EUROPEAN CENTRAL BANK

EUROSYSTEM

ECB LAMFALUSSY FELLOWSHIP PROGRAMME

WORKING PAPER SERIES

NO 1196 / MAY 2010

REPUTATIONAL CONTAGION AND OPTIMAL REGULATORY FORBEARANCE

by Alan D. Morrison
and Lucy White

EUROPEAN CENTRAL BANK

EUROSYSTEM




WORKING PAPER SERIES

NO 1196 / MAY 2010

ECB LAMFALUSSY FELLOWSHIP PROGRAMME

REPUTATIONAL CONTAGION AND OPTIMAL REGULATORY FORBEARANCE[1]

by Alan D. Morrison[2]

and Lucy White[3]

In 2010 all ECB publications feature a motif taken from the €500 banknote.


1 Comments by seminar audiences at Oxford, Harvard and the European Central Bank are gratefully acknowledged. This paper has been prepared by the authors under the Lamfalussy Fellowship Programme sponsored by the European Central Bank, according to clause 8 of the Fellowship Agreement. The first author received generous research support from the Oxford University Centre for Corporate Reputation, and the second author gratefully acknowledges support from the Paolo Baffi research fellowship scheme.

2 Said Business School, University of Oxford and CEPR, e-mail: alan.morrison@sbs.ox.ac.uk

3 Harvard Business School and CEPR, e-mail: lwhite@hbs.edu

Lamfalussy Fellowships

This paper has been produced under the ECB Lamfalussy Fellowship programme. This programme was launched in 2003 in the context of the ECB-CFS Research Network on "Capital Markets and Financial Integration in Europe". It aims at stimulating high-quality research on the structure, integration and performance of the European financial system.

The Fellowship programme is named after Baron Alexandre Lamfalussy, the first President of the European Monetary Institute. Mr Lamfalussy is one of the leading central bankers of his time and one of the main supporters of a single capital market within the European Union.

Each year the programme sponsors five young scholars conducting a research project in the priority areas of the Network. The Lamfalussy Fellows and their projects are chosen by a selection committee composed of Eurosystem experts and academic scholars. Further information about the Network can be found at http://www.eu-financial-system.org and about the Fellowship programme under the menu point "fellowships".

Address
Kaiserstrasse 29
60311 Frankfurt am Main, Germany

Postal address
Postfach 16 03 19
60066 Frankfurt am Main, Germany

Telephone
+49 69 1344 0

Internet
http://www.ecb.europa.eu

Fax
+49 69 1344 6000

Information on all of the papers published in the ECB Working Paper Series can be found on the ECB's website, http://www.ecb.europa.eu/pub/scientific/wps/date/html/index.en.html

ISSN 1725-2806 (online)

CONTENTS

Abstract 4

Non-technical summary 5

1 Introduction 7

2 The Model 11

3 Contagious bank failures 12

4 Regulatory forbearance 15

- 4.1 Forbearance equilibria 17
- 4.2 Numerical example 20
- 4.3 Policy implications 21

5 Auditing reputation 23

6 Conclusion 26

Appendix 28

References 31

Abstract

This paper examines common regulation as 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 to privately exhibit forbearance to the initially failing bank in the hope that it - and hence other vulnerable banks - survives. By 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
Keywords: Contagion, Reputation, Bank Regulation

Non-technical summary

In this paper we show that regulator reputation is a conduit for financial contagion. We show that even when there is no interbank lending and the returns on the assets in which two banks invest are uncorrelated, the failure of the first bank may cause depositors to withdraw from, or refuse to invest their funds in, the second bank. The reason for this is that if the regulator's initial reputation is sufficiently mediocre, a failure may cause depositors to lose confidence altogether in her ability to discriminate between good and bad banks, and thus in the quality of the second bank. As a result, the second bank may fail because of contagion arising from a drop in the regulator's reputation, even if the "fundamentals" of the second bank are apparently unchanged.

