Too Many to Fail and Regulatory Response to Banking Crises

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Abstract

This paper analyzes two interrelated aspects of banking crises: regulators’ choices to rescue versus close troubled banks and banks’ choices of whether to passively roll over and hide defaulting loans or to reveal and deal with them. Banks’ decisions to inefficiently roll over rather than reveal their bad loans will depend upon their financial state and the regulator’s expected policy choice. The regulator will apply the least costly policy—closure or rescue—to detected troubled banks. The analysis shows that if enough banks are discovered to be distressed, a situation labelled “too-many-to-fail” can arise, in which high social costs of bank closures make rescues less costly. Yet, the prospect of too-many-to-fail can cause banks to roll over their loans in expectation of being rescued if detected. The banks’ beliefs become self-fulfilling, and the regulator may be drawn into a situation where it is cheaper to rescue troubled banks. Finally, the prospect of being caught in a situation of too-many-to-fail may induce the regulator to set a low bank supervisory quality (detection probability), which will result in fewer detections of banks with loan rollovers but will permit the regulator to apply closure to detected banks.
1 Introduction

Banking sector problems are common throughout the world. A recent IMF study (1997) lists 130 countries as having experienced banking sector problems in the 1980s and 1990s. Once banking sector problems have occurred, regulators are faced with the question of whether to close troubled banks or to leave them open and rescue them. In practice regulators often become reluctant to close troubled banks once a banking crisis is perceived to be systemic. By allowing banks to continue in operation, regulators attempt to avoid negative externalities, such as losses in “inside” information regarding good borrowers of the banks being closed, financial contagion to other banks through the interbank loan market, or disruption of the payments system.

Yet, a factor complicating regulators’ decisions regarding closure versus rescue of troubled banks in a banking crisis is the presence of asymmetric information between banks and regulators regarding the quantity of bad loans’ on banks’ balance sheets. This asymmetric information creates a moral hazard problem on the part of banks. Troubled banks have the ability to hide their bad loans by rolling them over, and they regularly do so in practice. Loan rollovers may be motivated by an attempt on the part of insolvent banks to hide their insolvency or by gambling for resurrection by troubled banks. Like the granting of new, excessively risky loans, passive rollover of defaulting loans constitutes a risky action that will resolve the bank’s difficulty if the defaulting borrower eventually succeeds in repaying the loan; however, the low probability of success lowers the bank’s expected net worth. Rollover of bad loans (or “evergreening” as the practice is sometimes called) thus worsens banks’ financial conditions and exacerbates, or even generates, a banking crisis.

This paper focuses on these two, interrelated aspects of banking sector problems: regulators’ choices to rescue versus close troubled banks (where bank “closure” includes liquidations, mergers, or purchase and assumptions); and troubled banks’ choices of whether to passively roll over or to reveal and deal with their defaulting loans. Both closure and rescue policies have been observed in practice. Closure policies are observed most often, especially in response to situations in which only a few banks are experiencing difficulty. This type of
policy was also applied, after initial regulatory forbearance, in the U.S. Savings and Loans crisis. Countries that have applied various forms of rescue in banking crises include Japan, Norway, Mexico, Korea, Thailand, the Philippines and a number of economies in transition, including Hungary, the Czech Republic, and Poland.

The model of this paper departs from existing banking literature in two ways. First, most models of bank closure assume symmetric information between banks and regulators regarding the financial health of the bank at the point where the regulator must make the closure decision. In these models the regulator’s decision is based upon the expected future profit of the bank, which is known to the regulator and the bank. Second, the regulator’s closure decision in most models is made before the bank’s assets are actually in default; therefore, there is little scope for consideration of policies to deal with bad assets on banks’ balance sheets. The model of this paper adds to a small set of papers that formalize banks’ treatment of debt in default, assuming asymmetric information between the regulator and the bank concerning the level of default on the bank’s balance sheet.

Faced with a given number of banks that have been discovered to be in trouble, the regulator chooses the policy—rescue or closure—that is least costly. (The regulator cannot commit ex ante to a particular policy because ex post the policy must be credible.) Policy costs involve the following tradeoffs. The benefit of bank closure relative to rescue is that with closure the expected net worth of bank assets is increased, since proper disposal or transfer of the closed bank’s assets entails making efficient decisions with respect to defaulting borrowers (i.e., restructuring or liquidating them, rather than passively rescheduling loans). In more general terms, bank closures halt the excessively risky behavior in which troubled banks may be engaging; therefore, closure raises bank value. The extra cost of closure relative to rescue comes from the fact that closures can generate social costs due to negative externalities, which are increasing in the number of banks closed.

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1See, for example, Boot and Thakor (1993), Mailath and Mester (1994), Dreyfus et al. (1994), and Rochet and Tirole (1996). A notable exception to the assumption of symmetric information between regulators and banks is the work of Dewatripont and Tirole (1994), who assume that banks may make unobserved choices between continuing or stopping projects that default. However, these authors do not endogenize the bank’s choice, nor do they analyze the regulator’s bank closure or rescue decisions.

2See Aghion, Bolton, and Fries (1999), Corbett and Mitchell (2000), and Mitchell (2001). Two papers that model banks’ reporting of bad loans in contexts that are unrelated to regulatory response to banking crises are O’Hara (1993) and Rajan (1994).
I specify cost functions for the policies of closure and rescue and show that for small numbers of troubled banks identified by the regulator, closure is less costly than rescue; therefore, closure is the preferred policy. I then show that if the number of discovered troubled banks becomes high enough, the costs of closure may rise above the costs of rescue; hence, rescue becomes the preferred policy. I define this situation as one of “too-many-to-fail.”

This situation arises principally as a result of the external costs generated by large numbers of bank closures. But whereas the policy chosen by the regulator will be a function of the number of banks discovered to be in distress, the number of discovered distressed banks will itself depend upon the willingness of banks to reveal their bad debts.

The regulator discovers banks that have rolled over defaulting loans with some positive probability through monitoring (banking supervision). When banks reveal and efficiently address their bad loans (e.g., through bankruptcy procedures), these activities are costlessly observed by the regulator. Although rolling over bad loans lowers expected bank net worth, if rollover succeeds it will eliminate the bank’s financial distress. Loan rollovers also allow the banker to continue operating the bank, provided that the loan rollovers are not detected by the regulator. In contrast, if the bank’s financial state is poor enough, revealing bad loans may result in bank closure (if the regulator chooses the policy of closure), whereby the bank manager loses the private benefits of operating the bank.

A first result of the analysis is that when troubled banks have a high enough proportion of bad loans so that they would be insolvent even if they were to take efficient actions with respect to their defaulting debtors, these banks will always roll over their loans. While it is not surprising that insolvent banks will roll over their bad loans when they expect the policy of closure, it may be more surprising that they will roll over bad loans even when they expect the policy of rescue. In the latter case the motivation for loan rollovers is not to hide insolvency but to gamble for resurrection. In this case insolvent banks know that if their loan rollovers are discovered, they will be rescued and allowed to continue in

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3 The model of this paper formalizes and generalizes the description in Mitchell (1993) of a situation of too-many-to-fail among banks in transition economies. Perotti (1998) models a situation where governments in transition economies intervene to bail out firms when arrears in interenterprise credit become very large.

4 Although troubled banks may be insolvent, they are not illiquid. It is in fact quite common for insolvent banks to remain liquid for a considerable period. For example, most of the insolvent S&Ls during the U.S. S&L crisis were liquid up to the point of closure.
operation; therefore, they have little to lose by gambling through loan rollovers.

A second result pertains to banks that are distressed but not yet insolvent; i.e., banks which could remain solvent if they were to reveal and efficiently deal with their bad loans. When these banks expect the regulator to apply a policy of closure and when the probability of detection of loan rollovers is high enough, banks will reveal and deal with their bad loans. Troubled banks will thus remain solvent, and the regulator does not have to apply either rescue or closure. However, if enough banks are troubled, the possibility of a situation of too-many-to-fail creates a coordination problem. If each troubled bank believes that enough other banks will roll over their bad loans so that the high number of such banks discovered by the regulator will trigger too many to fail, then the troubled bank has the incentive to roll over its loans. The regulator is then forced into rescuing banks by the banks’ self-fulfilling beliefs, and banking sector problems are exacerbated, since banks’ loan rollovers have lowered their expected net worth.

A final result comes from the observation that banks’ treatment of bad loans and the regulator’s policy choice with respect to troubled banks are both functions of the number of troubled banks actually discovered by the regulator, hence of the quality of banking supervision. Banking supervisory quality (probability of detection of passive banks) is costly and is chosen by the regulator \textit{ex ante}, before any loan defaults have occurred. An interesting question is how the \textit{ex ante} choice of detection probability might be affected when the regulator takes into account the potential impact of this choice on banks’ subsequent willingness to reveal their bad loans and on the regulator’s \textit{ex post} policy choice once a banking crisis has occurred. Somewhat surprisingly, if the regulator believes that in a banking crisis troubled banks will roll over their loans in anticipation of triggering too many to fail, then the regulator will choose a lower detection probability. By doing this the regulator can ensure himself of discovering fewer troubled banks in a crisis, which allows him to commit implicitly to closing the troubled banks that he actually discovers. Moreover, the total costs generated by the choice of low supervisory quality and by closure of a smaller number of troubled banks are lower than the total costs that would be generated by the choice of a higher supervisory quality followed by rescues of many troubled banks.

This “softening” of banking supervision in the face of the prospect of too many to fail suggests that in emerging market economies, where the risk of banking sector problems
is high, it may be impossible for regulators to put into place strict banking regulations without running the risk of having to bail out the entire banking system. It may thus not be surprising to observe relatively lax standards of banking supervision or capital adequacy being employed in these countries, perhaps with these standards being strengthened over time. The result of supervisory softening also has a counterpart in developed economies. Regulators often relax regulations on bank solvency or loan write-offs during a banking crisis. For example, U.S. regulators relaxed the definition of bank solvency during the Savings and Loan crisis so that fewer banks would qualify as insolvent and so that the total costs borne by regulators in the handling of insolvent banks would be reduced. Japanese regulators also softened regulations during the Japanese banking crisis in order to allow more banks to qualify for favorable tax treatment of loan writeoffs.\(^5\)

2 Model

There are \(N\) banks of equal size in the economy, and each has liabilities of \(L\). In period 1 each bank has outstanding risky loans in the amount of \(B\). It also has other, nonrisky sources of income, \(I_0\), such as income from provision of services or from the holding of government debt. A number \(M\) of the banks in the economy will experience loan defaults at the beginning of period 1. For these banks, the fraction of the portfolio in default is given by \(\alpha\). Although \(M\) is assumed to be known to the regulator, which banks experience default is not known in the absence of monitoring.\(^6\)

The period-1 income for a bank that experiences loan defaults is given by \(I_0 + (1 - \alpha)B\). This bank chooses between two actions with respect to its defaulting loans: being passive or being active. The choice of passivity represents a decision to roll over (i.e., reschedule) loans, with no liquidation or restructuring of the defaulting debtors. The passive bank

\(^5\)Boot and Thakor (1993) show that regulators who are self-interested may engage in forbearance in order to preserve their reputations. The model of this paper shows that even when regulators are not self-interested, they may have a tendency to soften banking regulations in the face of a banking crisis. The softening here arises as a result of the inability of regulators to commit \(\textit{ex ante}\) to applying a tough policy to banks in a crisis.

