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Alan Morrison and Lucy White

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Alan Morrison, Said Business School, University of Oxford and CEPR
Lucy White, Harvard Business School and CEPR

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Centre for Economic Policy Research
77 Bastwick Street, London EC1V 3PZ, UK
Tel: (44 20) 7183 8801, Fax: (44 20) 7183 8820
Email: cepr@cepr.org, Website: www.cepr.org

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ABSTRACT

Reputational Contagion and Optimal Regulatory Forbearance*

Existing studies suggest that systemic crises may arise because banks either hold correlated assets, or are connected by interbank lending. This paper shows that common regulation is also a conduit for interbank contagion. One bank's failure may undermine confidence in the banking regulator's competence, and, hence, in other banks chartered by the same regulator. As a result, depositors withdraw funds from otherwise unconnected banks. The optimal regulatory response to this behaviour can be privately to exhibit forbearance to a failing bank. We show that regulatory transparency improves confidence ex ante but impedes regulators' ability to stem panics ex post.

JEL Classification: G21 and G28
Keywords: bank regulation, contagion and reputation

Alan Morrison
Said Business School
University of Oxford
Park End Street
Oxford OX1 1HP
UK

Email: alan.morrison@sbs.ox.ac.uk

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Lucy White
Harvard Business School
Baker 345
Soldiers Field Road
Boston, MA 02163
USA

Email: lwhite@hbs.edu

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1. Introduction

Existing studies suggest that systemic crises may arise either because banks hold correlated assets, or are connected by interbank lending. In this paper we show that sharing a common regulator can also be a conduit for financial contagion. If a financial regulator has a poor initial reputation, a bank failure may cause depositors to lose confidence in that regulator's ability to discriminate between good and bad banks. Since uninformed depositors rely upon the regulator to screen out unsound banks, they respond to a loss of confidence in the regulator by withdrawing from other banks with the same regulator (or regulations). Hence, banks in our model can suffer contagious failure even if their observable "fundamentals" are unchanged. The failure of one bank can cause depositors to run on another, even when the returns on the assets in which the second bank invests are uncorrelated with those of the first bank and there is no interbank lending.

We show in addition that, as perceived regulatory quality drops, bank creditors (who are uninsured in our model) withdraw their deposits from the bank at a quality threshold that is too high from a social point of view. This is because, for informational reasons, banks' creditors (uninsured depositors in our model) cannot capture all of the social value generated by the bank in which they invest; for incentive reasons, some returns must be captured by banks (and potentially, in a richer model, the entrepreneurs to whom they lend). As a result, our model can justify a regulatory decision not to close an unsound bank – that is, to *forbear* on unsound banks. Regulatory corrective action to close a weak bank reveals that the regulator has less skill in screening banks than previously expected. This revelation 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, which is socially beneficial.

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. While these factors were clearly important in the financial crisis of 2007-08, we we believe that our analysis generates some novel insights into these events that are missing from a reading of the existing literature. Specifically, we would argue that the importance of regulator reputation has been underemphasised and that, in part, the recent crisis was triggered by a loss of faith in the efficacy of 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 and Stafford, 2009) led to a loss of faith in regulatory assessments of banks. This meant that *all* banks that had been regulated in the same way became vulnerable to withdrawals from creditors concerned that banks were not as strong as they had previously believed.

We would further argue that the numerous recent bank rescues in the US and the EU can be understood 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 argue 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]

Our paper also helps explain 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 received secret bailouts, suffered no such run. When evidence emerged after the crisis that the UK authorities had provided secret loans to HBOS and RBS, some UK

[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 Alistair 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.

commentators expressed concern that the failure to reveal information about these loans might be perceived as dishonest;[2] 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. Public rescues, on the other hand, will inevitably result in reputational damage to the regulator and may therefore 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 the US, regulators took a different approach to trying to maintain their reputation. Secret rescues on the required scale were impossible, but rather than reveal exactly how many banks required capital injections, the US government took stakes in all of the big banks. It was unclear to what extent the problems of the US banking system were "solvency" problems, and to what extent they were simply "liquidity" problems. In this way the damage to the regulator's reputation for bank monitoring was limited, since some of the difficulties could be blamed on a global liquidity shortage that might be considered to be at least somewhat outside the regulator's purview.

Like us, Kane (1989) 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.

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. We conclude that - if the regulator's initial reputation is weak - it is socially better to design institutions so that regulators are unable to act in secret to forbear upon weak banks (for example, by giving the regulator very limited discretion and funding, and forcing transparency on all of its lending decisions). But there is a parameter region, where the regulator's reputation is intermediate, within which it is ex ante optimal to allow regulators discretion to manage their reputations and secretly to support the banking system. (When the regulator is sufficiently strong, transparency and secrecy

[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

are equally good policies.)

This conclusion is in contrast to work by Boot and Thakor (1993), who examine a model of regulator reputation in which the regulator's concern for his reputation arises from career concerns and 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 will survive even if the regulator's reputation is reduced. It is also suboptimal for regulators with very weak reputations, because they are sufficiently 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.

The only other paper of which we are aware to model banking regulators' reputation management explicitly is recent work by Shapiro and Skeie (2012). In contrast to our model, the regulator's auditing and monitoring skill is commonly known in Shapiro and Skeie's work, but its ability to fund bailouts is its private information. Their model also differs significantly from ours since they assume that forbearing on weak banks is more efficient than liquidating them, whereas we assume the converse. We think that our modelling choice in this dimension may better reflect the general concern that academics and policy-makers have expressed about the potentially damaging consequences of granting regulators to the freedom to forbear. (If forbearance were generally myopically optimal then it would be hard to explain the force behind the drive for the transparency of regulatory actions; presumably, we should not worry about giving regulators the funding and licence to forbear and inject cash secretly.) However, Shapiro and Skeie's simplification in this dimension allows them to address an interesting real world trade-off that we cannot. In their model, the regulator faces a conflict between, on the one hand, the incentive to prevent depositor panics by signaling its ability to fund bailouts if necessary and, on the other hand, the wish to sharpen banker incentives by conveying an inability to fund bailouts. If the former is more important, the regulator might signal by providing bailouts to banks that do not need funds; if the latter, the regulator might deny bailouts to banks that do need funds, even when providing funds would be optimal.

The remainder of the paper is set out as follows. Section 2 discusses the related literature on contagion apart from the papers on regulatory reputation mentioned above. Section 3 presents our basic model. Section 4 shows how bank regulator reputation can serve as a conduit for financial contagion. Section 5 derives our results for regulatory forbearance. Section 6 draws out policy conclusions in greater detail. Section 7 concludes. Longer proofs appear in the Appendix.

2. Related Literature

The prior literature has focussed 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 that were also important in the recent crisis. In the first class of models, contagion arises from the reduction in the value of interbank deposits. In Allen and Gale (2000), banks hold interbank deposits in order 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 (unanticipated) aggregate liquidity shock to the banking sector results in a general attempt to liquidate interbank deposits; the liquidations cause system-wide contagion that would be absent if banks were prevented from holding interbank deposits. This argument 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. However, Leitner (2005) shows that interbank lending can serve to commit banks to help other ailing banks ex post when ex ante it is desirable but impossible for them to contract 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. Allen, Babus and Carletti (2011) show how the combination of short-term bank debt and common assets among banks can lead to inefficient liquidation by creditors in response to negative information They show that a "less clustered" structure of interbank exposures – or longer-term debt – would mitigate this problem. Heider, Hoerova and 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 and 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 and 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 and Gale (2009) show that the price volatility caused by uncertain aggregate liquidity requirements reduces welfare, and argue that this problem can be resolved through appropriate Open Market operations.

Rochet and Tirole (1996) have a different explanation for why regulators allow extensive interbank lending, even 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, with each bank monitoring its neighbours. In equilibrium, this works well as a monitoring device. But, if one bank should fail, this failure indicates that the failing bank was inadequately monitored, and, hence, that the monitor of the failing bank 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 regulatory 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 is 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 and 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 and 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 and 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, as each bank's performance depends upon the regulator's ability, and the banks share a common regulator (or set of regulations).

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 and 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. According to our model, a public bank failure would very likely result in a loss of depositor confidence that would result in additional bank withdrawals across the system over and above those that would come from the interbank linkages.

An alternative empirical approach uses stock price information on banks to quantify systemic risk. Hartmann, Straetmans and 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; a result that is driven by the risk of contagion between European banks in different countries being relatively low. According to our model, one might 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 and 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 that 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.

3. 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 that yields a certain return of r. Second, he can invest it in a bank.