Conventional empirical models attempt to estimate the likelihood of contagion between banks examine the possibility of a "domino effect" of the type envisaged by Allen and Gale (2000). That is, they ask whether a chain of interbank lending linkages might cause the failure of one bank to endanger the survival of its creditor banks, and, in turn, the survival of their creditors. The implication of our model is that studies of this type underestimate the probability of contagion because they do not take into account the possibility of *reputational contagion*. The failure of one bank could cause depositors to reduce their estimate of the banking regulator's ability to keep unsound banks out of the system. As a result, they could withdraw their funds from other banks with a common regulator; this effect could destabilise the entire banking system.

A key ingredient of our model is that depositors do not capture all of the returns from depositing. Some of the profits generated from a deposit accrue to the bank that manages the deposit, rather than to the depositor. Banker profits have been controversial of late, but bankers must receive some form of incentive pay if they invest wisely and their investments succeed. Without such pay, they would have little incentive to exert themselves to select and monitor investments. In our model, banker incentive payments reduce the return that depositors receive on their investments. In a more general model, depositor returns would be further reduced by incentive payments to the entrepreneurs and the firms funded by the banker.

We assume that the banking regulator aims to maximise social welfare. Because depositors are unable to capture all the returns from their deposits, they place a lower value on depositing than the regulator. Reputational contagion may cause depositors to withdraw from the banking sector even though it would be preferable from a social point of view if they did not. In this situation, the regulator attempts to avoid the withdrawal by managing her reputation so as to avoid reputational contagion. She does this by limiting the information that the public has about bank failure that might result in reputational contagion. For example, suppose the regulator audits Bank 1 and learns that it is unsound. If she closes Bank 1 then the depositors will downgrade their assessment of her abilities, and so will run on Bank 2. It may be socially better for her privately to forebear on Bank 1, keeping the information learned through the audit secret: Bank 2 can then survive, provided that Bank 1 also manages to pull through. We show that such *private forbearance* can be a socially optimal policy.

Such secret rescues have been conducted by Central Banks in the past. An increasing emphasis on transparency in regulation and supervision over the last couple of decades has made secret rescues difficult, however. Many bank rescues in the 2007-9 crisis were carried out in the glare of publicity. Such publicity has costs in our model, because a public rescue is an insufficient response to a loss of confidence, unless it is bolstered by other confidence-restoring measures such as an increase in the generosity of deposit insurance or a tightening of capital requirements. Transparency is therefore a costly policy once a problem has occurred. However, committing up-front to a policy of transparency has a benefit because it makes depositors more confident that the regulator will be unable privately to forbear (that is, to conceal information that would make the depositors want to withdraw their funds from a bank), and so makes them more willing to deposit.

1. Introduction

In this paper we show that regulator reputation is a conduit for financial contagion. We show that even when the returns on the assets in which two banks invest are uncorrelated, and there is no interbank lending, the failure of the first bank may cause depositors to withdraw or refuse to invest their funds in the second bank. The reason behind this is that, if the regulator's initial reputation is sufficiently mediocre, a failure may cause depositors to lose confidence altogether in her ability to discriminate between good and bad banks, and thus in the quality of the second bank. Therefore the second bank may fail because of contagion arising from a drop in the regulator's reputation, even if the "fundamentals" of the second bank are apparently unchanged.

Our paper provides a contrast with previous models of financial contagion, which have focussed on contagion arising from one of two sources: interbank lending or correlation in the returns on the banks' underlying asset base. In the first class of models, starting with Allen & Gale (2000), banks may suffer idiosyncratic liquidity shocks and hold interbank deposits as a way of insuring against these. Ex post illiquid banks draw down their deposits in ex post liquid banks to meet depositors' short term liquidity demands. An unfortunate consequence of this is that if there is an aggregate liquidity shock, all banks will try to liquidate their interbank deposits, resulting in contagion across the system which 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, excessive interbank deposit deposits should be avoided as they are a threat to the stability of the system. Leitner (2005), however, shows that even if aggregate shocks are the only type of shock to hit the system, interbank lending can nevertheless be desirable in that it helps commit banks to help other ailing banks ex post when it is difficult to contract ex ante on providing such assistance. In his model, the role of the regulator is to coordinate private sector bailouts; such bailouts are feasible precisely when in the absence of an organised bailout banks face the threat of contagion.