\(^6\)Assuming that the regulator knows \(M\) is similar to assuming that the regulator has a good idea of the severity of banking sector problems; however, without monitoring he does not have a good idea of the financial state of each bank.
allows defaulting firms to continue operating according to the status quo. Bank passivity generates inefficiencies (and translates into lower loan recovery) whenever the borrower firm’s liquidation value is greater than its continuation value or its value with restructuring would be greater than its continuation value according to the status quo.

When a bank chooses to be active, it attempts to recover at least a portion of the outstanding debt, either through a formal bankruptcy proceeding or an out-of-court workout. I use the terms “active banks” and “banks using bankruptcy” synonymously throughout the paper. Active banks take the efficient restructuring or liquidation decision with respect to their defaulting debtors. At the same time, the use of bankruptcy (or out-of-court workout) is assumed to be costlessly observable by the regulator. Thus, when a bank chooses to be active, the regulator can costlessly observe the level of default in the bank’s portfolio.

I assume deposits are insured. Because depositors will not monitor the bank in the presence of deposit insurance, the regulator’s monitoring role is crucial. Monitoring of banks by the regulator takes place in period 1 after banks have observed their bad loans (which is private information to banks) and have chosen their actions with respect to these loans. Monitoring requires each bank to submit to a periodic bank examination, during which the regulator reviews bank income statements and attempts to determine if the bank has bad loans in its portfolio and if it has taken appropriate actions with respect to those loans. With probability $d$ the regulator discovers banks that have rolled over loans. Banks that have rolled over their loans but which are not discovered look to the regulator like banks with no defaulting loans. The parameter $d$ represents a costly monitoring capability which has been chosen by the regulator in period 0. (The choice of monitoring capability is discussed in more detail below.) Assumptions regarding the monitoring function and the informational abilities of the regulator follow from two stylized facts. (1) Observation of a bank’s financial standing is costly; and (2) it is in general much more difficult to identify a bank in financial difficulty than it is a bank that is healthy.7

The total number of distressed banks identified by the regulator will be the sum of the number of banks with defaulting loans that have chosen to be active and the number of

7An example consistent with this fact appears in U.S. banking history. New York was the first state in the United States to set up a bank supervisory authority. After its establishment in 1829, however, this authority was abolished in 1843 because the legislature believed that the commissioners “[w]ere superfluous when bankers were honest, and of no avail when bankers were dishonest.” (Klebaner, p. 44)
passive banks which the regulator has detected through monitoring. Given the number of distressed banks that the regulator has identified, he chooses the least costly of two policies, intervention (i.e., bank “closure”) or rescue, to apply to these banks. A key aspect of the model is that the regulator’s choice of policy must be subgame perfect. That is, the regulator is unable to commit in period 0 to applying a particular policy in period 1 if that policy is not the least costly one in period 1. If, given the number of troubled banks identified by the regulator in period 1, the policy of rescue is less costly than intervention, the regulator will choose to rescue the troubled banks.

It is clear that the inability of the regulator to precommit to applying a particular policy to troubled banks implies that banks with defaulting loans in period 1 will choose their actions with respect to these loans as a function of the policy that they expect the regulator to choose. The number of identified banks will thus be a function of the banks’ choices with respect to their defaulting loans and also of the parameter $d$, the probability of detection of passive banks.

Of interest is how the regulator’s choice of monitoring capability ($d$) in period 0 might be influenced by expected bank behavior in period 1 and by the regulator’s resulting policy choice in that period, given the number of troubled banks that have been identified. The regulator will choose $d$ in period 0 subject to a cost and subject to the regulator’s beliefs about the number $M$ of banks that are likely to face defaulting loans in period 1, the regulator’s anticipation of the number of troubled banks that will be identified, and the expected policy to be applied to these banks.

The time line below summarizes the sequence of events.

**Timing:**

**Period 0**
Regulator establishes costly monitoring capability $d$;

**Period 1**
Banks observe income and default, which are private information to the banks;
Banks choose action (passive or active) with respect to defaulters;
Regulator monitors and, with probability $d$, discovers passive banks;
Regulator chooses policy for all identified distressed banks

**Period 2**
Banks receive returns from loans in default in period 1 and repay liabilities $L$.

Bankers receive payoff, depending on whether discovered to be distressed in period 1 and depending upon regulator’s choice of policy.

### 2.1 Bank Strategies

Passive rollover of defaulting loans is assumed to be a riskier action than bankruptcy and to yield a lower expected level of loan recovery than bankruptcy. Bankruptcy yields a higher expected return than rollover because bankruptcy allows the bank to take the action (reorganization or liquidation) with respect to the firm that maximizes the value of the firm’s assets. The greater uncertainty of repayment with rollover than with bankruptcy arises because with rollover there is no meeting of the bank with the firm’s other creditors to gather information about and value the firm, as would occur with bankruptcy (see Harris and Raviv, 1990). The bank thus obtains less information about the value of the firm and the firm manager’s activities, and there is also greater scope for the firm manager to undertake unprofitable activities without getting caught.$^8$

Specifically, when a bank rolls over loans in the amount of $B$, the return is assumed to be $B$ with probability $q$ and $0$ with probability $(1 - q)$. The return from bankruptcy for defaulting loans in the amount of $B$ is given by $\tilde{B}$, with $B > \tilde{B} > qB$.

**Assumption 1:** The banker’s utility is given by $\max[\Pi, 0] + \rho$, where $\Pi$ represents bank profit (net worth) and $\rho$ represents a private benefit from operating the bank.$^9$

Assumption 1 implies that bank managers obtain a monetary benefit proportional to bank net worth, as long as net worth is positive, plus a private benefit of maintaining the bank in operation.

In subsequent sections I adopt differing assumptions regarding the level of default $\alpha$ on banks’ balance sheets (i.e., regarding the severity of the banking crisis). In all cases, however, the level of default $\alpha$ will be assumed to be high enough relative to the bank’s

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$^8$See Mitchell (2001) for an analysis of the indirect effect on bank net worth arising from borrower firm managers’ unprofitable activities in response to loan rollovers.

$^9$Similar objective functions are employed in Aghion, Bolton, and Fries (1999), Corbett and Mitchell (2000), Mitchell (2001), and Rajan (1994).
liabilities that a bank with loan defaults in period 1 cannot meet liabilities $L$ from period-1 income alone. (Full recovery of debts $B$, however, does allow the bank to cover its liabilities.) In addition, I assume that banks with loan defaults are in poor enough financial shape that their expected net worth will be negative if they roll over loans in default. The following assumption summarizes these statements.

Assumption 2: (i) $I_0 + B > L$; and (ii) $I_0 + (1 - \alpha)B + q\alpha B < L$.

Assumption 2 implies that rolling over loans constitutes a form of gambling for resurrection. With probability $q$ the bank will recover the full amount $B$ of the loan and will return to solvency. Failure of loan rollovers, which occurs with probability $(1 - q)$, guarantees that the bank is insolvent.

What happens to a bank when it chooses rollover? If it is not detected and if rollover succeeds, the bank will be solvent in period 2; in this case the banker will earn a positive monetary return plus the private benefit $\rho$ from keeping the bank in operation through period 1. If the bank is not detected and rollover fails, the bank will be insolvent in period 2 and the banker will earn no monetary return; however, she still earns $\rho$ since by not being detected the bank has been able to continue in operation during period 1. If the passive bank is detected by the regulator, then the banker’s payoff will depend upon the policy chosen by the regulator.

2.2 The regulator’s objective

The regulator’s objective in choosing the policy to apply to troubled banks in period 1 is to minimize costs, where the costs of a policy include any social costs linked to negative externalities created by the policy. The objective assumed for the regulator is a realistic one; for example, it is consistent with the directives in the U.S. legislation FDICIA. The regulator’s policy choice in period 1 will thus be the policy with the lowest costs, given the number of troubled banks that have been identified.

In the sections below I first analyze the regulator’s choice of policy in period 1, together

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10 I assume that the bank’s liabilities come due in period 2; therefore, the bank’s solvency is determined by its two-period earnings minus liabilities. Because no deposit liabilities come due in period 1, banks that are insolvent can remain liquid.

11 See Wall (1993). Dewatripont and Tirole (1994) also suppose this type of objective for regulators.
with banks’ choices with respect to their defaulting loans, given some value of \( d \). These are continuation equilibria, and they have the form \( (\text{Action}, \text{Policy}; d) \) where \( \text{Action} \) represents the action taken by banks and \( \text{Policy} \) is the regulator’s policy choice. Since the regulator’s policy choice occurs after the bank’s choice of action, the latter is analyzed via backward induction.

An equilibrium will be described as a triplet \( (d, \text{Action}, \text{Policy}) \) consisting of the regulator’s period-0 choice of \( \text{ex ante} \) monitoring capability \( d \), together with the continuation equilibrium that will be induced by \( d \) in period 1. Monitoring costs are assumed to be an increasing, convex function \( g(d) \) of the probability of detection of loan rollovers. The costs included in \( g(\cdot) \) represent resources that are necessary to ensure that each bank faces a probability \( d \) of discovery if it chooses to roll over its loans. These resources include personnel, training, regulations, etc. The regulator’s objective in choosing \( d \) (and the continuation equilibrium induced by \( d \)) is assumed to be the minimization of total expected costs arising from default on banks’ balance sheets. Expected costs consist of \( g(\cdot) \) plus the expected costs of the policy that will applied in period 1.

In the next section I describe more precisely what is meant by the policies of intervention and rescue, and I define the costs of these policies.

\section*{3 \ Ex post policies and their costs}

\subsection*{3.1 Rescue vs. intervention}

What is a bank rescue? A reading of the literature on banking sector problems reveals the absence of a universally accepted definition. Some authors have interpreted bank rescue to be any policy other than bank liquidation. (See Goodhart, 1993) According to this interpretation, a merger of a troubled bank with another bank constitutes a bank rescue, even if the troubled bank’s management is removed. Other authors have associated the term bank rescue with the policy of continuation and recapitalization of the troubled bank. Bank mergers would not be considered rescues according to this interpretation. Contributing to the ambiguity is the term bank bailout, which is suggestive of rescue but which has been used to describe the regulatory response to the U.S. savings and loans crisis, in which troubled S&Ls were liquidated but depositors reimbursed.
Much of the ambiguity surrounding the term bank rescue arises from the fact that the policies that constitute rescue depend upon the group of agents whose point of view is being adopted. From the point of view of depositors, any policy resulting in reimbursement of deposits would constitute a rescue. Thus, depositors were bailed out in the U.S. Savings and Loans crisis although the S&Ls were liquidated. In terms of bank stockholders, any policy that preserves the value of a troubled bank’s equity, such as a bank merger in which the original bank’s stockholders receive equity in the acquiring bank, would constitute a rescue. Yet, from the point of view of bank management, a bank merger in which the management is replaced would not constitute a rescue.