Banks are run by bankers, each of whom is able to invest funds received from depositors in a constant returns to scale project that occurs in either period 1 or period 2. For simiplicity, bankers in this model have no capital of their own to invest. Projects return R per dollar invested if they succeed, and they otherwise return 0. We classify bankers as *sound* and *unsound*; sound bankers are endowed with a monitoring technology, and unsound bankers are not. The probability that a given bank is sound depends upon the regulatory environment, which we discuss below.

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. Since bankers in our model have no capital and limited liability, they make no payments to depositors when their projects fail.[3] 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.

We now introduce a *regulator*. In this Section of the paper, the regulator's only tool is an imperfect screening technology that allows it to distinguish between sound and unsound bankers. This

[3] We examine the use of capital requirements and deposit insurance in related work: see Morrison and White (2005) and Morrison and White (2011).

role could arguably be performed by a private screening body such as a ratings agency. However, in Section 5 when we consider regulatory forbearance, we will give the regulator the power to audit and to close failing banks. This role is harder to delegate to a third party such as a ratings agency.

The regulator uses its screening technology to allocate banking licences.[4] In order to show that it may in some circumstances be socially optimal for the regulator to forbear on failing banks, we assume that the regulator has no selfish career-type concerns. Instead, 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 fraction of sound banks in the economy depends upon the quality of the regulator. Regulatory technologies are of two types: a bank licensed by a *good* regulator is sound with probability $\phi > \frac{1}{2}$, while a bank licensed by a *bad* regulator is equally likely to be sound or unsound. 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*.[5]

[4]For a discussion of the allocation of banking licences and regulatory screening in practice, see Barth, Caprio and Levine (2001, Figures 21, 22 and 23). In a study that covers the five years prior to 2001, Barth et al find that a significant fraction of bank licence applications is denied, ranging from 6.3% in Europe and Central Asia to 56.92% in South Asia. These figures probably understate the willingness of central banks to refuse licence applications, as many applicants withdraw from the process when it becomes apparent that their application will not succeed. The primary reasons given for denying bank licences were "incomplete application," "inadequate capital amount or quality," and "banking skills."

[5]We could also consider a *corrupt* regulator with a good screening technology, who awarded licences to unsound banks for reasons such as bribery and nepotism. Our results would be unchanged if opportunities for corrupt behaviour arose randomly, with probability $\frac{1}{2}$. The regulator's reputation can therefore be thought of more broadly as representing the quality of the institutional environment in which it operates.

When the regulator is bad, the expected return from depositing in a randomly selected bank is

$$(R-Q)\left(p_L+\frac{1}{2}\Delta p\right);$$

depositing will not occur if this is less than depositors' outside option, r. We assume that this is the case even when the fee Q for depositing is equal to zero:

$$\frac{1}{2}<\frac{r-Rp_L}{R\Delta p}. \tag{2}$$

Equation (2) implies that depositing will not occur if the regulator's reputation α is sufficiently weak.

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 4 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.

4. 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 $Q(p_L+\Delta p)-C$ to the bank from monitoring exceeds the return Qp_L from not doing so: in other words, if the following monitoring incentive compatibility constraint is satisfied:

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

Figure 1 is an extensive form for the stage game that we consider in this Section when agents assign a prior probability α to the event that the regulator is good; all agents update this prior after the success or failure of the bank's project. For $i=1,2,3,4$ we write S_i and F_i for the probability that the indicated notes in the success and failure information sets obtain. These probabilities can be read from the Figure: for example, $S_1=\alpha\phi p_H$ and $F_4=(1-\alpha)\frac{1}{2}(1-p_L)$.

It is immediate from Figure 1 that the first period bank is sound with probability $\alpha\phi+\frac{1}{2}(1-\alpha)$.

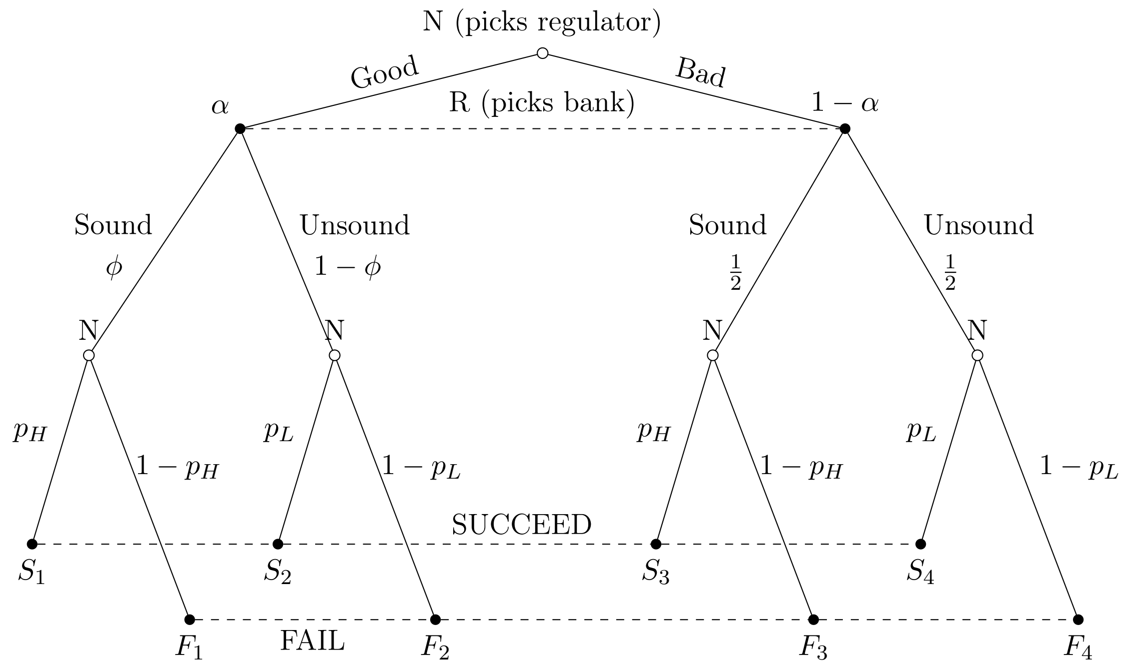


Figure 1: **Simplified extensive form for the game without auditing.** The prior probability that the regulator is good is α; the probability that a bank is sound is ϕ when the regulator is good, and is $\frac{1}{2}$ when the regulator is bad. Banks succeed with probability p_H if they are sound, and p_L if they are unsound. Neither depositors nor regulators know the regulator's type; at the end of the first period, depositors update their priors at the SUCCESS and FAIL information sets.

We write $U_D(\alpha)$ and $U_R(\alpha)$ for the respective per-period utilities that the depositors and the regulator derive from a bank with reputation α:

$$U_D(\alpha) = (R - Q)\left(\frac{1}{2}(p_L + p_H) + \alpha\left(\phi - \frac{1}{2}\right)\Delta p\right); \tag{4}$$

$$U_R(\alpha) = \frac{1}{2}(R(p_L + p_H) - C) + \alpha\left(\phi - \frac{1}{2}\right)(R\Delta p - C). \tag{5}$$

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

Lemma 1 *Both $U_D(\alpha)$ and $U_R(\alpha)$ are monotonically increasing in α, with $U_D(\alpha) < U_R(\alpha)$.*

We assume that depositing is attractive when $\alpha = 1$ and that depositing is not socially desirable when $\alpha = 0$: in other words that

$$U_R(0) < r < U_D(1). \tag{6}$$

Note that, by Lemma 1, Equation (6) implies that depositing is unattractive when $\alpha = 0$ and that banking is socially useful when $\alpha = 1$. The condition is satisfied precisely when conditions (7) and

(8) are satisfied:

$$\frac{1}{2}\left(R\left(p_L + p_H\right) - C\right) < r \tag{7}$$

$$\left(R - Q\right)\left(p_L + \phi\Delta p\right) > r. \tag{8}$$

It is possible to find parameters satisfying these conditions when Q satisfies equation (9):

$$Q < \frac{R\Delta p\left(\phi - \frac{1}{2}\right) - \frac{1}{2}C}{p_L + \phi\Delta p}. \tag{9}$$

Conditions (3) and (9) can be satisfied simultaneously provided the following condition is satisfied:

$$C < \frac{R\Delta p^2\left(\phi - \frac{1}{2}\right)}{p_L + \Delta p\left(\phi - \frac{1}{2}\right)}. \tag{10}$$

We adopt equation (10) as an assumption.