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; to ensure that there are adequate levels of liquidity in the banking system, they argue that short term rates in normal times should be high. 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 answer to the question of why regulators allow extensive interbank lending when this 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. However, because in their model banks monitor 'in a circle', if one bank fails this indicates that its monitor has failed to monitor properly; that the monitor's monitor has failed to monitor the monitor, and so on, resulting in a systemic meltdown. Our model is in contrast to this first class of models since we simplify by assuming that there is no interbank lending or monitoring. Instead, the regulator should be monitoring the banks, and contagion can still occur despite the lack of interbank lending, because a failure of one bank may signal that the regulator has not been performing his monitoring function very effectively; in turn, this can lead depositors to question the soundness of other banks in the same regulatory system.

The second class of models of systemic banking failures focus 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 so in a sense, this type of crisis is not really driven by contagion across banks per se, but by fundamental shocks hitting 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 which are too correlated from a social point of view. Nevertheless, contagion can occur in this type of situation 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, which push up the returns to investment in impaired assets, and so reduce the equilibrium prices of other investments. In a sense, 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 yet depositors rationally anticipate that returns on bank deposits are correlated because how well the bank performs is a function of 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, which do not take into account 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. The weakness - as Gropp et al point out - is that they are estimated over relatively calm periods, so if some shocks do not occur during that period, the risk of contagion from these shocks may 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 is what drives contagion, then the extent one 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.

On the other hand, one might argue that behind the current crisis is a loss of faith in both US and EU regulators. Under the Basle II Accord, regulators rely heavily on ratings information to assess capital requirements, and ratings have recently been found to be unreliable for the structured finance assets held on and off-balance sheet by many banks (Coval, Jurek & Stafford (2009)). We would argue that the numerous recent bank rescues in the EU and US can be understood as at least partly designed to maintain depositor confidence in the banking system as a whole. In particular, the analysis in this paper shows that it may be socially optimal to rescue a bank not because it is systemically important in the traditional sense (that is, not because it necessarily has large interbank exposures, although it may have these as well) but because its failure would do undue damage to the regulator's reputation and might undermine depositor confidence in other banks for that reason. Why, for example, did the UK government rescue the Northern Rock Bank in September 2007? Or the German government rescue Hypo Real Estate? Whilst interbank linkages are not public information, in neither case did any argument appear in the press that these banks were rescued because they were too "connected" to be allowed to fail (in contrast to the bailout of AIG, for example). Instead, government officials talked about how it was important to maintain depositor confidence in the financial system, an argument consistent with the finding of this paper that sometimes it may be socially optimal (at least ex post once the crisis has occurred) to forebear rather than admit that there had been a failure of regulation.[1]

The importance of maintaining depositor confidence in the regulatory system has been emphasised by Kane (1989*b*), in a different context. Discussing the State's decision to bail out the Ohio Deposit Insurance Fund event though in fact, contrary to popular belief at the time the State was not in fact a guarantor of this fund, Kane argues that it was nevertheless important for the State to step in because the public implicitly deemed the State responsible for the losses as it had failed in its regulatory duty. We find that the type of forbearance decisions taken in the Ohio case, and in the Savings and Loans Crisis can be part of an ex post optimal policy response. The regulator's reputation as a competent monitor is socially valuable and it behoves him to do what he can to conserve it; this may even include "gambling for resurrection". In the case of the Savings and Loans crisis, Kane (1989*a*) and Rom (1996) also argue that the incentives provided by the system must bear a greater proportion of the blame than the actions of individuals for what was, in hindsight, enormously expensive failed gamble, although Kane can claim credit for having predicted the outcome and would also argue that individuals have a moral duty not to succumb to the incentives the system creates. We show that, given that the regulator learns bad news about a bank's prospects, social welfare may actually be higher if the regulator is able secretly to exhibit forbearance towards this bank and hope that its investments recover. However, if the public anticipates such behaviour in advance, they will be more circumspect in investing their deposits initially, so that ex ante welfare may be higher if the regulator can commit to adopt a tough policy in such situations.