This paper employs policy definitions that incorporate the effects on bank management. The motivation for defining policies in this way is the view that bank management possesses private information regarding the bank’s financial state, and the management controls to a large extent the degree of revelation of this information to outsiders, including regulators, depositors, and bank stockholders. The policy applied by regulators to troubled banks will influence the extent to which bank management willingly reveals the bank’s financial state.

A policy of intervention represents a “tough” policy, which includes any of the following types of activities: additional bank audits to better determine the financial state of the bank, followed by imposition of appropriate treatment of defaulting debtors whose loans were rolled over; replacement of bank management; bank liquidation; merger with another bank; government control of the bank for some period. Any policy that does not result in continuation of the bank under the same management or that involves active interference in the bank’s operations (and thus causes the banker to lose the private benefit $\rho$) falls under the category of intervention. According to this definition a merger of a troubled bank or some of its assets with another bank constitutes a policy of intervention. This classification of merger as a form of intervention rather than rescue is consistent with the empirical observation that the original bank’s management is often removed in troubled bank mergers.

A policy of rescue, in contrast, is a “soft” policy in which the bank is continued in operation, and the bank is recapitalized if necessary. More precisely, a bank rescue will be defined as a policy of continuation and recapitalization of the troubled bank, together with preservation of the bank manager’s control. Bank rescues involve no active interference
by the regulator in the bank’s operations; therefore, the regulator does not impose on the bank efficient treatment of defaulting debtors or of any other assets.

One policy for which the classification of intervention or rescue is not immediately obvious is the creation of an asset management company (AMC) to which banks transfer a portion of their bad debt. Whether the creation of AMCs qualifies as intervention or rescue depends upon several factors, such as whether the AMC is a private or a public institution and how much discretion banks are allowed to exercise regarding the loans that are transferred to the AMC. In practice, this type of policy may require detailed examination and assessment by regulators of the bank’s loan portfolio in order to determine the bank’s true financial health, with decisions being taken by a regulatory body with regard to the bank’s transfer of loans. In this case the policy would qualify as intervention.\(^1\)

Another policy with an ambiguous classification as either intervention or rescue is bank nationalization. If nationalization implies government involvement in bank management, then bank nationalization qualifies as an intervention policy. If, however, when a bank is nationalized, the government provides recapitalization but leaves complete control to the original management, then this form of nationalization falls into the category of rescue. In the latter case the bank manager retains all of her private benefits of control.

The costs of both intervention and rescue policies will be shown below to depend upon the number of banks to which the policy is applied. A situation where too many to fail takes effect will be defined as one in which, given the number of financially distressed banks identified by the regulator, it becomes less costly to apply rescue than intervention to these banks. In the subsections below I derive simple, illustrative cost functions for rescue and

\(^1\)The following is a description of the resource requirements of this type of policy based on Swedish experience with it. “After a preliminary application, the bank [requiring financial support] had to submit information for an assessment of its current situation and future prospects. Then the Bank Support Authority [a supervisory authority created during the crisis for the purpose of administering the policy] would judge whether there was a need for support. If it was needed, more detailed information was required, including a comprehensive valuation of all bank assets—performing and nonperforming—together with a detailed assessment of future cash flows and profits from the bank’s ordinary operations. On this basis the BSA, after considering the views expressed in consultations with the central bank and the supervisory authority, took a preliminary decision, which was forwarded to the Ministry of Finance for final endorsement. The decision stipulated the form and conditions under which support would be provided.” (Ingves and Lind, 1997, p. 426.)
intervention policies that allow for the possibility of a situation of too many to fail. This possibility will arise as a result of a convexity of intervention costs in the number of banks to which intervention is applied. Much of the discussion of costs associated with intervention policies, therefore, is aimed at justifying the convex form of the intervention cost function used in the analysis. Obviously, if intervention costs are always lower than rescue costs for any given number of distressed banks, then the situation of too many to fail can never occur, and intervention will always be the regulator’s policy choice.

3.2 Costs of rescue

The policy of rescue involves recapitalization of banks in period 1. One component of rescue costs, then, is the recapitalization cost for distressed banks that are rescued by the regulator. However, there also is a second component of rescue costs: the expected future deposit insurance liabilities with respect to insolvent banks that are not discovered in period 1 by the regulator (and are, therefore, not recapitalized). Given that the regulator wishes to minimize costs, the amount of recapitalization that will be extended to a rescued bank will always be the minimum amount necessary to ensure the solvency of the bank.

Because, by definition, the policy of rescue involves no outside interference in the bank’s operations, the regulator imposes no change in the bank’s treatment of its defaulting debtors. Thus, if rescue is applied to a bank that has rolled over loans in default, these loans remain rolled over, and there is a decrease in expected bank net worth due to the inefficient treatment of defaulting borrowers. This decrease in net worth is taken into account in the amount of recapitalization given to the bank.

13 The results of the model also go through if recapitalization is given in period 2.
14 For expositional simplicity, recapitalization and deposit insurance liabilities are included at their full values in the rescue cost function. To the extent that these are simply costless transfers, they do not represent real costs for the regulator. However, if generating one dollar of recapitalization costs more than one dollar (and if deposit insurance liabilities cannot be covered by the deposit insurance fund), these transfers do generate real costs. Assuming that the costs of rescue equal only some fraction of the amount of recapitalization would in fact reinforce the results of the paper.
15 Caprio and Honohan (1999) note that “bank supervisors do not have the inside information or the resources to challenge the bank’s assessment of its loans on a case-by-case basis,” and “even with the best accounting systems, it is difficult to prevent a bank from concealing a nonperforming loan simply by making a new loan to cover the repayment, a practice known as ‘evergreening.’” These quotes capture the
Consider a bank that has rolled over its loans, is discovered by the regulator, and is then rescued. Given that there is a positive probability that the loan rollovers will fail and the bank will recover nothing on its defaulting loans in period 2, the minimum amount of recapitalization that must be given to this bank in period 1 in order to guarantee its solvency in period 2 is given by

\[ R_P(\alpha) = L - I_0 - (1 - \alpha)B. \]  

Recapitalization for the passive bank is just equal to the bank’s total liabilities minus its period-1 income.

Consider a troubled bank that chooses bankruptcy for its defaulting debtors and is rescued. By definition, this active bank has revealed its bad loans and is efficiently dealing with its defaulting borrowers. The amount of recapitalization extended to this bank will be given by

\[ R_A(\alpha) = \max[0, (L - I_0 - (1 - \alpha)B - \alpha B)]. \]  

It is clear that \( R_P(\alpha) > R_A(\alpha) \); the cost of recapitalization is higher for passive banks that are rescued than for active banks.

Now consider a bank that rolls over its loans and is not discovered by the regulator and, therefore, is not rescued. As noted above, there are implicit costs generated by this bank in the form of expected deposit insurance liabilities in period 2. Namely, if rollover fails the passive bank will be insolvent in period 2, and the regulator will have to reimburse depositors. In period 1 the expected future deposit insurance reimbursement is given by

\[ Z(\alpha) = (1 - q)(L - I_0 - (1 - \alpha)B). \]  

Note that \( Z(\alpha) = (1 - q)R_P(\alpha) \); expected future deposit insurance liabilities for undiscovered passive banks are lower than the recapitalization that must be offered to passive banks that are rescued.\(^{16}\)

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\(^{16}\)Alternative assumptions could be made with respect to the timing of recapitalization. For example, the choice of rescue in period 1 could be taken to imply that the regulator promises to recapitalize the bank in period 2 if it turns out that the bank is insolvent in period 2 after its returns on defaulting loans have

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features of asymmetric information between banks and regulators that would effectively require regulators to undertake what is termed here a policy of intervention in order to reverse any inefficient treatment by banks of their defaulting loans.
We may now define the total costs associated with the policy of rescue. Suppose, for simplicity, that all banks with default have the same proportion $\alpha$ of their portfolio in default. Suppose, for the moment, that all banks with default are passive. Let $M$ be the number of banks with default and $d$ the probability of detection of a passive bank. Rescue will then be applied to $dM$ banks. Total rescue costs are given by

$$C_{\text{Res}}(M, d|\text{Pass}) = dM \cdot [R_P(\alpha)] + (1-d)M \cdot [Z(\alpha)]$$

$$= [1 - q(1-d)] \cdot M \cdot R_P(\alpha). \quad (4)$$

Note that $C_{\text{Res}}(M, d|\text{Pass})$ is increasing in $d$; the lower is $d$, the lower are the costs of rescue. In effect, with a lower detection probability the regulator can benefit from the “gambling” undertaken by the passive bank in rolling over its loans. If rollover succeeds, the regulator’s future deposit insurance liabilities will be zero.$^{17}$ Eqn. (4) thus implies that when all troubled banks are passive, the regulator would prefer a situation of complete forbearance; i.e., $d = 0$, to a situation where $d$ is positive and $dM$ banks are rescued.

Now suppose that all $M$ banks with default are active; rescue will then be applied to all $M$ banks. In this case rescue costs are given by

$$C_{\text{Res}}(M, d|\text{Act}) = M \cdot R_A(\alpha). \quad (5)$$

If active banks are solvent, $R_A(\alpha) = 0$, and rescue costs are zero. Note that the right-hand side of Eqn. (5) is independent of the value of $d$; when banks are active, loan defaults are costlessly revealed to the regulator.

### 3.3 Intervention costs

Because various policies involving several different types of costs fall under the category of intervention, it is difficult to specify a general cost function for this policy category. If loan rollovers succeed, the bank will receive no recapitalization but if loan rollovers fail, the bank receives $R_P(\alpha)$. Modeling the timing of recapitalization in this way would change none of the qualitative results of the analysis. One minor change, however, would be that with this timing the expected recapitalization of passive banks $R_P(\alpha)$ would now just equal the expected deposit insurance liabilities $Z(\alpha)$ of undiscovered passive banks.

$^{17}$Dewatripont and Tirole (1994) also discuss how regulators may benefit from banks’ gambling during a banking crisis.
identify below several types of costs associated with intervention policies, then I specify a simple cost function that focuses on only some of these costs. The goal is to specify a cost function with a functional form that is precise enough to permit comparative statics results to be derived.

Before identifying costs involved with intervention policies, however, it should be recalled that intervention policies generate a benefit, which is the increase in passive banks’ net worth by the regulator’s forcing efficient treatment of defaulting debtors (and thereby raising loan recovery). The efficient treatment of defaulting borrowers is implemented either through outside intervention in the bank’s operations (for example, the regulator running the bank or replacing the bank manager) or through transfer of the bank’s assets to other agents or institutions (e.g., mergers with healthy banks, creation of bridge banks, or bank liquidations).