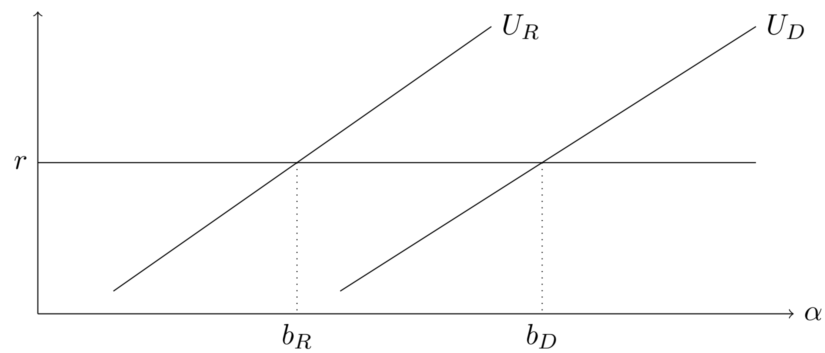


Figure 2: **Regulator and depositor utilities for the unaudited banking sector**. The regulator and depositors derive respective utilities $U_R(\alpha)$ and $U_D(\alpha)$ when the regulator's reputation is α. Banking is socially desirable precisely when $U_R(\alpha) \geq r$; depositing is individually rational precisely when $U_D(\alpha) \geq r$.

Figure 2 plots the respective depositor ad regulator utilities $U_R(\alpha)$ and $U_D(\alpha)$ as a function of the regulator's reputation, α. Both curves are monotone increasing in α and by Assumption (6), each lies below r for low enough α and above r for high enough α. We write b_R and b_D for the respective boundary regulator reputations at which $U_R(\alpha)$ and $U_D(\alpha)$ are equal to r; expressions for b_R and b_D appear in the Appendix. Banking is socially useful precisely when $\alpha > b_R$ and it is individually rational for depositors precisely when $\alpha > b_D$.

Because $b_R < b_D$, there is a range $b_R \leq \alpha \leq b_D$ of reputations within which banking is socially desirable but, because depositors are unwilling to deposit, there is no banking sector. This is because depositors receive only a fraction $R - Q < R$ of the returns on successful bank investments and so fail fully to internalise their social benefits. In our model the remainder of the surplus generated by banks managing depositor funds goes to bankers as informational rents, but it is easy to see that in a more general model some of this surplus would also be captured by the entrepreneurs and firms to which the banks lend for incentive reasons. The key assumption is that regulator values the surplus that accrues to bankers and entrepreneurs even though depositors do not.

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

$$\alpha_F(\alpha) = \frac{\alpha\phi(1-p_H)+\alpha(1-\phi)(1-p_L)}{\alpha\phi(1-p_H)+\alpha(1-\phi)(1-p_L)+(1-\alpha)\left(1-\frac{1}{2}(p_L+p_H)\right)}. \tag{11}$$

Clearly, if $\alpha_F(\alpha) < b_D$ 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 expected quality of the second period banks. Hence, regulatory reputation serves in this model as a conduit for financial contagion. Proposition 1 identifies the trigger first period regulator reputation t_F below which first period bank failure results in a contagious run on the second period banking sector.

Proposition 1 *Let*

$$t_F = \frac{b_D\left(1-\frac{1}{2}(p_L+p_H)\right)}{b_D\left(1-\frac{1}{2}(p_L+p_H)\right)+(1-b_D)\left(\phi(1-p_H)+(1-\phi)(1-p_L)\right)} \tag{12}$$

If the first period regulator reputation α lies between b_D and t_F then first period banking will occur, but first period bank failure will cause a contagious closure of the second period banking sector. Moreover, if $\alpha_F(\alpha) > b_R$, this contagion is socially damaging.

Proof. The Proposition follows from Lemma 2 and the fact that $\alpha_F(t_F) = b_D$.

The main results of this Section are illustrated in Figure 3, which shows the way that the banking sector's properties depend upon the regulator's reputation α. When α is very low ($\alpha < b_R$) banking adds so little value that neither the regulator nor the depositors regard it as worthwhile; conversely,

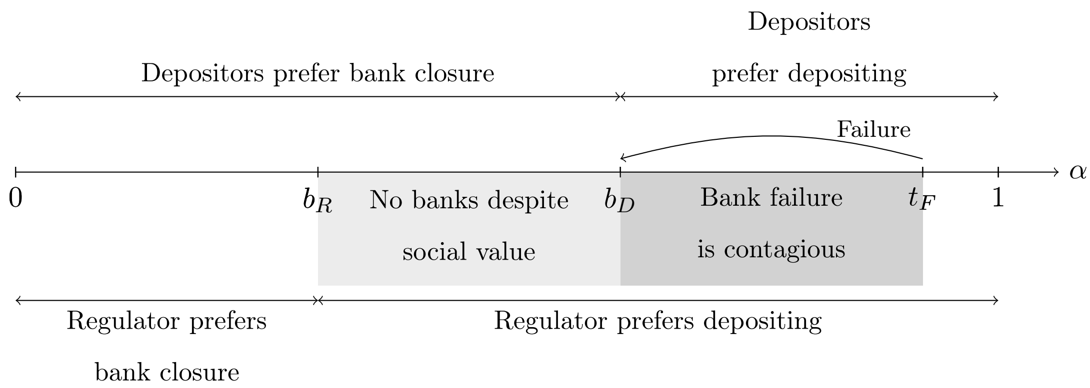


Figure 3: **Reputation boundaries and trigger points**. For $\alpha < b_R$ banking has no social value. For $\alpha \geq b_D$ banking is socially useful and worthwhile for depositors. For $b_R \leq \alpha < b_D$ banks are socially useful, but depositors refuse to deposit. The prior reputation $\alpha = t_F$ is updated upon failure to b_D. Hence, when the prior regulator reputation α lies between b_D and t_F bank failure in the first period causes a contagious closure of the second period banking sector.

for high α ($\alpha \geq b_D$), banking is so productive that depositors and regulators favour depositing. For the intermediate range $b_R \leq \alpha < b_D$, shaded in light grey in the Figure, banking is socially useful but, because depositors fail to internalise all of its value, they refuse to deposit. The dark grey region of reputations ($b_D \leq \alpha < t_F$) is identified in Proposition 1. Within this region banking occurs in the first period, but the posterior regulator reputation after bank failure is so low as to preclude second period banking: in other words, first period bank failures in this region are contagious.

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 and possible forbearance.

5. 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, the regulator 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 or liquidate (we will use these terms synonymously) the bank at this interim date if this is socially optimal. (For example, other things being equal it would be optimal to liquidate the bank if the audit reveals it to be unsound). The contagion effects highlighted in Proposition 1 carry through to the richer model of this section. In addition, we can show that, although ceteris paribus, closing an unsound bank has a larger net present value than leaving it open, the regulator may in some cases choose not to liquidate the bank because of the likely impact on its reputation. The regulator's reputation is important because bank 2 will not be able to operate if the regulator's reputation is too low, even when it is socially beneficial for it to do so.

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 good and bad regulators are endowed with an auditing technology that yields a perfect signal of banker type with respective probabilities λ_G and $\lambda_B < \lambda_G$. The signal is accompanied by hard and verifiable data if the banker is unsound, but not if he is sound. Armed with this verifiable data, the regulator may close down the bank if it wishes, 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 can never occur unless the audit has returned a bad signal. We assume that

$$r > L > Rp_L. \tag{13}$$

Hence the regulator will never wish to close down a sound bank (which is expected to return $Rp_H > L$), and, *ceteris paribus*, would prefer to close down an unsound bank (which is expected to return $Rp_L < L$ if it remains open). Note that, as our model is written, the regulator does not need to inject funds in order to maintain an unsound bank 1 through to the end of period 1. However, we will discuss below how the model can be re-interpreted such that there are no proceeds from liqudation at the interim date, and instead an amount L must be injected, with an expected return of Rp_L at the end of period 1, so that, as before, the expected loss from forbearance (not closing bank 1 when it is discovered to be unsound) is $L - Rp_L$.

We start by considering the second period. The extensive form for this stage game is illustrated in Figure 4. 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. The stage game after the audit is laid out in Section 4. Depositors update their reputation priors in the information sets LIQUIDATE, SUCCESS, FAILURE; we denote with lower case letters the prior probability that each node in the information set is reached.

