alpha_L(\alpha)\right)\right) - (r+L) > 0. \tag{31}$$

To obtain condition (21), use equation (30) to substitute $\alpha = \alpha^*_{CR}(Q)$ in this equation.

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