Whereas the benefit of intervention comes from the increase in bank value due to the reversal of inefficient loan rollovers, costs of intervention policies arise from at least two potential sources: lower bank asset values due to “fire-sale” conditions when banks are liquidated; and losses in the asset values of good borrowers when their banks are closed. Both types of costs have been cited in the literature. Dreyfus, Saunders, and Allen (1994) and James (1991) note the possibility of depressed prices of a liquidated bank’s assets due to the sale of these assets at “fire-sale” prices. Diamond and Rajan (2000, 2001), James, (1991), and Maileth and Mester, (1993) make reference to diminished asset values of good borrowers due to a loss of “inside” information when the troubled bank is closed or when its assets are transferred to another institution. Yet another potential source of intervention costs affecting good borrowers is invoked by Jordan (1998) and Peek and Rosengreen (1995), who cite reductions in new loans to existing borrowers when troubled banks are left in operation but must shrink their operations in order to meet capital-asset

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18 What is important for the model is the existence of a risky action that can be associated with “gambling for resurrection” and that is halted with intervention. As Rajan (1994) notes, modeling banks’ choices of risky loan rollovers versus less risky revelation of bad loans is formally equivalent to allowing banks to choose between making excessively risky new loans versus safer loans in period 1. In a similar manner, the benefit of intervention cited here as the increase in bank net worth due to the reversal of loan rollovers could be thought of more generally as increasing bank value due to the halting of all excessively risky behavior.
requirements. Intervention policies may also give rise to significant external costs. It is now well accepted that a bank’s financial distress may create systemic costs which could be avoided by recapitalization and continuation of the troubled bank. Examples include Rochet and Tirole (1996) and Flannery (1996), both of which concern interbank credit markets.

All of the differing types of intervention costs possess the characteristic that they are increasing in the number of banks to which the intervention policy is applied. In addition, several of these costs are likely to be convex in the number of banks to which intervention is applied. For example, in the case of the systemic costs analyzed by Rochet and Tirole (1996), while the failure of a single bank may decrease liquidity at a lender bank but may not be sufficient to render the lender bank insolvent, the simultaneous failure of several borrower banks may well render the lender bank insolvent and thus a candidate itself for a policy of intervention.\footnote{Obviously, failure of a bank that is large enough could cause its lenders to become insolvent. This issue of “too-big-to-fail” is studied by Rochet and Tirole.}

Another example of convexity of intervention costs is given by the loss in the value of bank assets due to depressed asset prices upon liquidation of the bank. Whereas the forced sale of one bank’s real estate collateral might not have a significant effect on overall real estate prices, the simultaneous sales of several banks’ real estate assets could cause a general real-estate price decline.

Finally, the costs related to loss of finance for good borrowers due to information losses when their original lender bank fails are also likely to be convex in the number of failed banks. Suppose, as in Diamond and Rajan (2000, 2001), that the value of a loan transferred from the original bank to a new lender is only a fraction $\beta$ of its value with the original bank. This implies a proportional loss of $(1 - \beta)$ in the value of a displaced borrower. In addition, if in order to extract $\beta$ of the displaced borrower’s value the new lenders must also be banks (i.e., if arms-length lenders could not extract as much as $\beta$), then it is likely that the fraction $\beta$ will decrease (and the per-borrower loss will increase) as the number of failed banks increases.

More precisely, because of the limited size of banks’ trained personnel, the ability of a given bank to take on and acquire information about a large number of new clients in a short period of time is limited. The fewer the number of banks remaining in operation in the
economy and the greater the number of displaced borrowers searching for new finance, the less resources that a given bank can devote to any given displaced borrower; or equivalently, the lower the probability that any given displaced borrower will be able to obtain new finance. Thus, if enough banks fail, the expected value of a displaced borrower’s assets will fall below $\beta$ of its value with the original lender. The total loss in firm values if all $N$ banks in an economy fail will then be greater than $N$ times the loss in firm values when only one bank in the economy fails. Failure of a large proportion of the banks in the banking system can thus result in significant losses in finance for good firms, thereby provoking a recession.\(^{20}\)

3.3.1 Intervention cost function

The intervention cost function formalized here focuses on one of the convex costs described above, namely the loss in asset values of good borrowers displaced from failing banks.\(^{21}\) For expositional purposes I make a number of simplifying assumptions. First, good borrowers (firms with performing loans) are assumed to be evenly distributed across failing banks. Second, a nonfailing bank is assumed to be able to expand its portfolio by a maximum proportion $\lambda$ of the number of displaced borrowers of a failing bank and still recover $\beta$ of the value of displaced borrowers’ loans. Acquiring displaced borrowers above this limit is assumed (for simplicity) to result in zero recovery by the new bank for all borrowers exceeding the limit. This situation can be thought of as one where, given the number of displaced borrowers displaced from failing banks of troubled banks with healthier banks than bank closures. Importantly, however, the costs with mergers are nonzero. (See James, 1991.) Moreover, if a large enough number of banks in the economy becomes financially distressed, mergers of all the troubled banks with healthy banks will become difficult, if not impossible. Regulators will have to resort to bank liquidations, which will give rise to convex costs. Thus, even in economies where regulators traditionally respond to bank distress by merging distressed banks with healthier ones, the costs of intervention become convex for a large enough number of distressed banks.\(^{21}\) The focus on losses in viable borrowers’ values is made both for modelling simplicity and for its generality. Systemic costs relating to interbank loan markets such as those modeled by Rochet and Tirole (1996) and Flannery (1996) apply only in economies where these markets are well developed and relatively unrestricted. On the other hand, dependence of firms on bank lending is quite general across economies; even in economies with well developed financial markets, a substantial proportion of firms relies heavily on bank finance.
borrowers already taken on, bank personnel have no time to acquire any information about any additional borrowers; therefore, recovery on additional loans is very low.

Define the following variables:

\[ N = \text{number of banks in the economy} \]
\[ i = \text{number of banks to which intervention is applied} \]
\[ V = \text{expected value per troubled bank of all good borrowers of the bank} \]
\[ \lambda = \text{proportion of the displaced borrowers of a failing bank for which a nonfailing bank can recover} \beta \text{ of the value of assets} \]

Let \( \omega(i, N) \) be the expected percentage loss in the value of a viable borrower displaced from a bank to which intervention has been applied. Then \( \omega(\cdot) i V \) represents economy-wide expected losses in displaced borrowers’ values when intervention is applied to \( i \) banks. The functional form assumed for \( \omega(\cdot) \) generalizes assumptions made by Diamond and Rajan (2000, 2001), who assume that the percentage loss in asset value of a displaced borrower always equals \((1 - \beta)\), and Mailath and Mester (1993), who assume that all borrowers displaced from closed banks lose their finance.

The function \( \omega(\cdot) \) is defined by:

\[
\omega(i, N) = \begin{cases} 
1 - \beta, & \text{if } \lambda > 0 \text{ and } i \leq \lambda(N - i) \\
1 - \left( \frac{\lambda(N - i)}{i} \right) \cdot \beta, & \text{if } i > \lambda(N - i)
\end{cases}
\]

The term \( \frac{\lambda(N - i)}{i} \) represents the proportion of displaced borrowers in the economy that actually succeed in obtaining finance from a new bank once all nonfailing banks have reached their expansion limits; i.e., once \( i > \lambda \cdot (N - i) \). Note that for \( \lambda < \infty \), the function \( \omega(\cdot) \) is constant up to the critical value \( i = \lambda(N - i) \), beyond which \( \omega(\cdot) \) becomes increasing in \( i \).\(^{22}\)

The value of \( \omega(\cdot) \) approaches one and the proportion of displaced borrowers that actually obtain finance goes to zero as \( i \) approaches the total number of banks in the economy. The

\(^{22}\)For example, if \( \lambda = 1 \) and \( N = 5 \), two troubled banks may be successfully intervened with per-borrower loss in value equal to \( 1 - \beta \). Once the number of troubled banks exceeds two, intervention creates additional per borrower losses in displaced borrowers’ asset values.
total loss in asset values of good borrowers when \( i = N \) equals \( NV \). The function \( \omega(\cdot) \) is illustrated in Figure 1.

According to the definition of \( \omega(\cdot) \), when \( \beta = 0 \) or \( \lambda = 0 \), displaced borrowers lose all of their finance. This situation corresponds to the assumption made in Mailath and Mester (1993). If \( \lambda = \infty \), then all displaced borrowers always find new finance, and the expected percentage loss in asset values of displaced borrowers always equals \( 1 - \beta \). This corresponds to the assumption of Dianmond and Rajan (1999, 2000). The lower is \( \beta \) and the lower is \( \lambda \), the higher are the total losses in asset values of displaced borrowers due to intervention.

Suppose that \( \beta = 1 \) and that \( 0 < \lambda < \infty \). When \( \beta = 1 \), new lender banks can recover the entire value of displaced borrowers’ assets, as long as the number of displaced borrowers taken on does not exceed the new lender banks’ expansion limits. That \( \lambda \) is finite, however, implies that nonfailing banks will be able to expand their portfolios only up to a limit. Thus, when \( \beta = 1 \) and \( 0 < \lambda < \infty \), there always exists a range of intervened banks for which intervention would generate no losses in asset values of displaced borrowers; i.e., for which \( \omega(i, N) = 0 \). However, for \( i \) large enough, losses in displaced borrowers’ asset values become positive. For expositional purposes, I make the following assumptions.

**Assumption 4:** \( \beta = 1 \).

**Assumption 5:** \( 0 < \lambda < \infty \).

In addition to the losses in the value of displaced borrowers, there are two other categories of costs associated with intervention: (1) payments equal to the difference in the value of an insolvent bank’s liabilities and its assets; and (2) expected future deposit insurance liabilities for passive banks that remain undiscovered in period 1 (and, therefore, to which intervention is not applied). The second category is identical to this category for rescue policies: the expected liabilities of an undiscovered passive bank equal \( Z(\alpha) \), which was defined in Eqn. (3) above. The first category is also similar to the case discussed above with respect to rescue, where active banks are still insolvent. That is, a bank to which intervention is applied has its loan rollovers reversed; therefore, its expected net worth is equal to what it would have been if the bank had been active with respect to its defaulting loans. If the bank is still insolvent, the government will have to reimburse depositors in the case of bank liquidation or subsidize the acquiring bank in the case of merger with another
bank. The difference between the value of the intervened bank’s liabilities and assets is equal to \( \max[0, (L - I_0 - (1 - \alpha)B - \alpha\tilde{B})] \), which is just equal to \( R_A(\alpha) \) defined in Eqn. (2) above.

We may now define total intervention costs. Suppose, first, that all \( M \) troubled banks are passive and that \( d \) is the probability of discovering a passive bank. The number of intervened banks is \( dM \). Intervention costs are given by:

\[
C_{\text{Int}}(M, d|\text{Pass}) = dM[\omega(dM, N) \cdot V] + dM[R_A(\alpha)] + (1 - d)M[Z(\alpha)].
\] (6)

The first term on the right-hand side of (6) is the expected loss in value of displaced good borrowers of intervened banks. Assumptions 4 and 5 guarantee that this loss is zero for a range of values of \( dM \) “low enough.” The second term is the difference between the liabilities and assets of intervened banks that are insolvent. This term is zero if intervened banks are no longer insolvent once their loan rollovers have been reversed. The third term represents the expected future deposit insurance liabilities for undetected passive banks. This term is identical to its counterpart in the rescue cost function.