Analogous to equations (4) and (5), we can write $W_D(\alpha)$ and $W_R(\alpha)$ for the respective expected

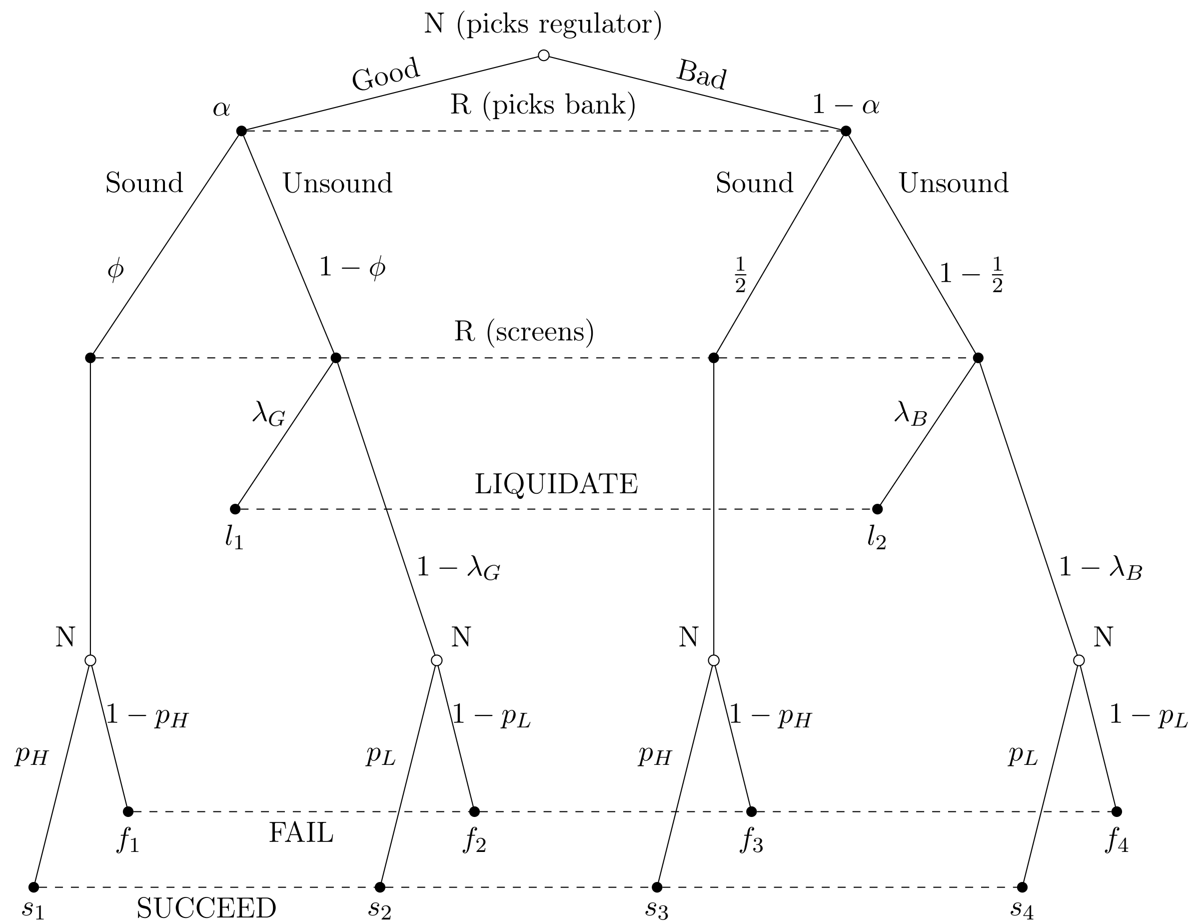


Figure 4: **Simplified extensive form for the game with auditing**. The Figure illustrates the second period stage game, where the regulator always elects to liquidate an unsound bank. The prior probability that the regulator is good is α. After licences are awarded, good and bad regulators receive a perfect signal of bank type with respective probabilities λ_G and λ_B; banks that are revealed to be bad are liquidated. The remainder of the stage game plays out in the same way as Figure 1. Depositors update their priors in the LIQUIDATE, SUCCESS, and FAIL information sets.

time 1 utilities of the depositor and the regulator when the regulator's reputation is α:

$$W_D(\alpha) = U_D(\alpha) + \alpha(1-\phi)\lambda_G + \frac{1}{2}(1-\alpha)\lambda_B(L-(R-Q)p_L) \quad (14)$$

$$W_R(\alpha) = U_R(\alpha) + \alpha(1-\phi)\lambda_G + \frac{1}{2}(1-\alpha)\lambda_B(L-Rp_L). \quad (15)$$

The following results are analogous to those of Lemma 1.

Lemma 3 *Both $W_D(\alpha)$ and $W_R(\alpha)$ are monotonically increasing in α, with $W_D(\alpha) < W_R(\alpha)$.*

Note in addition that $W_D(\alpha) > U_D(\alpha)$ and $W_R(\alpha) > U_R(\alpha)$: the ability to audit makes depositing more attractive, and it raises aggregate welfare. It follows from equation (6) 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, $W_R(0) < r$, or

$$\frac{1}{2}(R(p_L+p_H)-C) < r - \frac{1}{2}\lambda_B(L-Rp_L). \quad (16)$$

By analogy with Section 4, there exist boundary regulator reputations β_R and β_D, with $\beta_R < \beta_D$, such that the regulator prefers not to open a banking sector when its time 1 reputation is lower than β_R, and depositors refuse to deposit when the time 1 reputation is lower than β_D. β_R and β_D correspond to the b_R and b_D of Figure 2. Since $W_R(\alpha) > U_R(\alpha)$ and $W_D(\alpha) > U_D(\alpha)$ it is clear that $\beta_R < b_R$ and $\beta_D < b_D$: 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. Expressions for β_R and β_D appear in the Appendix.

Lemma 4 characterises the effect of bank liquidation upon regulator reputation.

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

$$\alpha_C(\alpha) = \frac{\alpha(1-\phi)\lambda_G}{\alpha(1-\phi)\lambda_G + \frac{1}{2}(1-\alpha)\lambda_B}.$$

Note that the regulator need not act upon a bad audit signal; it could choose to ignore it, or to liquidate. This renders the post-failure updating of regulator reputation more complex, because the updating is conditioned upon the regulator's closure policy. If the regulator elects never to liquidate after a bad signal then the posterior reputation is $\alpha_F(\alpha)$; if the regulator does liquidate then the posterior reputation is given by

$$\begin{aligned}\alpha_{LF}(\alpha) &= \frac{f_1+f_2}{f_1+f_2+f_3+f_4} \\ &= \frac{\alpha(\phi(1-p_H)+(1-\phi)(1-\lambda_G)(1-p_L))}{\alpha(\phi(1-p_H)+(1-\phi)(1-\lambda_G)(1-p_L))+\frac{1}{2}(1-\alpha)(1-p_H+(1-\lambda_B)(1-p_L))}.\end{aligned}$$

These observations are collected in Lemma 5.

Lemma 5 *If a regulator has prior reputation α then its posterior reputation upon failure depends upon its liquidation strategy as follows:*

$$\alpha_{FailurePosterior}(\alpha) = \begin{cases} \alpha_F(\alpha), & \text{if the regulator ignores bad audits} \\ \alpha_{LF}, & \text{if the regulator liquidates after bad audits.} \end{cases} \tag{17}$$

We now identify first period regulator reputation trigger values, below which failure or liquidation of the first period bank results in reputational contagion that prevents the second period bank from opening.

Proposition 2 *Define τ_F, τ_{LF} and τ_C to be the unique solutions of the equations $\alpha_F(\tau_F) = \beta_D$, $\alpha_{LF}(\tau_{LF}) = \beta_D$, and $\alpha_C(\tau_C) = \beta_D$. Then*

1. *When the regulator does not liquidate upon receiving a poor auditing signal, bank failure results in a second period run precisely when the prior reputation α is below τ_F;*
2. *When the auditor liquidates upon receiving a poor auditing signal, bank failure results in a second period run precisely when the prior reputation α is below τ_{LF};*
3. *Bank liquidation results in a second period run precisely when the prior reputation α is below τ_C;*
4. *$\tau_C - \tau_F$ and $\tau_F - \tau_{LF}$ are both positive, zero or negative according to whether μ is positive, zero, or negative, where*

$$\mu = \lambda_B(1-p_H)\left(\phi - \frac{1}{2}\right) - (1-\phi)(\lambda_G - \lambda_B)\left(1 - \frac{1}{2}(p_L + p_H)\right). \tag{18}$$

The parameter μ is negative when the good regulator's auditing technology is sufficiently stronger than the bad regulator's: that is, when $(\lambda_G - \lambda_B)$ is large enough. Intuitively, it seems reasonable that a high $(\lambda_G - \lambda_B)$ should also improve the relative posterior of the regulator upon liquidation relative to failure. Conversely, if $(\lambda_G - \lambda_B)$ is small, so that good and bad regulators are using similar technology to identify unsound banks, the fact that an unsound bank has been found and liquidated indicates that the original screening was ineffective. In other words, when $(\lambda_G - \lambda_B)$ is low, the certain signal of poor quality revealed by liquidation might be expected to render liquidation a worse signal of regulator quality than failure. Lemma 6 confirms this intuition.