The central importance of the regulator's concern with his reputation in our model makes it similar to Boot & Thakor (1993). However, in their model the regulator's reputational concern is purely selfish, so that regulatory forbearance is never an optimal policy. In our model, by contrast, when regulator reputation is intermediate, forbearance can sometimes be in the public interest. The key insight is that depositors do not capture all of the the social benefits associated with bank investment when they decide whether to deposit. Therefore it can be socially valuable for the banking system to exist even when depositors choose to withdraw. If a regulator's bad information about a bank is made public, in a situation where depositors are already somewhat uncertain about the regulator's competence, this information can cause them to withdraw their funds when it would be socially preferrable for them to wait and see whether the adverse event indeed materialises. By contrast, if the regulator's initial reputation is strong enough, he can afford to deal swiftly in closing a bank on the arrival of bad news without confidence in other banks deteriorating too severely. So forbearance is an optimal policy only for regulators in whom the public already lacks confidence. The appropriate degree of forbearance therefore depends on the level of regulator reputation. Differently from Boot & Thakor (1993), regulators whose reputation is marginally acceptable should optimally forbear less than their more competent peers.

[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 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. 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 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.[2] 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 her to distinguish between sound and unsound bankers.[3] 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

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

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

to audit and to close failing banks. As we argue in the conclusion, this role is harder to delegate to a third party.

The regulator uses her technology to allocate banking licences. Since we wish to show that it may in some circumstances be socially optimal for the regulator to forebear on failing banks, we assume that she 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 her socially optimal concern for her reputation. We therefore assume that the same regulator is appointed for both periods of our model. For simplicity, we assume that she 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 her 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 she has. All agents assign a common prior probability α that she is good. We refer to α as the regulator's *reputation*.

The regulator's reputation is updated in response to any signals which 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 she 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. In section 4 we allow the regulator to intervene to close failing banks. We show that concerns about reputational financial contagion can cause the regulator to exhibit *forbearance*, failing to close bank 1 although this would be myopically optimal. Such forbearance is socially optimal, even though closure of a failing bank is always a positive net present value action, because maintaining the regulator's reputation has social value. In section 5 we analyze an extension of our model, in which regulators 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 her ex ante screening reputation. Section 6 concludes.

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 she 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 which 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 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.

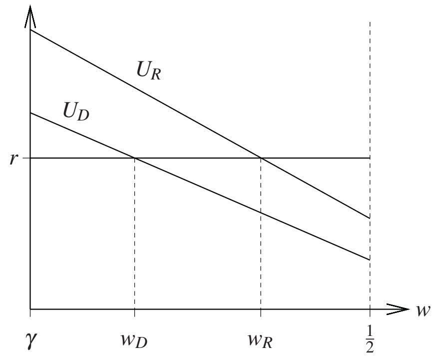

Figure 1: U_D and U_R are the utilities of depositors and regulators, respectively. If regulator reputation falls between w_D and w_R then banking is socially valuable, but depositors withhold their funds from the banks.

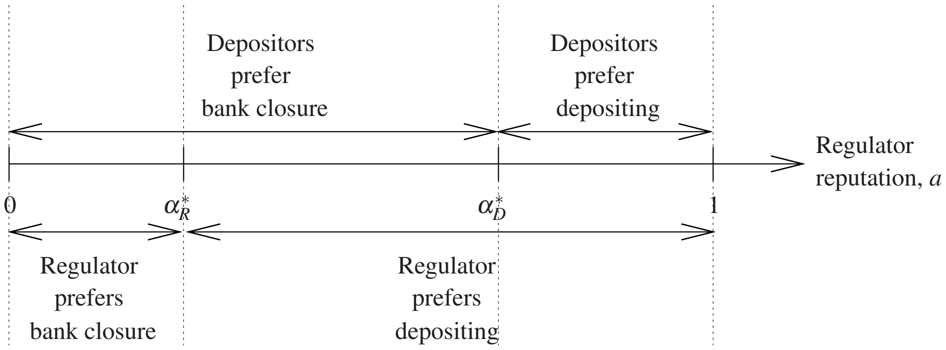

Figure 2: α_R and α_D are threshholds for the regulator's reputation, α. When $\alpha < \alpha_R$, the regulator and the depositor would both prefer the banking sector to close; when $\alpha \geq \alpha_D$, the regulator and the depositor would both prefer the banking sector to remain open. For reputation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