Comparison of (6) with (4) reveals that if \( d = 0 \), costs are equal for both policies. In addition, recall that for the case of rescue, total rescue costs are increasing in \( d \) for passive banks; therefore, the regulator would prefer forbearance to rescuing any positive number of passive banks. In order to avoid completely trivial results of the analysis, we need for the regulator to prefer to intervene in some positive number of banks rather than to engage in complete forbearance. The following assumption (motivated in the Appendix) guarantees that \( C_{\text{Int}}(N, M, d|\text{Pass}) \) is decreasing for some range of positive \( d \).

**Assumption 6:** The regulator never prefers complete forbearance to intervening in some positive number of passive banks; i.e., \( \alpha\tilde{B} > q[L - I_0 - (1 - \alpha)B] \).

Suppose now that all troubled banks are active. The number of banks to which intervention is applied is now \( M \). As was noted above for rescue, when active banks are solvent there is no need to apply intervention. Thus, it is only if active banks are still insolvent that intervention will actually be applied. Suppose that all \( M \) troubled banks are active and insolvent. Then intervention costs are given by

\[
C_{\text{Int}}(M, d|\text{Act}) = M[R_A(\alpha) + \omega(\cdot)V].
\] (7)
3.3.2 Rescue costs versus intervention costs

We may now compare the costs of rescue and intervention, given the behavior of troubled banks.

**Passive troubled banks.** When all troubled banks are passive, the difference in the costs of intervention and rescue are given by

\[ C_{\text{Int}}(M, d|\text{Pass}) - C_{\text{Res}}(M, d|\text{Pass}) = dM \cdot \left\{ [R_A(\alpha) - R_P(\alpha)] + \omega(\cdot)V \right\}. \]

The term \([R_A(\alpha) - R_P(\alpha)]\) is negative and represents the reduction in the regulator’s costs with intervention relative to rescue due to the gains in bank values from reversing loan rollovers. Given that \(R_A(\alpha) - R_P(\alpha)\) is always negative, intervention costs will be lower than rescue costs as long as \(\omega(\cdot)\) is small. This is guaranteed for some range of values of \(dM\) by Assumptions 4 and 5.

A situation of too-many-to-fail (TMTF) is defined as one in which the number of intervened banks \(dM\) becomes high enough so that \(C_{\text{Int}}(\cdot) - C_{\text{Res}}(\cdot)\) becomes positive. The motivation in the Appendix of Assumption 6 shows that in the case where \(M \leq \lambda(N - M)\), \(\omega(\cdot) = 0\) for all \(d\); therefore, in this case intervention will always be preferred to rescue for passive banks. On the other hand, when \(M > \lambda(N - M)\), TMTF may be triggered for \(d\) high enough. Inspection of (8) reveals that a necessary condition for TMTF to be triggered is that \(V > [R_P(\alpha) - R_A(\alpha)]\). This condition requires that the total asset values of the good borrowers of a failing bank exceed the total gains in the bank’s value due to reversals of risky loan rollovers. Given that a bank with a level of capital equal to eight percent of risk-weighted assets need only have eight percent of its loans in default to become insolvent, the case where the total value of good borrowers of the bank is greater than the gain in the defaulting borrowers’ assets from reversing loan rollovers is quite realistic.

In order to allow for the possibility of a situation of TMTF, I make the following assumption.

**Assumption 7:** \(V > [R_p(\alpha) - R_A(\alpha)]\).

The following lemma, which follows from the discussion in the Appendix and from Assumption 7, identifies the necessary conditions for TMTF to be triggered when banks are passive.
Lemma 1 Suppose that all troubled banks are passive. (i) If \( M > \lambda(N-M) \) and \( \omega(M,N)V > [R_p(\alpha) - R_A(\alpha)] \), then there exists a value \( d^*(M) \) such that \( \omega(d^*(M)M,N)V = [R_p(\alpha) - R_A(\alpha)] \) and for which TMTF is triggered. Intervention is less costly than rescue for \( d < d^*(M) \), and rescue is less costly than intervention for all \( d \geq d^*(M) \); (ii) If \( M \leq \lambda(N-M) \) or if \( M > \lambda(N-M) \) and \( \omega(M,N)V \leq [R_p(\alpha) - R_A(\alpha)] \), then for all \( d > 0 \), intervention is less costly than rescue.

The condition that \( \omega(M,N)V > [R_p(\alpha) - R_A(\alpha)] \) requires that when \( d = 1 \), the total loss in value of displaced borrowers with a policy of intervention will exceed the gain in bank value due to reversals of loan rollovers with intervention. Rescue thus becomes less costly than intervention for \( d \) high enough. Figure 2 illustrates case (i) of the lemma.

Active troubled banks. Comparison of the costs of intervention and rescue when troubled banks are active gives

\[
C^{Int}(M,d|\text{Act}) - C^{Res}(M,d|\text{Act}) = M[\omega(M,N)V].
\]

Note that the term \( M[R_A(\alpha)] \), which appeared in the costs for each policy, disappears when the difference in costs is taken. Note also that the right hand side of (9) is independent of the value of \( d \) and is always nonnegative. This implies that when troubled banks are active (and insolvent), rescue will always be weakly preferred to intervention and will be strictly preferred if \( \omega(\cdot) \) is positive.

The result that the costs of rescue are always lower than intervention costs whenever insolvent banks actively reveal their defaulting loans seems surprising. The extreme nature of this result is in part an artifact of the model, which does not incorporate a moral hazard effect of bank rescues. The moral hazard effect would imply that the regulator’s choice of rescue would raise banks’ beliefs about the possibility of future rescues and therefore would encourage them to make excessively risky loans in the future, possibly leading to a new banking crisis. Incorporating a moral hazard effect of rescue in the model would raise the costs of rescue relative to intervention.

I do not include this effect in the model because it would require introducing features that would make the model intractable, such as more than two periods; a choice of new, risky investment for banks in period 2, in addition to the rollover/bankruptcy decision with respect to defaulting loans in period 1, etc. Moreover, even if these features were included,
there could still arise situations in which the number of troubled banks is large enough so that the costs arising from losses in finance for displaced borrowers would become greater than the moral hazard costs of rescue. Thus, including a moral hazard effect in the model would not eliminate the possibility of TMTF.

Although I do not explicitly model the moral hazard effect, I take partial account of this effect in an indirect manner via the following assumption.

**Assumption 8:** For values of $M$ for which $C_{Int}(\cdot|Act) - C_{Res}(\cdot|Act) = 0$, $G$ chooses intervention.

Assumption 8 implies that when troubled banks are active but insolvent, intervention will be chosen for all values of $M$ for which $\omega(M, N) = 0$. The following lemma summarizes the discussion.

**Lemma 2** Suppose that all troubled banks are active but insolvent. If $M \leq \lambda(N - M)$, intervention is preferred to rescue for all $d$. If $M > \lambda(N - M)$, rescue is preferred to intervention for all $d$.

Lemma 2 states that when banks are active but insolvent, TMTF will be triggered whenever the number of intervened banks causes the losses in the value of displaced borrowers to become positive. This occurs for all $M > \lambda(N - M)$, since active banks are costlessly identified by the regulator. Note that when banks are active, the value of $d$ has no influence on the value of $\omega(\cdot)$ and on the regulator’s policy choice; therefore, it does not enter the conditions of Lemma 2.

The discussion of this section demonstrates that the policy chosen by the regulator will be a function of the following variables: the number $M$ of troubled banks relative to the total number $N$ of banks in the economy; the fraction $\alpha$ of banks’ portfolios in default; the probability $d$ of detecting passive banks; and bank behavior with respect to defaulting loans. The regulator will choose the policy which minimizes costs, given bank behavior and given the number of discovered troubled banks. Lemmas 1 and 2 show that if the number of troubled banks is small or if the regulator’s monitoring capacity is very weak, then intervention will be the chosen policy. If the number of troubled banks becomes large enough (and the monitoring capacity not too weak), then TMTF will be triggered and bank rescues will occur.
Yet, bank behavior with respect to defaulting loans is endogenous and is itself a function of the regulator’s expected policy choice. The next section examines the behavior of troubled banks and the continuation equilibria induced by differing values of \( d \). In Section 4 I derive continuation equilibria under two assumptions: (1) \( \alpha \) is so high that all troubled banks are insolvent even if they choose to be active; and (2) \( \alpha \) is low enough that troubled banks can remain solvent if they choose to be active (although, as indicated by Assumption 2, these banks will have negative expected net worth if they roll over their defaulting loans). The first case may be thought of as one in which the banking crisis is severe, in the sense that the level of financial distress among troubled banks is high. The second case represents a less severe banking crises, or a banking crisis at an early stage.

In Section 5 I analyze the equilibrium \((d, \text{Action, Policy})\) by including the regulator’s choice of \( d \) in period 0, assuming that the regulator takes account of the continuation equilibrium induced in period 1 by \( d \). As in Section 4 I first consider the case where all troubled banks are insolvent, then I analyze the case where troubled banks can remain solvent. The results of these sections illustrate how bank behavior differs as a function of the level of distress \( \alpha \) and how equilibrium outcomes also differ as a function of \( \alpha \). Finally, in Section 6 I discuss the general model where both “types” of distressed banks exist: banks which are insolvent even if they are active and less distressed banks which can remain solvent as long as they are active.

## 4 Continuation equilibria

### 4.1 Insolvent banks

In this subsection I assume that the proportion \( \alpha \) of banks’ portfolios in default is sufficiently high that all \( M \) banks with default will be insolvent even if they choose to actively reveal and deal with their bad loans. Because distressed banks are insolvent, even if these banks use bankruptcy for their defaulters, their expected earnings cannot cover their liabilities. As noted above, however, these banks are nevertheless assumed to be liquid: if they roll over their loans in period 1 and are not discovered, they are able to stay in operation during period 1, and the banker will enjoy the private benefit \( \rho \). Call the level of default \( \alpha_b \), where the subscript \( b \) represents “bad” banks. The following assumption guarantees that active
banks are insolvent.

**Assumption 9:** \( \Pi^A(\alpha_b) = I_0 + (1 - \alpha_b)B + \alpha_b \hat{B} - L < 0 \).

A continuation equilibrium has the form \((\text{Action}, \text{Policy}; d)\). In order to characterize continuation equilibria, I first derive banks’ actions given a particular policy, then I use backward induction to identify the regulator’s choice of policy.

### 4.1.1 Best responses to monitoring and choice of policy

**Intervention.** Suppose that the policy is intervention. Application of intervention to a bank will result in a utility level of zero for the banker. (It is shown in the Appendix that it is optimal for the regulator to remove the banker’s private benefit when intervention is applied.) The expected utility to a passive banker is thus

\[
U(\text{Pass}|\text{Int}, d) = (1 - d) \cdot \{q[I_0 + B - L] + \rho\}. \tag{10}
\]

With probability \((1 - d)\) the passive bank is not detected; therefore, intervention is not applied. In this case, with probability \(q\) rollover will succeed and the banker will receive a monetary payoff of \([I_0 + B - L]\). Given that the bank is not detected, the banker obtains the private benefit \(\rho\) whether or not rollover succeeds. With probability \(d\) the bank is detected, and the banker’s utility is zero.