Lemma 6 *The posterior regulator reputation upon second period bank liquidation exceeds the posterior upon failure precisely when* $\mu < 0$.

We now investigate the regulator's optimal first period response to a poor auditing signal. The regulator updates its prior reputation α to the posterior $\alpha_C(\alpha)$ as soon as it receives this signal, but the depositors can perform this update only if they observe closure. We consider separately the cases where $\mu > 0$ and $\mu < 0$.

First, suppose that $\mu > 0$. Then, by part 4 of Proposition 2, we must have $\tau_C > \tau_F > \tau_{LF}$. The effects of bank liquidation and failure for different reputation parameters are given by parts 1-3 of the Proposition, and are illustrated in Figure 5.

Depositors revise their assessment of the regulator's reputation down upon a bank liquidation. But, referring to Figure 5, when $\alpha > \tau_C$, this revision does not result in the closure of the second period bank. Hence, the regulator liquidates bad banks for these α values, since this maximises the first period surplus. When $\tau_F > \alpha > \tau_C$, again referring to Figure 5, first period bank liquidation causes the second period bank to fail, but first period bank failure does not. Hence, the regulator might choose to forbear on an unsound first period bank so as to protect the second period bank. The social return to liquidation of the first period bank is $L+r$, comprising the sum of the liquidation value L of the first period bank and the value r of the second period depositors' outside option. The

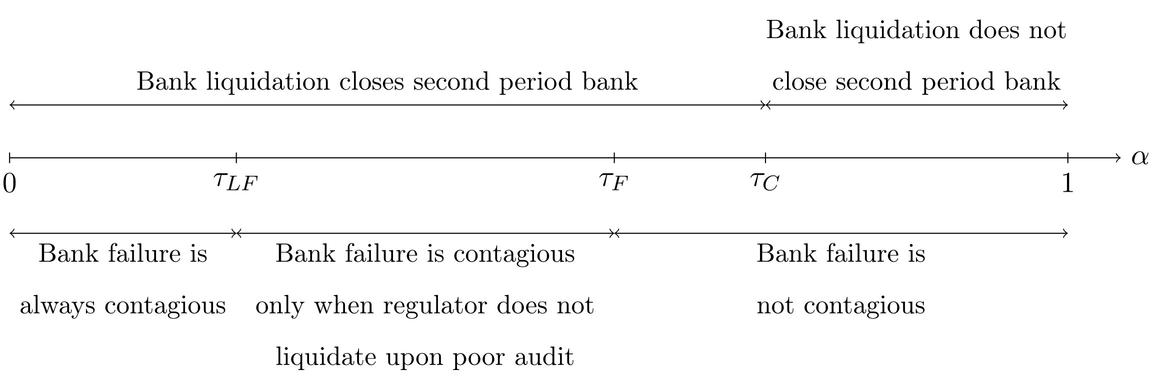


Figure 5: **Reputation triggers when** $\mu > 0$. By part 4 of Proposition 2, when $\mu > 0$, $\tau_{LF} < \tau_F < \tau_C$. The effect of first period bank failure and liquidation is illustrated for each reputation.

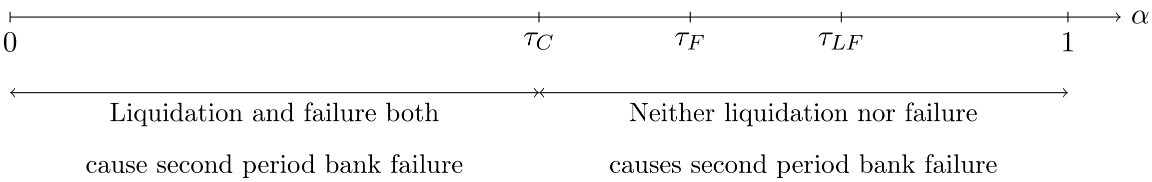


Figure 6: **Reputation triggers when $\mu < 0$.** By part 4 of Proposition 2, when $\mu < 0$, $\tau_{LF} > \tau_F > \tau_C$. The effect of first period bank failure and liquidation is illustrated for each reputation.

social return to forbearance is $Rp_L + W_R(\alpha_C(\alpha))$. Hence the regulator elects to forbear precisely when

$$L - Rp_L < W_R(\alpha_C(\alpha)) - r. \tag{19}$$

Figure 5 indicates that, if $\alpha < \tau_{LF}$, then irrespective of the strategy that the regulator adopts, depositors will abandon the second period banking sector if the first period bank fails. Hence, a decision not to liquidate an unsound period 1 bank in this case is tantamount to regulatory gambling for resurrection: if the regulator does not liquidate then there will be a second period banking sector only if the first period bank does not fail. Once again, the social return to liquidation is $L + r$. The social return to gambling for resurrection is $p_L(R + W_R(\alpha_C(\alpha))) + (1 - p_L)r$: with probability p_L the first bank succeeds and yields R, after which the second period banking sector yields $W_R(\alpha_C(\alpha))$; with probability $1 - p_L$ the first period bank fails and returns nothing, after which the second period bank does not open. The social return to gambling for resurrection exceeds that from liquidation precisely when

$$L - Rp_L < p_L(W_R(\alpha_C(\alpha)) - r). \tag{20}$$

Finally, we consider the case where $\tau_{LF} < \alpha < \tau_F$. As indicated in Figure 5, the depositor response to bank failure depends upon the way that they believe the regulator reacts to a bad audit. If depositors believe that the regulator does not liquidate after a poor audit then first period bank failure is contagious. With this depositor belief the decision not to audit is tantamount to regulatory gambling for resurrection, which will therefore happen if condition (20) is satisfied. If, on the other hand, depositors believe that the regulator liquidates upon a bad audit then first period bank failure is not contagious. Non-liquidation with this depositor belief is forbearance; the regulator will therefore elect to liquidate when condition (19) is violated. Finally, suppose that the following intermediate condition is satisfied:

$$p_L \left(W_R \left(\alpha_C \left(\alpha \right) \right) - r \right) < L - Rp_L < W_R \left(\alpha_C \left(\alpha \right) \right) - r. \tag{21}$$

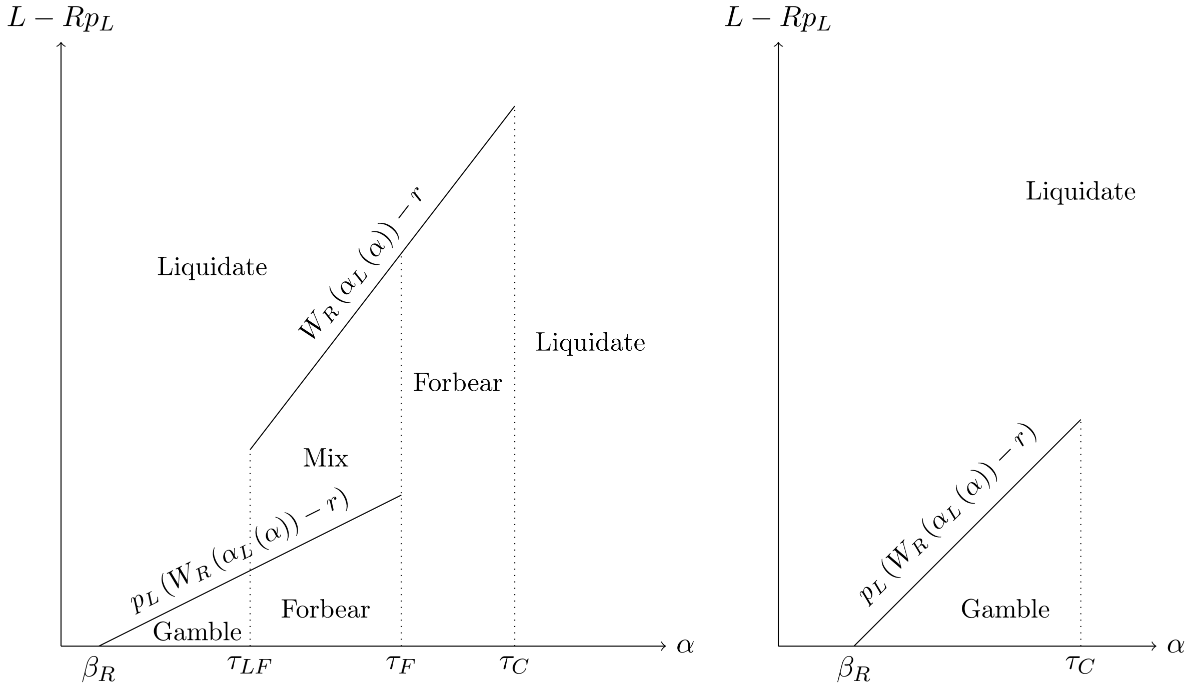
Then a depositor belief that the regulator liquidates upon a bad signal leads the regulator to forbear, and a belief that the regulator forbears upon a bad signal leads the regulator to forbear. Hence, the regulator mixes when condition (21) is satisfied: the probability of liquidation is increasing in $L - Rp_L$.