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 of 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, she is able to audit the bank to determine for sure whether it is sound or unsound. In addition, we endow her with the power to close the bank at this stage it if this is socially optimal (for example, if she 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 her 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.[4] 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 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_{L}>r), and *ceteris paribus* would prefer to close down an unsound bank (which is expected to return Rp_{L} 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:

$$W_D(w) = U_D(w) + (1-\pi(w))\lambda(L-(R-Q)p_L); \tag{15}$$

$$W_R(w) = U_R(w) + (1-\pi(w))\lambda(L-Rp_L). \tag{16}$$

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 her 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, this raises

[4] 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.

expected returns from the banking sector and both the depositors and the regulator will 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. Lemma 4 provides a formula for the regulator's posterior 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 she liquidates a bank. Lemma (4) describes α_F and α_L.

LEMMA 4. *Suppose that the regulator has a prior reputation of α. Then her posterior reputation after she 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 her posterior reputation α_F after a failure. The intuition 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 forebear 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. Any lower initial reputation and depositors would not be willing to invest in bank 2 after bank 1 is closed.

Note that when the interim period 1 audit demonstrates that the period 1 bank was unsound, the regulator updates her prior over her reputation to $\alpha_L(\alpha)$ irrespective of whether she actually closes the bank. α^*_{CR} is the prior reputation after which this update will leave her 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

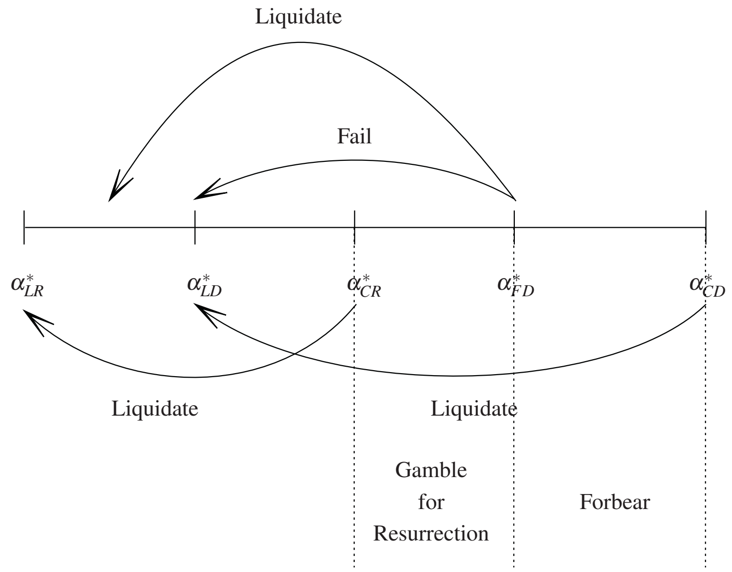

Figure 3: **Reputational updating when regulators can audit.** It is socially optimal to close banks after an audit reveals low type when the posterior regulator reputation is less than α^*_{LR}; depositors will withdraw their funds when the posterior reputation is less than $\alpha_{LD} > \alpha_{LR}$. 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.