The expected utility for an active bank is given by \(U(\text{Act}|\text{Int}, d) = 0\). This follows from the fact that active banks are costlessly identified by the regulator, and application of intervention removes the banker’s private benefit \(\rho\). Comparison of \(U(\text{Pass}|\text{Int}, d)\) and \(U(\text{Act}|\text{Int}, d)\) reveals that given a policy of intervention \(U(\text{Pass}|\text{Int}, d) > U(\text{Act}|\text{Int}, d)\); insolvent banks will choose passivity for any value of \(d\).

**Rescue.** With rescue the amount of recapitalization given to the bank in period 1 is \(R_P(\alpha_b) = L - I_0 - (1 - \alpha_b)B\). Note that if the passive bank’s loan rollover fails, its net worth in period 2, including the recapitalization will just equal zero. On the other hand, if the passive bank’s loan rollover succeeds, the bank’s net worth will be strictly positive. In each case the banker obtains the private benefit \(\rho\).

The passive banker’s expected utility with rescue, then, is

\[
U_b(\text{Pass}|\text{Res}, d) = d\{q[I_0 + B - L] + R_P(\alpha_b) + \rho\} + (1 - d)\{q[I_0 + B - L] + \rho\}
= q[I_0 + B - L] + dR_P(\alpha_b) + \rho. \tag{11}
\]
When the bank is active, it receives an amount of recapitalization that guarantees that its net worth is zero in period 2. Therefore, \( U_b(\text{Act}|\text{Res}, d) = \rho \). Comparison of \( U_b(\text{Pass}|\text{Res}, d) \) and \( U_b(\text{Act}|\text{Res}, d) \) reveals that given a policy of rescue, the insolvent bank will also choose passivity.

The following lemma summarizes the discussion.

**Lemma 3** When all troubled banks are insolvent, these banks will choose passivity independently of the regulator’s expected policy choice.

Lemma 3 implies that the regulator who minimizes costs has no power to induce insolvent banks to choose to be active with respect to defaulting loans. Namely, neither a high value of \( d \) nor the threat of intervention exerts a disciplinary effect on insolvent banks. Yet, although insolvent banks always choose passivity, the motivation for this choice differs according to the regulator’s expected policy. When the expected policy is intervention, the bank’s motivation for passivity is to avoid signalling its negative net worth, in order to avoid losing the private benefit from operating the bank. In contrast, when the expected policy is rescue, the insolvent bank’s motivation for passivity is to gamble for resurrection. If gambling for resurrection were not possible (i.e., if loan rollovers were not riskier than bankruptcy), the insolvent bank would be indifferent between being active and being passive given a policy of rescue, since the banker’s utility would equal \( \frac{1}{2} \) in both cases.

### 4.1.2 Continuation equilibrium for insolvent banks

Given that insolvent banks always choose passivity, it suffices to determine the sign of the RHS of (8) for a given value of \( d \) to determine the regulator’s policy choice. Lemma 1 guarantees that for any \( d \) there will be a range of \( M \) for which intervention is the optimal choice. On the other hand, Lemma 1 implies that for any given \( d \) there exists an \( M \) high enough so that TMTF is triggered. Define the critical value \( M^*(d) \) such that \([R_P(\alpha) - R_A(\alpha)] = \omega(dM^*(d), N)V\). For values of \( M > M^*(d) \), TMTF is triggered and the regulator’s policy choice will be rescue. (Note that \( M^*(d) > \lambda(N - M) \).) It is clear that \( M^*(\cdot) \) is a decreasing function of \( d \).

The following proposition follows immediately.
Proposition 1 Suppose that all troubled banks are insolvent. For all \( d \), there exists an \( M^*(d) \) such that the continuation equilibrium when all troubled banks are insolvent is (Passivity, Intervention) for \( M \in [0, M^*(d)] \), and the continuation equilibrium is (Passivity, Rescue) for \( M \in (M^*(d), N] \).

Proposition 1 suggests that it may be useful to make a distinction between the severity of a banking crisis and how widespread the crisis is. The severity of the banking crisis refers to the level of solvency (\( \delta \)) of the affected banks. How widespread the crisis is refers to the number \( M \) of banks that are affected relative to the number of banks in the economy. A banking crisis becomes systemic when the crisis is severe and widespread. Proposition 1 implies that given a value of \( d \), when the banking crisis is severe banks will always roll over their defaulting loans (or otherwise engage in excessive risk-taking). The regulator will apply intervention as long as the banking crisis is not systemic (i.e., as long as a large enough number of banks are not affected). When the crisis becomes systemic, TMTF is triggered, and the regulator opts for bank rescues.

4.2 Solvent but troubled banks

Suppose now that banks with bad debt have a level \( \alpha_g \) of default low enough that they are able to remain solvent if they are active. Hence, banks with loan defaults are financially distressed but not insolvent. Assumption 2, however, implies that if banks with loan defaults choose to be passive, their expected net worth is negative.

Let \( \delta_g \) represent the proportion of banks’ portfolios in default, where the subscript \( g \) represents “good” banks. Because an active bank’s expected net worth is positive, it will not have a motivation to choose passivity in order to hide negative net worth. The only possible motives for passivity are either to take advantage of the deposit insurance put option (i.e., to gamble for resurrection) or to trigger a situation of TMTF.

The following assumption guarantees that active banks are solvent.

**Assumption 10:** \( \Pi^A = I_0 + (1 - \alpha_g)B + \alpha_g B - L > 0 \).

In order for a troubled bank ever to choose passivity, gambling for resurrection must be valuable to the bank. Gambling for resurrection can only be valuable to a troubled “good” bank if the expected gain from gambling is greater than the increase in expected
bank net worth from using bankruptcy instead of rollover for defaulting debtors. The gain from gambling derives from the banker’s limited liability; if loan rollovers fail, the banker is not liable for uncovered deposit liabilities. If loan rollovers succeed, the bank’s net worth is higher than it would have been had it used bankruptcy for defaulting debtors. The following definition gives the parameter values that are necessary for troubled banks ever to choose passivity.

**Definition 1:** Gambling for resurrection is *valuable* to the good bank if

\[ q[I_0 + B - L] > I_0 + (1 - \alpha_g)B + \alpha_g \tilde{B} - L. \]  

(12)

The left-hand side of (12) is the banker’s expected monetary payoff in the case of rollover. Because of limited liability, this value is greater than expected bank net worth with rollover. The right-hand side is the banker’s monetary payoff when the bank uses bankruptcy. (This value equals bank net worth when the bank is active.) The condition in (12) can be reexpressed as

\[ (1 - q)L > [I_0 - (1 - \alpha_g)B + \alpha_g \tilde{B}] - q[I_0 + B], \]

which implies that the decrease in expected liabilities exceeds the loss in the banker’s expected monetary payment when the bank chooses passivity relative to bankruptcy. In other words, the deposit insurance put option is valuable to the bank. In order to allow for the possibility that good banks choose passivity, I make the following assumption.

**Assumption 11:** Gambling for resurrection is valuable to good banks.\(^{23}\)

### 4.2.1 Solvent bank best responses to monitoring and choice of policy

**Intervention.** When the policy is intervention, the expected utility to a passive banker is

\[ U_g(\text{Pass}|\text{Int}, d) = (1 - d) \cdot \{q[I_0 + B - L] + \rho\}, \]  

(13)

which is identical to \( U_b(\text{Pass}|\text{Int}, d) \) in the previous section. The expected utility of an active banker is given by

\[ U_g(\text{Act}|\text{Int}) = I_0 + (1 - \alpha_g)B + \alpha_g \tilde{B} - L + \rho. \]  

(14)

\(^{23}\)An example of parameter values that satisfy both Assumptions 6 and 11 are \( \alpha = .4, B = 1000, \tilde{B} = 500, q = .3, I_0 = 150, \) and \( L = 900. \)
Note that $U_g(\text{Act}|\text{Int})$ is independent of $d$, and $U_g(\text{Pass}|\text{Int},d)$ is decreasing in $d$. Assumption 11 implies that $U_g(\text{Pass}|\text{Int},d) > U_g(\text{Act}|\text{Int})$ for $d = 0$. On the other hand, for $d = 1$, $U_g(\text{Act}|\text{Int}) > U_g(\text{Pass}|\text{Int},d) = 0$. Thus, there exists a critical value $\tilde{d}$ such that $U_g(\text{Pass}|\text{Int},\tilde{d}) = U_g(\text{Act}|\text{Int})$. The bank will choose passivity for $d \in [0,\tilde{d})$ and bankruptcy for $d \in [\tilde{d},1]$.

**Rescue.** When the policy is rescue, the passive banker’s expected utility is

$$U_g(\text{Pass}|\text{Res},d) = d\{q[I_0 + B - L] + R_P(\alpha_g)\} + (1-d)\{q[I_0 + B - L] + \rho\},$$

$$= q[I_0 + B - L] + dR_P(\alpha_g) + \rho. \quad (15)$$

The active banker’s expected utility is

$$U_g(\text{Act}|\text{Res}) = I_0 + (1-\alpha_g)B + \alpha_g\tilde{B} - L + \rho.$$ 

Note that $U_g(\text{Act}|\text{Res}) = U_g(\text{Act}|\text{Int})$, since the active bank remains solvent and thus does not receive any recapitalization with a policy of rescue. Assumption 11 implies that $U_g(\text{Pass}|\text{Res},d) > U_g(\text{Act}|\text{Res})$ for all $d$; therefore, the good bank always chooses passivity when the regulator’s expected policy choice is rescue. The following lemma summarizes the behavior of good banks.

**Lemma 4** Suppose that troubled banks are not insolvent. Then, (i) given a policy of intervention, there exists a value $\tilde{d}$ such that troubled banks will choose passivity for $d \in [0,\tilde{d})$ and bankruptcy for $d \in (\tilde{d},1]$; (ii) given a policy of rescue, troubled banks will choose passivity for all $d$.

This lemma shows that setting a high value of $d$, combined with the threat of intervention, can discipline good banks to be active.

### 4.2.2 Continuation equilibrium for solvent banks

Statement (i) of Lemma 4 suggests that in order to characterize continuation equilibria it is necessary to consider separately the cases where $d < \tilde{d}$ and where $d > \tilde{d}$.

**Case 1:** $d \leq \tilde{d}$

In this case, good banks will choose passivity independently of the regulator’s policy choice. Thus, this case resembles the analysis of insolvent banks in the previous section.
In particular, for any \( d \) implied by this case, there exists a critical value \( M^*(d) < N \) such that the costs of intervention become higher than the costs of rescue for \( M > M^*(d) \). We may restate Proposition 1 for this case, taking into account that the critical value \( M^*(d) \) for which TMTF is triggered differs for the banks in this section and the insolvent banks that were analyzed in the previous section.

**Lemma 5** Suppose that \( M \) banks are troubled but solvent. For all \( d < \bar{d} \), there exists an \( M^*_g(d) \) such that the continuation equilibrium is \((\text{Passivity, Intervention})\) for \( M \in [0, M^*_g(d)) \), and \((\text{Passivity, Rescue})\) for \( M \in [M^*_g(d), N] \).