Now consider the case where $\mu < 0$. Then, by part 4 of Proposition 2, $\tau_C < \tau_F < \tau_{LF}$. The effects of bank liquidation and failure are given by parts 1-3 of the Proposition, and are illustrated in Figure 6. It is clear from the Figure that only two cases need to be considered: when α is greater and less than τ_C. When $\alpha > \tau_C$ liquidation of the first period bank does not cause second period bank failure and, hence, the regulator liquidates upon a poor audit so as to maximise first period returns. If $\alpha < \tau_C$ then, irrespective of depositor beliefs, first period bank failure is contagious. It follows that the regulator will not liquidate upon a poor audit precisely when the gambling for resurrection condition (20) is satisfied.

Proposition 3 summarises this discussion.

Proposition 3 *Suppose that the regulator's prior reputation is α and that the regulator receives a bad signal when it audits the first period bank.*

1. *If $\alpha > \tau_C$ then the regulator liquidates the bank;*
2. *If $\mu > 0$ then*
   (a) *If $\tau_F < \alpha < \tau_C$ the regulator forbears on the bank precisely when condition* (19) *is satisfied, and liquidates the bank if it is not;*
   (b) *If $\tau_{LF} < \alpha < \tau_F$ then the regulator liquidates the bank when condition* (19) *is violated, mixes between liquidation and forbearance when condition* (21) *is satisfied, and forbears on the bank when condition* (20) *is satisfied;*
   (c) *If $\alpha < \tau_{LF}$ then the regulator gambles for the resurrection of the banking sector when condition* (20) *is satisfied, and otherwise liquidates the first period bank.*
3. *If $\mu < 0$ then the regulator gambles for resurrection when condition* (20) *is satisfied, and otherwise liquidates the first period bank.*



(a) $\mu > 0$: by part 4 of Proposition 2, $\tau_C > \tau_F > \tau_{LF}$.

(b) $\mu < 0$: by part 4 of Proposition 2, $\tau_C < \tau_F < \tau_{LF}$.

Figure 7: **Equilibrium behaviour of the regulator after a bad first period audit signal**. The Figure indicates the dependence of regulator strategy upon prior reputation α and the immediate benefit $L - Rp_L$ of liquidation. In regions labelled "Forbear" and "Gamble" the regulator protects its reputation by not liquidating a bank with a poor audit; the bank subsequently fails then there is second period contagion to the second period bank in "Gamble" regions, but not in "Forbear" regions. In the "Mix" region the regulator randomises between closure and liquidation after a poor first period audit.

Proposition 3 is illustrated in Figure 7; Figures 7a and 7b illustrate the respective cases where μ is positive and negative. The regulator responds to a poor first period audit by liquidating when its reputation is strong enough to survive the shock of an announcement that it was wrong ($\alpha > \tau_C$), or when the benefits $L - Rp_L$ are sufficiently large. Note that the benefits needed to convince the regulator to liquidate are diminishing in its prior reputation, and that, when $\mu > 0$, they step down when $\alpha = \tau_{LF}$, below where forbearance is tantamount to gambling for resurrection.

6. Policy Implications

6.1. Bailing out Banks

In the model as we have presented it, the regulator forbears upon a bank when it privately knows that continuation of the bank has a negative NPV. The regulator is not required to invest funds and, hence, the discussion thus far does not help us to analyse bank bailouts per se. Nevertheless, it is easy to show that at the cost of a slightly increased level of complexity that the phenomena at the center of our model are also relevant in the context of bailouts.

Bailouts occur when banks are liquidity-constrained. To introduce this constraint into our model, consider a three-date investment opportunity similar to that of Section 5. Now, when depositors provide them with funds, each bank has access to the following investment technology. First, the technology requires a date 0 investment. It can then be partially or completely liquidated at date 1 for a known and certain payment of L per dollar of liquidated investment. Any investment that is not liquidated will return R or 0 per dollar invested at time 2; the probability of return R is p_L if the project is not monitored, and $p_H = p_L + \Delta p$ if it is. As in Section 5, $r > L > Rp_L$.

The depositor contract in this altered model will be the source of the bank's liquidity shocks. Each depositor may invest \$1 at date 0. In return, he has the right to withdraw L at date 1 or to wait until date 2, when he receives $R - Q$ if his bank succeeds. Depositors might withdraw their funds for two reasons. First, they might decide at time 1 that the liquidation value L exceeds the expected return from retaining their deposits. Second, they may withdraw in response to an unanticipated liquidity shock of size L. We assume that the date 0 probability of such a shock is δ, and that that probability is low.

Banks can respond to date 1 depositor withdrawals in two ways. They can liquidate their investments piecemeal, or they can sell outstanding depositor claims for \$$L$ on the dollar. By construction, a depositor's withdrawal can be met exactly by liquidating the investment that he financed. As a result, there are no Pareto-inferior equilibria involving self-fulfilling runs of the type that Diamond and Dybvig (1983) study.

In the case where there is no auditing, studied in Section 4, no news emerges at the interim date and, hence, the liquidation value \$$L$ is less than the expected payoff from not liquidating. (This must be true or else depositors would not have found it worthwhile to invest in the first place.) Any early withdrawals can therefore be covered by selling the deposit claims concerned to fresh investors. Hence, there is no premature liquidation of bank assets. The regulator's expected utility $U_R(\alpha)$ is therefore given by Equation (5). The depositor's expected utility is given by $U'_D(\alpha) = (1-\delta) U_D(\alpha) + \delta L$, where $U_D(\alpha)$ is given by Equation (4). Provided δ is small, the ex ante analog to Equation (6) holds: $U_R(0) < r < U'_D(1)$ so that, as in Section 4, there exist b'_R and $b'_D > b'_R$ such that banking is socially useful for $\alpha > b'_R$ and depositing is individually rational precisely when $\alpha > b'_D$. Similarly, as in Proposition 1 there will be a trigger regulator reputation $t'_F < t_F$ below which any first period bank's failure causes a contagious failure of the second period bank.

Now suppose that, as in Section 5, the regulator is able to perform a date 1 audit of the bank. As in Section 5 we assume that the regulator is able credibly to communicate poor auditing results, but not strong results. The regulator cannot liquidate poor banks. However, if it reveals that it received a poor signal it precipitates a total depositor withdrawal to which the bank must respond by liquidating its assets. Hence, the effect of a revealed poor audit is identical to that of a date 1 liquidation in Section 5. The forbearance and gambling identified in Section 5 is therefore equivalent in the set-up of this Section to non-revelation of auditing results. As in the case without audit, the only effect of this modification upon the calculations of Section 5 is that the utility $W'_D(\alpha)$ of the depositors is slightly reduced by the (probability δ) possibility that they may experience a liquidity shock. The results of Section 5 therefore go through unchanged: there are reputation triggers $\tau'_C > \tau'_F > \tau'_{LF} > \beta'_R$ such that the results of Proposition 3 go through, with "forbearance" and "gambling" interpreted as non-revelation decisions in the wake of poor audits.

Bailouts are a response in this set-up to a generalized liquidity shock. Hence, suppose that all depositors experience a probability δ date 1 liquidity shock, and suppose that there are no other investors to take their place. The ex ante probability of such a shock is not relevant to our analysis, as it does not affect the time 0 depositor participation constraints, which depend only upon α, R and δ. We assume for simplicity that it is zero.

Regulators faced with a generalized liquidity shortage can make good the bank shortfall by purchasing outstanding deposit contracts themselves (if necessary, they can create money to do so). They will choose to do so if they received no information from a time 1 audit, if they received good news, or if they received bad news and decide - for reputation management reasons - to forbear or to gamble.