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, she could elect not to close it, 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 forebearance 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. In other words, period 1 bank failure 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 time 1 regulatory reputations below which the regulator and the depositors, respectively, regard bank 2 as untenable. The regulator updates her own reputation after learning from an audit that the period 1 bank is unsound; if her 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 banker and updating her own assessment of her reputation, but she knows that liquidating the unsound Bank 1 would result in the failure of Bank 2. Hence, as discussed above, she 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 $\alpha < \alpha_{FD}^{*}$, she 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 with probability p_L, precisely when the first period bank succeeds. If there is a second period banking sector, the regulator uses the updated reputation $\alpha_L(\alpha)$ to assess it, since she 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 $\pi(w)(\Delta pR - C) > R$, 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 $\alpha_{FD}^{*} \leq \alpha \leq \alpha_{CD}^{*}$ 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. Her decision to forbear arises because she 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 $\alpha_{FD}^{*} \leq \alpha \leq \alpha_{CD}^{*}$ 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:

$$(Rp_H - C - L)(1-\sigma)(r - L\lambda - (R-Q)(1-\lambda)p_L) \\ -(r - Rp_L)(1-\sigma)((R-Q)(\Delta p + \lambda p_L) - L\lambda) - \\ ((R-Q)p_H - r)(L - Rp_L)(1-\lambda)(1-\sigma) > 0. \quad (21)$$

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.

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

In parts 1 and 3 of this proposition, the regulator does not exhibit forbearance. In part 1 this is because the consequential damage to her reputation does not cause a contagious failure of the second period banking sector. In part 3 it is because, although she anticipates that the closure will cause a contagious failure of the second period banking sector, she no longer believes after updating her first period priors that a second period banking sector is socially worthwhile. Hence, in both of these cases, the regulator loses nothing in the second period by capturing the value $L - Rp_L$ of closing the first period unsound bank.

In our model, when a regulator exercises forbearance on a bank, she does not have to input any funds - she merely has to allow it to continue its operations when she knows that 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. By contrast, the Bank of England's support of Northern Rock in September 2007 was all too public. In comments to Parliament, Mervyn King remarked that he was unable to arrange secret support of the bank 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 he may receive, then her reputation cannot be saved by forbearing on an unsound bank: her reputation was impaired as soon as depositors learned that he had chartered an unsound bank. 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 and – for reputational values $\alpha \in [\max(\alpha^*_{FD}, \alpha_{FBR}), \alpha^*_{CD}]$ – chose not to do so, 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 have taken place in the current crisis have been 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.[5] 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

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

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 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 keep track of how capital requirements are updated as the regulator's reputation evolves, but the anaysis of Morrison & White (2005) suggests that tightening the capital requirements that bank 2 would face can be used to screen out any unsound applicants. In this way, it would be possible to run a small banking system when depositors have very little confidence in the regulator.

It should be noted, however, that capital requirements and the general taxation supporting subsidised deposit insurance are costly instruments to use. Therefore the ability to tighten capital requirements or to raise taxes does not remove the need for reputation management by the regulator. Depending on the circumstances, it may be that forbearing on a given bank (bank 1) is 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 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, there would be a tradeoff, and regulatory turnover In reality, since in developed countries at least, public confidence in financial regulation has at least as much to do with the systems that are used to monitor banks as it does with the personnel that undertake this task, enforcing term limits for regulators may have little impact; and forcing frequent change of 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 forebearance, 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.[6] 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 utilities of the depositor and the regulator are given by equations (22) and (23):