As in Section 4.1 the critical value \( M^*_g(d) \) is the value of \( M \) for which the sign of \((8)\) becomes positive. Note that for good banks \( R_A(\alpha_g) = 0 \). Also, \( R_P(\alpha_g) < R_P(\alpha_b) \). This implies that the critical value of \( M \) at which TMTF is triggered is greater for the banks analyzed in this section than for the banks analyzed in Section 4.1.

**Case 2:** \( d > \bar{d} \).

For values of \( d \) in this case, troubled banks will choose to be active if they believe that intervention will be the regulator’s policy choice and passive if they believe that rescue will be chosen. When troubled banks are active, they remain solvent; therefore, in this case intervention is not actually applied to any bank, and the regulator’s policy cost is zero.

In order to fully characterize the continuation equilibria, we must compare the costs of intervention and of rescue when banks are passive. The difference in costs between intervention and rescue is given by \((8)\). As for Case 1, it is possible to show that there exists a critical value \( M^*_g(d) \) such that when all banks are passive, intervention is preferred to rescue for \( M \in [0, M^*_g(d)) \), and rescue is preferred to intervention for \( M \in [M^*_g(d), N] \).

However, we know that in the range of \( d \) implied by this case, banks will choose to be active when the expected policy choice is intervention. Thus, for \( d > \bar{d} \) and \( M \in [0, M^*_g(d)] \), the continuation equilibrium is given by \((\text{Active, Intervention})\).

When \( d > \bar{d} \) and \( M > M^*_g(d) \), a coordination problem arises, and there exist two continuation equilibria: \((\text{Active, Intervention})\) and \((\text{Passive, Rescue})\). Namely, if troubled banks believe that other troubled banks are choosing to be active and that too few passive banks will be discovered to trigger TMTF, then the continuation equilibrium will be \((\text{Active, Intervention})\).
In contrast, if a troubled bank believes that all other troubled banks are choosing passivity, then the troubled bank will also have the incentive to choose passivity, since by definition of $M > M_g^*(d)$, the number $dM$ of discovered troubled banks will be high enough to trigger TMTF. In this case the continuation equilibrium will be (Passive, Rescue). Which continuation equilibrium actually occurs will depend upon troubled banks’ beliefs about the strategies of other troubled banks.

The following proposition summarizes the discussion of continuation equilibria.

**Proposition 2** Suppose that $M$ banks are troubled but solvent. (i) If $d < \hat{d}$, the continuation equilibrium is (Passive, Intervention) for $M \in [0, M_g^*(d)]$ and (Passive, Rescue) for $M \in (M_g^*(d), N]$; (ii) If $d \geq \hat{d}$ and $M \in [0, M_g^*(d)]$, the continuation equilibrium is (Active, Intervention); (iii) if $d \geq \hat{d}$ and $M \in (M_g^*(d), N]$, there are two continuation equilibria: (Active, Intervention) and (Passive, Rescue).

Statements (i) and (iii) of Proposition 2 demonstrate that TMTF may be triggered even in a banking crisis that is not initially severe. In contrast, statements (i) and (ii) show that if the banking crisis is not too widespread (i.e., $M$ is low enough), $d$ can serve a disciplinary role: a high enough value of $d$ combined with a threat of intervention motivates troubled banks to become active. Even when the number $M$ of troubled banks is high, a systemic banking crisis can still be avoided as long as troubled banks are active with respect to their defaulting loans. However, statement (iii) demonstrates that if the number of troubled banks is high and banks choose to be passive, the passivity can generate a banking crisis in which TMTF is triggered. In this situation the coordination problem created by the prospect of TMTF has led to an increase in bank passivity.

### 5 Allowing for the ex ante choice of monitoring quality

Section 4 has analyzed bank behavior and the regulator’s policy choice in period 1, given some monitoring quality $d$. Suppose now that the regulator can anticipate the onset of a

\footnote{Recall that although active banks are costlessly identified by the regulator, there is no need to apply any policy to these banks.}
banking crisis (or the probability of onset) as well as the number $M$ of banks that are likely to be affected by a crisis. How might he design *ex ante* regulatory institutions in light of the likelihood of a crisis and its outcome? In other words, how might the choice of supervisory capability $d$ depend upon the likelihood and nature of a crisis?

In this section I allow the regulator to choose the *ex ante* monitoring capability $d$ in period 0, taking account of the continuation equilibrium that will be induced in period 1. The regulator knows the value of $M$ (that is, how widespread the banking crisis will be); however, he does not know which particular banks will be affected in a crisis.\textsuperscript{25} The regulator chooses $d$ to minimize the expected total costs (monitoring costs plus *ex post* policy costs) associated with loan defaults on banks’ balance sheets, subject to the constraint that the policy choice in period 1 must be subgame perfect.

The optimal choice of $d$ can be found as follows. For each policy–intervention and rescue–find the optimal value of $d$ consistent with that policy being subgame perfect in period 1, taking into account troubled banks’ best responses in expectation of the policy. The requirement that the policy be subgame perfect restricts the range of $d$ over which the optimization is performed for that policy. The optimization exercise yields two candidate equilibria: $(d^R, \text{Action, Rescue})$ and $(d^I, \text{Action, Intervention})$, where Action represents banks’ best responses to the policy. Comparison of expected total costs for each candidate equilibrium identifies the lowest-cost candidate, and this candidate represents the unique equilibrium.

As in Section 4, I first consider the case of a severe crisis, where all troubled banks are insolvent; then I consider the case of a less severe crisis, where troubled banks can remain solvent. Before analyzing these cases, however, it is possible to derive two general results. The first result relates to equilibria involving the policy of rescue.

**Lemma 6** The regulator prefers engaging in complete forbearance to being in a situation of TMTF. That is, any equilibrium involving the policy of rescue has the following form: $(0, \text{Passivity, Rescue})$.

\textsuperscript{25}Although the analysis of this section assumes that the regulator knows $M$ with certainty, a similar (but more complicated) analysis could be undertaken under the assumption that the regulator does not know $M$ but has a prior over this variable. The choice of $d$ in the latter case would be that which minimizes expected costs, where the expectation is taken over $M$. This more complicated analysis would not produce qualitatively different results.
Lemma 6 makes use of two results from earlier sections. First, any continuation equilibrium involving the policy of rescue will induce banks to choose passivity. (Recall that insolvent banks always choose passivity, and solvent banks choose passivity if the expected policy is rescue.) Second, when \( d = 0 \), rescue is a subgame perfect policy. This observation follows from the fact that intervention and rescue policy costs are equal for \( d = 0 \):

\[
C_{\text{Res}}(M, 0|\text{Pass}) = C_{\text{Int}}(M, 0|\text{Pass}).
\]

Finally, the result stated in the lemma implies that the value \( d = 0 \) yields lower expected total costs than any positive value of \( d \) for which rescue is the subgame perfect policy. This derives from the observation that both monitoring costs \( g(\cdot) \) and \textit{ex post} rescue costs \( C_{\text{Res}}(M, d|\text{Pass}) \) are increasing in \( d \). A general conclusion that can be drawn from the lemma is that no equilibrium will involve a positive value of \( d \) and a rescue policy. Any equilibrium in which \( d \) takes on positive value will involve a policy of intervention.

A second general result relates to equilibria with intervention. Suppose that banks are passive. Suppose, further, that \( M \) is high enough so that TMTF can be triggered for some value \( d^*(M) \). Then, intervention costs are lower than rescue costs for all \( d \in [0, d^*(M)] \), and rescue costs are lower than intervention costs for \( d \in [d^*(M), 1] \). Let \( d^I \) be the solution to

\[
\min_{d \in [0, d^*(M)]} C(d, \text{Int}) = g(d) + C_{\text{Int}}(M, d|\text{Pass}).
\]

It is possible to show that \( d^I \) lies in the range of \( d \) for which \( C_{\text{Int}}(M, d|\text{Pass}) \) is decreasing in \( d \).\(^{26}\)

**Lemma 7** Let \( \hat{d} \) be the value of \( d \) such that \( C_{\text{Int}}(M, d|\text{Pass}) \) reaches a minimum. Let \( d^I \) to be the solution to (16). Then \( 0 \leq d^I < \hat{d} < d^*(M) \).

**Proof:** See Appendix.

Lemma 7 implies that in any equilibrium of the form \((d^I, \text{Passive, Intervention})\) the value of \( d \) will never be set at a value close to that which would trigger TMTF, since the intervention cost function \( C_{\text{Int}}(M, d|\text{Pass}) \) is increasing in \( d \) around \( d^*(M) \).

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\(^{26}\)Note that the specific value of \( d^I \) will be a function of \( M \).
5.1 Equilibrium when all troubled banks are insolvent

Recall that insolvent banks choose passivity independently of the regulator’s policy. This fact, together with Lemmas 6 and 7 imply that there are two candidate equilibria: (0, Passive, Rescue) and (dI, Passive, Intervention), where dI solves (16). A question that needs to be considered is whether dI is always strictly positive, or whether there are some parameter values for which the regulator might choose dI = 0. The following lemma states that dI will be strictly positive as long as the marginal cost of establishing a small monitoring capacity is not too large.

**Lemma 8** Suppose that all troubled banks are insolvent. Let  be the value of at which CInt(M, d, Pass) reaches a minimum in d. Let dI be the solution to (16). Then, (i) if g'(0) ≥ M[Z(α) − RA(α)], dI = 0; (ii) if g'(0) < M[Z(α) − RA(α)], then 0 < dI <  .

**Proof:** See Appendix.

Condition (i) of the lemma states that dI will only be set to zero if the cost of establishing even a small positive detection probability is very high; specifically, this cost must be greater than the total gain in bank value from reversing loan rollovers relative to undetected passivity. If the marginal cost of implementing a positive monitoring capability d is not this high, then dI will be strictly positive.

Note that when dI = 0, the equilibrium (dI, Passive, Intervention) is identical to (0, Passive, Rescue), since when the regulator undertakes no monitoring at all, he does not discover any passive banks and applies neither intervention or rescue to any bank. It is now possible to characterize the equilibrium when troubled banks are insolvent.

**Proposition 3** Suppose that all troubled banks are insolvent. (i) If g'(0) ≥ M[Z(α) − RA(α)], then the regulator engages in complete forbearance, and the equilibrium is (0, Passive, Rescue); (ii) If g'(0) < M[Z(α) − RA(α)], then the equilibrium is (dI, Passive, Intervention), where 0 < dI <  and  is the value of d such that CInt(M, d, Pass) reaches a minimum.

Proposition 3 states that if the marginal cost of establishing a low monitoring capacity is not too high, then the unique equilibrium when all troubled banks are insolvent is to set a positive value of d and to apply intervention to all discovered passive banks. If the
marginal cost of establishing even a low monitoring capacity is very high, then the regulator will engage in complete forbearance. In this case $d = 0$ and no bank is explicitly intervened or recapitalized; all insolvent banks are allowed to continue in operation, and the regulator will face future expected deposit insurance liabilities for banks whose loan rollovers fail.