Thus our model can be used to demonstrate that public bailouts can be optimal. Such bailouts occur whenever the interim audit generates no information, or when the audit is strong. Bailouts are completely indiscriminate for intermediate reputations ($\beta'_R < \alpha < \tau'_C$) and low enough $L - Rp_L$: for these parameterizations, labelled "Forbear" and "Gamble" in Figure 7, the regulator bails out even bad banks in order to protect its reputation. Note, though, that the optimality of public bailouts hinges upon the assumption that there is a generalized liquidity crunch at time 1 so that private investors cannot rescue banks. If private investors had funds then, because their investment has a positive net present value, they should be prepared to rescue banks by providing liquidity. Thus our model, cannot, for example, explain the *public* bailout of Continental Illinois, which did not occur during a general liquidity crisis. We believe that this public bailout was motivated by the desire to avoid the classic form of contagion arising from interbank lending (discussed in section 2), which we do not model here.[6] Note that a public bailout in the situation when private funding is believed to be available might then be perceived as inside information that a private sector bailout will not occur, and, hence, as a negative signal of bank quality; such updating is outside the scope of our formal analysis.

6.2. Secret versus Transparent Regimes

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, Governor of the Bank or England, 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. Some press comment at the time suggested that the Bank would nevertheless perform secret bailouts in the months ahead.[7] These

[6]Interestingly, although the bailout of Continental Illinois, eventually became very public, it also provides an example of a (failed) attempt at secret forbearance. In fact, the Office of the Comptroller of the Currency (OCC) had been aware of the bank's problems for some time before these became generally known and yet did little to restrain the bank: see Federal Deposit Insurance Corporation (1997, pp. 243-246). Moreover, when Continental experienced a run in May 1984, "the Comptroller of the Currency, departing from the OCC's policy of not commenting on individual banks, took the extraordinary step of issuing a statement denying the agency had sought assistance for Continental and noting that the OCC was unaware of any significant changes in the bank's operations, as reflected in its published financial statements, that would serve as the basis for rumors about Continental." We thank the referee for drawing our attention to this incident.

[7]See, for example, "Bank bail-outs to be kept secret", Dan Atkinson and Simon Watkins, http://www.thisismoney.co.uk/money/news/article-1630519/Bank-bail-outs-to-be-kept-secret.html. This article claims that "The Bank of England has imposed a permanent news blackout on its £50bn-plus plan to ease the credit

episodes suggest that regulators perceive benefits in 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 publicize 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 maximize depositors' returns by promptly closing the bank and generating L rather than Rp_L. Since a regulator with the power secretly to forbear could have chosen this action but does not to do so in the "Gamble," "Forbear" and "Mix" regions of Figure 7, enforcing transparency must be strictly worse ex post than allowing secret forbearance. To reinterpret in terms of bailouts, it is strictly better *ex post* to be able to lend to an unsound bank secretly than to be obliged to publicize the results of its audit when doing so.

Requiring transparency does have an *ex ante* benefit, however. When the regulator is able to perform secret bailouts, the minimum regulator reputation at which a banking sector can exist is β_R. In contrast, without secret bailouts, the minimum regulator reputation consistent with banking is $b_R < \beta_R$. 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 and, hence, 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.

This discussion is illustrated in Figure 8. Transparency is optimal precisely when the regulator wishes to commit ex ante to liquidate upon a poor signal. Such a commitment is desirable when it is necessary to ensure that depositors choose to invest in banks. That situation arises when the prior reputation α is so low that depositor participation is rational only when bad banks will be liquidated: as shown in the Figure, this is the case for $b_R \leq \alpha < \beta_R$. For higher values of α depositors participate irrespective of transparency policy, so that the policy matters only when the regulator wishes to retain the option to forbear upon bad banks. Hence, when $\alpha \geq \tau_C$ the transparency policy is irrelevant, because the regulator liquidates all bad banks and, when $\beta_R \leq \alpha < \tau_C$, the

crunch. Ferocious and unprecedented secrecy means taxpayers will never know the names of the banks that have been supported through the special liquidity scheme, which was unveiled by Bank Governor Mervyn King last week. Requests under the Freedom of Information Act are to be denied." It later came to light that at least two large banks were did received secret loans from the Bank of England: see footnote 2, and the discussion in the introduction to which it is attached.

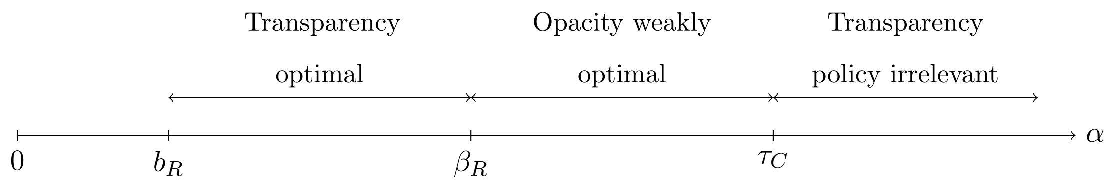


Figure 8: **Optimal transparency policy**. When the prior reputation α lies below b_R depositors will not invest in banks at all, irrespective of transparency policy. When $b_R \leq \alpha < \beta_R$ banking is possible only if audit results are transparent, so that depositors can be sure that banks will be liquidated upon a bad audit. When $\beta_R \leq \alpha < \tau_C$ opacity is useful when regulators would prefer ex post to forbear after a bad audit: as in Figure 7, this is the case when the surplus $L - Rp_L$ is low enough; for higher $L - Rp_L$ the regulator prefers liquidation after a poor audit, and so the transparency policy is irrelevant. For $\alpha \geq \tau_C$ the regulator liquidates irrespective of transparency policy.

transparency policy is similarly unimportant when the return $L - Rp_L$ from liquidating bad banks is high enough. When $\beta \leq \alpha < \tau_C$ and $L - Rp_L$ is lower opacity is the optimal policy, because it leaves the regulator free to take the socially optimal course of forbearing on bad banks.

6.3. Interpreting Recent US regulatory events

During the financial crisis of 2007-8, banks saw many of their regular sources of short term funding dry up. Therefore, one could argue that the liquidity shock model above (subsection 6.1) can be applied to explain the success of the US government's troubled asset relief programme (TARP) and the Federal Reserve's TALF. These measures provided short term relief to banks in the wake of the market freeze following the Lehman bankruptcy in 2009. Revelations about the extent to which regulators had allowed banks to invest in highly rated but nevertheless ulitimately risky securities (such as MBS and CLOs) may have damaged the regulator's reputation sufficiently that any further bank failures could have lead to contagion to other healthy banks. In this situation, the regulator would (optimally) choose to forbear on all failing banks, which, in the presence of a global liquidity shock, implies providing liquidity to all banks. This is what the TARP and TALF programmes did.

However, as remarked above, as long as the regulator publicly supports all banks, the suspicion remains that the regulator is supporting unsound banks as well as sound ones, which limits the extent to which the regulator's reputation can recover. If there are only sound banks, then after the liquidity shock has ended, these banks should be able to replace public funding with private funding - and, if they are not able to do so, then agents may draw the conclusion that the banks that continue to rely on public money are unsound. The US Federal Reserve sought to resolve this situation by undertaking a stress test of the banks with a public announcement of results. These stress tests can be viewed within our model as a commitment to auditing the banks and making the results public. Two points are worth noting. First, there was no benefit to making public the audit results during the time of the liquidity shock, if there was insufficient private money available to refinance the banks anyway. Second, some banks did fail the stress tests. These banks did not actually fail (as did bank 2 in our simple model), but they were required to provide more capital. We comment on this difference in the following section.

6.4. 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 and White (2011) 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 subsidized deposit insurance scheme funded out of general taxation to encourage agents to deposit in banks. [8] 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 subsidized deposit insurance scheme as advocated by Morrison and White (2011), and further, that if the regulator is forced to publicize 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 followed as the 2007-09 crisis evolved.

Regulators have also responded to the crisis by instructing the banks under their supervision to

[8] Since everyone is risk-neutral, subsidized recapitalisations are an equivalent remedy in their model. Unsubsidized measures, by contrast, are ineffective.

raise more capital. In a static but more complex version of the present model Morrison and 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. If banks are unable or unwilling to raise more capital when the perceived increase in risk causes this to be necessary, then they instead will have to shrink their balance sheets if they wish to continue operations (that is, in the context of our model, accept fewer deposits and fund fewer projects). The result is that instead of bank 2 failing entirely, in the current stark model, bank 2 would be able to operate on a smaller scale (with the resulting negative impact on the projects it is no longer able to fund). The ability in practice to tighten regulation means that is possible to run a smaller banking system when depositors have very little confidence in the regulator.