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

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

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

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

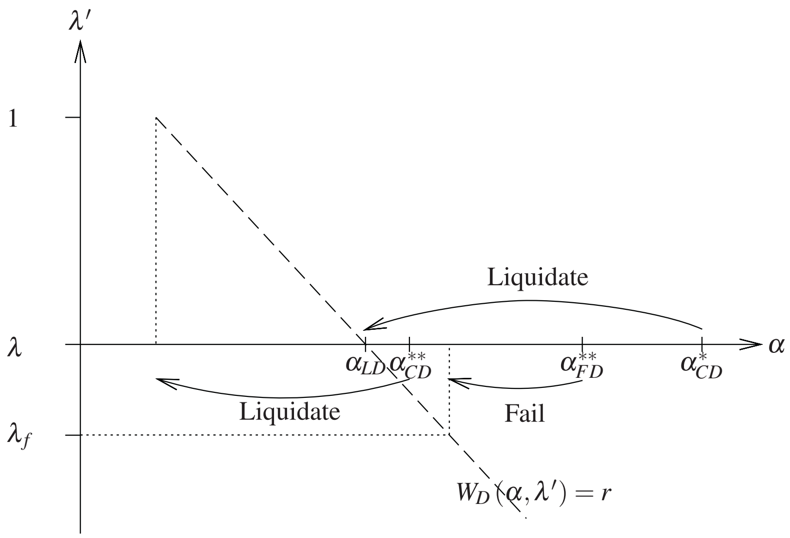

Figure 4: **Updating of screening and auditing abilities.** The regulator's screening reputation is denoted α; the prior auditing reputation is λ, and the posterior is λ'. The dashed line represents (α, λ') pairs for which the depositors are indifferent between depositing and their outside option; the line has a negative slope because, from the depositors' point of view, auditing and screening are substitutes.

after bank failure as follows:

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

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 forebears for $\alpha_{FBR} > \alpha \geq \alpha^*_{CD}$, and that it liquidates for $\alpha \geq \alpha^*_{CD}$.

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

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

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

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

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

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 forebears 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 forebears 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.
   (b) If the first period bank is not closed down then:
      i. If $\alpha \geq \alpha_F^*$ then there is a second period banking sector whether or not the first period bank succeeds;
      ii. 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;
      iii. If $\alpha_F^* \leq \alpha < \alpha_{CD}^{**}$ then there is a second period banking sector whether or not the first period bank succeeds;
      iv. 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.

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. A regulator can try to mitigate these problems, rendering investment more 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 her 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 her 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 banks failure hence has greater systemic implications than small bank failure. If so, it is be 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 could result in a policy of "too old to fail".

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:

$$W_D'(w) = -\frac{(1-\sigma)\sigma((R-Q)\Delta p-(L-(R-Q)p_L)\lambda)}{(w-2\sigma w+\sigma)^2}; \tag{25}$$

$$W_R'(w) = -\frac{(1-\sigma)\sigma((R\Delta p-C)-(L-Rp_L)\lambda)}{(w-2\sigma w+\sigma)^2}; \tag{26}$$

$$W_R(w)-W_D(w) = \frac{(1-w)\alpha(Qp_H-C)+Qw(1-\lambda)(1-\sigma)p_L}{w-2\sigma w+\sigma} \tag{27}$$

$$\geq \frac{C}{\Delta p}p_L\frac{(1-w)\sigma+w(1-\lambda)(1-\sigma)}{w-2\sigma w+\sigma} > 0; \tag{28}$$

$$W_R'(w)-W_D'(w) = \frac{(1-\sigma)\sigma(C-Q(\Delta p+\lambda p_L))}{(w-2\sigma w+\sigma)^2} \leq 0. \tag{29}$$

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:

$$w_{LD} = \frac{\sigma((R-Q)p_H-r)}{\sigma((R-Q)p_H-r)+(1-\sigma)(r-(R-Q)(1-\lambda)p_L-\lambda L)};$$

$$\alpha_{LD} = \frac{(1-\sigma)(r-(R-Q)(1-\lambda)p_L-\lambda L)-\sigma((R-Q)p_H-r)}{(1-2\gamma)((1-\sigma)(r-(R-Q)(1-\lambda)p_L-\lambda L)+\sigma((R-Q)p_H-r))}.$$

Similarly, we obtain

$$w_{LR} = \frac{\sigma(Rp_H-C-r)}{\sigma(Rp_H-C-r)+(1-\sigma)(r-Rp_L(1-\lambda)-\lambda L)};$$

$$\alpha_{LR} = \frac{(1-\sigma)(r-Rp_L(1-\lambda)-\lambda L)-\sigma(Rp_H-C-r)}{(1-2\gamma)((1-\sigma)(r-Rp_L(1-\lambda)-\lambda L)+\sigma(Rp_H-C-r))}.$$

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

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

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:

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

Lengthy but elementary manipulations then yield

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

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:

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

Then manipulations again yield

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

Derivation of Condition (21)

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

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

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

References

Acharya, V. V., 2001. A theory of systemic risk and design of prudential bank regulation. Working paper, Stern School of Business, New York University.

Acharya, V. V., 2003. Is the international convergence of capital adequacy regulation desirable? Journal of Finance 58, 2745 – 81.

Acharya, V. V., Shin, H. S., Yorulmazer, T., 2009. A theory of slow-moving capital and contagion. Discussion Paper DP7147, Centre for Economic Policy Research, London, UK.

Allen, F., Carletti, E., Gale, D., 2009. Interbank market liquidity and central bank intervention. Journal of Monetary Economics 56, 639–652.

Allen, F., Gale, D., 2000. Financial contagion. Journal of Political Economy 108, 1 – 33.

Boot, A. W. A., Thakor, A. V., 1993. Self-interested bank regulation. American Economic Review 83, 206 – 212.

Chari, V. V., Jagannathan, R., 1988. Banking panics, information and rational expectations. Journal of Finance 43, 749–61.

Coval, J. D., Jurek, J. W., Stafford, E., 2009. The economics of structured finance. Journal of Economic Perspectives 23, 3–25.

Degryse, H., Nguyen, G., 2007. Interbank exposures: An empirical examination of contagion risk in the Belgian banking system. International Journal of Central Banking.

Diamond, D. W., Rajan, R. G., 2009. Illiquidity and interest rate policy. Working Paper 15197, National Bureau of Economic Research, Cambridge, Mass.

Freixas, X., Martin, A., Skeie, D., 2009. Bank liquidity, interbank markets, and monetary policy. Staff Report 371, Federal Reserve Bank of New York, New York, NY.

Gorton, G., 2009. Information, liquidity, and the (ongoing) panic of 2007. American Economic Review Papers and Proceedings 99, 567–572.

Gropp, R., Lo Duca, M., Vesala, J., 2009. Cross-border bank contagion in europe. International Journal of Central Banking, International Journal of Central Banking 5, 97–139.

Hartmann, P., Straetmans, S., de Vries, C., 2005. Banking system stability: A cross-Atlantic perspective. Working Paper 11698, National Bureau of Economic Research, Cambridge, Mass.

Heider, F., Hoerova, M., Holthausen, C., 2009. Liquidity hoarding and interbank market spreads. Working Paper 1126, European Central Bank, Frankfurt, Germany.

Kahn, C. M., Santos, J. A. C., 2005. Allocating bank regulatory powers: Lender of last resort, deposit insurance and supervision. European Economic Review 49, 2107–2136.

Kane, E. J., 1989*a*. How incentive-incompatible deposit-insurance funds fail. Working Paper 2836, National Bureau of Economic Research, Cambridge, MA.

Kane, E. J., 1989*b*. The S&L Insurance Mess: How Did It Happen? Urban Institute Press, Washington, DC.

Leitner, Y., 2005. Financial networks: Contagion, commitment, and asymmetric information. Jouirnal of Finance 60, 2925–2953.

Mistrulli, P. E., 2007. Assessing financial contagion in the interbank market: Maximum entropy versus observed interbank lending patterns. Working Paper 641, Bank of Italy, Rome, Italy.

Morrison, A. D., White, L., 2004. Is deposit insurance a good thing and if so, who should pay for it? Discussion Paper 4424, Center for Economic Policy Research, London, UK.

Morrison, A. D., White, L., 2005. Crises and capital requirements in banking. American Economic Review 95, 1548 – 1572.

Morrison, A. D., White, L., 2009. Level playing fields in international financial regulation. Journal of Finance 64, 1099–1142.

Rochet, J.-C., Tirole, J., 1996. Interbank lending and systemic risk. Journal of Money, Credit and Banking 28, 733–762.

Rom, M. C., 1996. Public Spirit in the Thrift Tragedy. University of Pittsburgh Press.

Scharfstein, D. S., Stein, J. C., 1990. Herd behavior and investment. American Economic Review 80, 465–479.