Our model is deliberately simple in order to allow us to solve the Bayesian updating problem of banks' uninsured creditors. Hence, we do not allow for the possibility of tightening capital requirements and/or increasing the generosity of the subsidy provided to the deposit insurance scheme when regulatory reputation (as perceived by banks' uninsured creditors) drops below a critical level. Doing so would clearly render it less critical that regulators be able to manage their reputations since, in that case, other instruments would be available. However, although welfare would no longer drop discontinuously at α_{LD}, it seems likely that there would still be a role for reputation management, and, hence, our model's conclusions would be robust to this extension. Forbearing on a given bank may be less costly than raising deposit insurance or capital requirements for another after the first bank has been publicly liquidated. This is particularly true if policies that require banks to raise more equity, or that feature higher general taxation to finance bigger deposit insurance subsidies, are considered to be increasingly costly at the margin and in times of crisis.

6.5. 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 β_R but above b_R. 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 and Santos (2005)). In the United Kingdom, regulatory powers were shared between the Financial Services Authority, which was 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 criticized in the wake of the 2007 failure of the Northern Rock bank, because it was apparently unable sufficiently rapidly to commit to recapitalize and to bail out the Northern Rock Bank. There criticisms may valid, 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 $b_R \leq \alpha < \beta_R$.

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.[9] Term limits for the regulators themselves may therefore be ineffective, and forcing frequent changes to regulatory systems is unlikely to be a practical proposition. [10]

7. 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 reputation - or perceived ability - to solve these problems is therefore an important asset: the size of the financial sector depends upon it.

[9] In this context, see also Footnote 5.

[10] For example, in the wake of the 2007-09 financial crisis, US and European regulators have been impelled to "redesign" bank regulation to revamp confidence in the financial system. This has proved very difficult to achieve in practice, with various academics suggesting that in fact Basel III instead represents "Business as usual" for the banks: see for example Hellwig (2010) or "Battle to regulate banks as just begun," Anat Admati and Martin F. Hellwig, *Financial Times*, June 2, 2011.

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.By contrast, implementing "best practice" across the board may create systemic risk.

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:

$$U_D'(\alpha) = (R - Q)\left(\phi - \frac{1}{2}\right)\Delta p > 0;$$
$$U_R'(\alpha) = (R\Delta p - C)\left(\phi - \frac{1}{2}\right) > 0;$$
$$U_R(\alpha) - U_D(\alpha) = Qp_L + (Q\Delta p - C)\left(\alpha\phi + \frac{1}{2}(1-\alpha)\Delta p\right) > 0.$$

where the final inequality follows from equation (3).

Expressions for b_D, and b_R b_R solves $U_R(\alpha) = r$ and b_D solves $U_D(\alpha) = r$. Rearranging these formulae yields the following expressions:

$$b_R = \frac{r - \frac{1}{2}(R(p_L + p_H) - C)}{\left(\phi - \frac{1}{2}\right)(R\Delta p - C)}$$
$$b_D = \frac{r - \frac{1}{2}(p_L + p_H)(R - Q)}{(R - Q)\left(\phi - \frac{1}{2}\right)\Delta p}$$

Proof of Lemma 2 We have

$$\alpha_F(\alpha) = \frac{F_1 + F_2}{F_1 + F_2 + F_3 + F_4}, \tag{22}$$

where the probabilities F_i relate to the nodes in the FAILURE information set of Figure 2. The result follows by substituting the following values into Equation (22):

$$F_1 = \alpha\phi\left(1 - p_H\right); \tag{23}$$

$$F_2 = \alpha\left(1 - \phi\right)\left(1 - p_L\right); \tag{24}$$

$$F_3 = \frac{1}{2}\left(1 - \alpha\right)\left(1 - p_H\right); \tag{25}$$

$$F_4 = \frac{1}{2}\left(1 - \alpha\right)\left(1 - p_L\right). \tag{26}$$

Proof of Lemma 3 Straightforward calculation yields

$$W_D'\left(\alpha\right) = U_D'\left(\alpha\right) + \alpha\left(\lambda_G - \lambda_B\right)\left(L - \left(R - Q\right)p_L\right) > 0;$$

$$W_R'\left(\alpha\right) = U_R'\left(\alpha\right) + \left(\left(1 - \phi\right)\left(\lambda_G - \lambda_B\right) + \frac{1}{2}\lambda_B\right)\left(L - Rp_L\right) > 0;$$

$$W_R\left(\alpha\right) - W_D\left(\alpha\right) = \left(Q\Delta p - C\right)\left(\alpha\phi + \frac{1}{2}\left(1 - \alpha\right)\Delta p\right) + Qp_L\left(1 - \alpha\left(1 - \phi\right)\lambda_G - \frac{1}{2}\left(1 - \alpha\right)\lambda_B\right) > 0.$$

Expressions for β_D and β_R β_D solves $W_D\left(\alpha\right) = r$; β_R solves $W_R\left(\alpha\right) = r$. After some manipulation this yields

$$\beta_D = \frac{r - \frac{1}{2}\left(R - Q\right)\left(p_L + p_H - \lambda_B p_L\right) - \frac{1}{2}\lambda_B L}{\left(R - Q\right)\left(\phi - \frac{1}{2}\right)\Delta p + \left(\left(1 - \phi\right)\lambda_G - \frac{1}{2}\lambda_B\right)\left(L - \left(R - Q\right)p_L\right)};$$

$$\beta_R = \frac{r - \frac{1}{2}\left(R\left(p_L + p_H - \lambda_B p_L\right) - C\right) - \frac{1}{2}\lambda_B L}{\left(R\Delta p - C\right)\left(\phi - \frac{1}{2}\right) + \left(\left(1 - \phi\right)\lambda_G - \frac{1}{2}\lambda_B\right)\left(L - Rp_L\right)}.$$

Proof of Lemma 4 The result follows immediately from Figure 1: $\alpha_F\left(\alpha\right) = \frac{F_1 + F_2}{F_1 + F_2 + F_3 + F_4}$.

Proof of Proposition 2 Parts 1, 2, and 3 of the Proposition are true by definition. Substitution into the definitions and rearrangement yields

$$\tau_F = \frac{\beta_D\left(1 - \frac{1}{2}\left(p_L + p_H\right)\right)}{\beta_D\left(1 - \frac{1}{2}\left(p_L + p_H\right)\right) + \left(1 - \beta_D\right)\left(\phi\left(1 - p_H\right) + \left(1 - \phi\right)\left(1 - p_L\right)\right)};$$

$$\tau_{LF} = \frac{\frac{1}{2}\beta_D\left(1 - p_H + \left(1 - \lambda_B\right)\left(1 - p_L\right)\right)}{\frac{1}{2}\beta_D\left(1 - p_H + \left(1 - \lambda_B\right)\left(1 - p_L\right)\right) + \left(1 - \beta_D\right)\left(\phi\left(1 - p_H\right) + \left(1 - \phi\right)\left(1 - \lambda_G\right)\left(1 - p_L\right)\right)}$$

$$\tau_C = \frac{\frac{1}{2}\lambda_B\beta_D}{\frac{1}{2}\lambda_B\beta_D + \left(1 - \beta_D\right)\left(1 - \phi\right)\lambda_G}.$$

Direct substitution then gives us

$$\tau_C - \tau_F = \frac{\beta_D (1-\beta_D)}{\delta_1 \delta_2}\mu;$$
$$\tau_F - \tau_{LF} = \frac{\beta_D (1-\beta_D)}{\delta_1 - (1-p_L)\delta_2}\mu,$$

where

$$\delta_1 = (\phi (1-p_H) + (1-\phi)(1-p_L))(1-\beta_D) + \left(1 - \frac{1}{2}p_L + p_H \beta_D\right) > 0;$$
$$\delta_2 = (1-\phi)\lambda_G (1-\beta_D) + \frac{1}{2}\lambda_B \beta_D > 0;$$
$$\delta_1 - (1-p_L)\delta_2 = \phi (1-p_H)(1-\beta_D) + \frac{1}{2}\beta_D ((1-p_H) + (1-p_L)(1-\lambda_B)) > 0.$$

The result is then immediate.

Proof of Lemma 6 The result follows immediately from the fact that

$$\alpha_L (\alpha) - \alpha_{LF} (\alpha) = -\frac{\alpha (1-\alpha)}{\delta_3 \delta_4}\mu,$$

where

$$\delta_3 = \alpha (1-\phi)\lambda_G + \frac{1}{2}(1-\alpha)\lambda_B > 0;$$
$$\delta_4 = \alpha ((1-p_H) + (1-\phi)(1-\lambda_G)(1-p_L)) + \frac{1}{2}(1-\alpha)(1-p_H + (1-\lambda_B)(1-p_L)) > 0.$$

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