At first glance Proposition 3 may appear to suggest that TMTF will never be triggered in a severe banking crisis. This seems to run counter to observed practice, where it is precisely in severe, widespread banking crises that regulators often decide to resort to bank rescues. The proposition, however, does not rule out this event. It suggests only that if, \textit{ex ante}, regulators accurately anticipate the risk of a severe banking crisis, they will avoid establishing bank supervisory regulations that are so stringent as to cause regulators to find themselves later in a position of having to rescue the entire banking sector. Stringent supervisory rules (a high monitoring capability) are costly to implement and will have no disciplinary effect on banks in a severe banking crisis. This does not imply, however, that bank rescues will never occur. In fact, Proposition 1 of Section 4.1 suggests that if the regulator has not accurately anticipated the banking crisis at the point at which supervisory quality $d$ is established, then TMTF may be triggered once a crisis occurs, and troubled banks will be rescued if enough banks are troubled.

Note that the equilibrium level of monitoring $d^I$ depends upon $M$, or how widespread the banking sector problems are. A comparative statics question of interest is the effect on the $d^I$ of an increase in $M$. One corollary that follows immediately from Proposition 3 is that if the increase in $M$ is large enough for TMTF to be triggered at the original equilibrium level of $d^I$, then the new equilibrium value of $d$ will be lower. On a more general level, however, the effect on $d^I$ of an increase in $M$ is uncertain. On the one hand, an increase in $M$ would be expected to increase $d$ since the marginal gain from increased monitoring of banks and reversals of loan rollovers increases. On the other hand, if $M$ is high enough so that the losses of displaced borrowers are positive, an increase in $M$ would be expected to exert a negative effect on $d$, since marginal gains from more intervention are reduced by the greater losses of displaced borrowers. The relative strengths of these two effects will determine the ultimate sign of the change in $d^I$. One case where the effect on $d^I$ of an increase in $M$ would be unambiguously positive is that where $M \in [0, \lambda(N - M)]$. Losses of displaced borrowers, $\omega(\cdot)$, equal zero for all values of $M$ in this case; therefore,
an increase in $M$ will cause an increase in $d^I$. The following proposition summarizes the discussion.

**Proposition 4** Suppose that all troubled banks are insolvent. The equilibrium value $d^I$ may increase or decrease with an increase in $M$.

**Proof:** See Appendix.

### 5.2 Equilibrium when all troubled banks are solvent

We now analyze the regulator’s period-0 choice of $d$ when troubled banks are not insolvent. Because the possibility of TMTF creates a coordination problem among troubled banks, it is necessary to distinguish between the case where TMTF cannot be triggered and the case where TMTF can be triggered.

**Case 1: No possibility of TMTF.** Since intervention is less costly than rescue for all $d$, it suffices to identify the optimal value of $d$ given a policy of intervention. Yet, because bank behavior changes at the critical value $\bar{d}$, it is necessary to compare the solutions to two optimization problems. The first is

$$\min_{d \in \{0, \bar{d}\}} C(d, \text{Int}|\text{Pass}) = g(d) + C^{\text{Int}}(M, d|\text{Pass}).$$

(17)

The solution to this problem resembles that of (16) above. The solution, which I label $d^I_1$, is described by Lemmas 7 and 8 above. In particular, if $g'(0)$ is not too large, $d^I_1$ will be strictly positive but situated in a region where $C^{\text{Int}}(\cdot|\text{Pass})$ is decreasing in $d$.

The second optimization problem is given by

$$\min_{d \in [\bar{d}, 1]} C(d, \text{Int}|\text{Act}) = g(d),$$

(18)

where we recall that given $d \geq \bar{d}$ and a policy of intervention, troubled banks will choose to be active, in which case the intervention policy is not actually applied to any bank. It is clear that the costs in the above problem are increasing in $d$; therefore, the solution to this problem is $d^I_2 = \bar{d}$. The following lemma summarizes the candidate equilibria in this case.

**Lemma 9** Suppose that troubled banks are solvent. When the value of $M$ is low enough that TMTF cannot be triggered for any $d$, the equilibrium will be determined by $\min\{g(\bar{d}), [g(d^I_1)]+$
$C^{Int}(M, d^*_1 | \text{Pass})\},$ where $d^*_1$ solves (17). If the first term in the brackets is lower, the equilibrium will be $(\tilde{d}, \text{Active, Intervention}).$ If the second term is lower, the equilibrium will be $(d^*_1, \text{Passive, Intervention}).$

Note that, in principal, $d^*_1$ may be equal to $\tilde{d}.$ This would be the case if the solution to (17) were a corner solution. The case of greater interest for this paper, however, is that where $d^*_1$ is an interior solution. In this case $\tilde{d} > d^*_1,$ and the equilibrium will only involve $\tilde{d}$ if the reduction in ex post policy costs due to the disciplinary effect of setting a higher value of $d$ offsets the increase in monitoring costs from a higher monitoring level. In this case the regulator increases $d$ beyond the point where the marginal increase in monitoring cost equals the marginal benefit from increased intervention in passive banks.

Lemma 9 shows that if an increase in supervisory quality to the point of deterring passive behavior is not too costly, then the regulator will set the monitoring quality $\tilde{d}$ in order to discipline banks and to avoid a crisis. On the other hand, if setting such a high supervisory quality is very costly, then the regulator will set the lower quality $d^*_1$ and apply intervention to discovered troubled banks.

**Case 2: TMTF possible.** As was noted above, given any $M$ in this case, there exists a critical value $d^*(M)$ such that when banks are passive, intervention will be less costly than rescue for $d < d^*(M)$ and rescue will be less costly than intervention for $d \geq d^*(M).$ Yet, because of the potential change in bank behavior at $\tilde{d},$ we must distinguish between two subcases: (a) $d^*(M) \leq \tilde{d}$ and (b) $d^*(M) > \tilde{d}.$

**Case 2a: $d^*(M) \leq \tilde{d}.$**

In this case rescue is less costly than intervention for $d = \tilde{d};$ therefore, this case corresponds to that described in statement (iii) of Proposition 2, in which the value $\tilde{d}$ may induce two continuation equilibria. Namely, if banks choose to be passive, the continuation equilibrium at $\tilde{d}$ will be $(\text{Passive, Rescue}),$ whereas if banks choose to be active, the continuation equilibrium will be $(\text{Active, Intervention}).$ Thus, whether $\tilde{d}$ serves a disciplinary role will depend upon banks’ beliefs, which determine their actions and the particular continuation equilibrium that will occur with $\tilde{d}.$

Suppose that the regulator believes that $\tilde{d}$ will induce the continuation equilibrium $(\text{Active, Intervention}).$ Then, in terms of bank behavior this situation resembles that of Case 1, in which banks will choose passivity for $d < \tilde{d},$ and they will become active at $\tilde{d}.$
(Note that we can use Lemma 6 to rule out possibility of an equilibrium of the form \((d, \text{Passive, Rescue})\) with \(d \geq d^*(M)\)). The following lemma states describes the candidate equilibrium in this case.

**Lemma 10** Suppose that troubled banks are solvent and that \(M\) is high enough that TMTF may be triggered for \(d^*(M) < \tilde{d}\). Then, when the regulator believes that \(\tilde{d}\) will induce the continuation equilibrium (Active, Intervention), the equilibrium will take the form described in Lemma 9.

Now suppose that the regulator believes that \(\tilde{d}\) will induce the continuation equilibrium (Passive, Rescue). In this case \(\tilde{d}\) has lost its disciplinary power, and troubled banks will always have the incentive to choose passivity independently of the expected policy. (Recall that, given \(d < \tilde{d}\) banks choose passivity, and given a policy of rescue, troubled banks choose passivity for all \(d\).) This case then becomes similar to the case of insolvent banks, and the equilibrium is described by Proposition 3.

**Case 2b**: \(d^*(M) > \tilde{d}\)

In this case TMTF is not triggered at \(\tilde{d}\); the regulator can credibly use intervention and \(\tilde{d}\) to discipline banks. Thus, this case is similar to that of Case 1. The equilibrium in this case is described by Lemma 9.

We may now characterize the equilibrium.

**Proposition 5** Suppose that troubled banks are solvent. (i) Suppose that the following conditions hold: \(M\) is high enough so that TMTF is triggered at \(d^*(M); \ d^*(M) \leq \tilde{d}\); and the regulator believes that the continuation equilibrium induced by \(\tilde{d}\) will be (Passive, Rescue). Then, the equilibrium is given by \((d^*_1, \text{Passive, Intervention})\), where \(d^*_1\) solves \(\min_{d \in [0, \tilde{d}]} C(d, \text{Int} | \text{Pass}) = g(d) + C^\text{Int}(M, d | \text{Pass})\). (ii) If the conditions of (i) do not hold, the equilibrium will be determined by \(\min\{g(\tilde{d}), [g(d^*_1) + C^\text{Int}(M, d^*_1 | \text{Pass})]\}\). If the first term in the brackets is lower, the equilibrium will be \((\tilde{d}, \text{Active, Intervention})\). If the second term is lower, the equilibrium will be \((d^*_1, \text{Passive, Intervention})\).

Proposition 5 implies that when the number \(M\) of troubled banks is so low that TMTF can never be triggered or when TMTF can be triggered but the monitoring level \(\tilde{d}\) still induces banks to become active, the equilibrium will be either \((d^*_1, \text{Passive, Intervention})\)
or $(\tilde{d}, \text{Active, Intervention})$, where $d_I \leq \tilde{d}$. In contrast, when TMTF can be triggered for values of $d$ less than $\tilde{d}$ and when $\tilde{d}$ loses its disciplinary power due to the coordination problem (i.e., when banks will choose passivity when $d = \tilde{d}$ in the expectation of triggering TMTF), then the equilibrium will be $(d_I, \text{Passive, Intervention})$. The regulator will maintain $d$ at the lower level in order to avoid TMTF. This proposition implies that supervisory quality is never higher when banks’ actions can trigger TMTF than when they cannot, and supervisory quality may be strictly lower in the former situation. If in the absence of TMTF the regulator would set a value of $d$ to discipline banks, he now may soften banking regulations in order to avoid a situation of TMTF. Troubled banks will choose passivity in response to the softened banking regulations; however, the regulator will apply intervention to the passive banks that are detected.

6 Discussion and Conclusion

Sections 4 and 5 have considered two versions of the model: one where all troubled banks are insolvent and the other where all troubled banks can remain solvent if they are active with respect to their defaulting loans. Insolvent banks always choose passivity with respect to their defaulting loans. In equilibrium, the regulator will choose the optimal value of $d$, given passivity on the part of troubled banks, and apply intervention to all detected passive banks.

Solvent but troubled banks will be passive with respect to their defaulting loans if $d$ is low enough or if they expect rescue to be the policy chosen by the regulator. However, if $d$ is high enough and the policy of intervention is credible for high $d$, troubled banks will choose to be active. In this case the regulator may opt for a value of $d$ that is higher than the value which equalizes the marginal cost of greater monitoring and the marginal benefit of increased detection of passive banks. The higher value of $d$ disciplines troubled banks and induces them to become active. However, the high value of $d$ may also create a coordination problem if enough banks are troubled. If when all banks decide to be passive at this value of $d$, rescue would be less costly than intervention, the regulator may be drawn into a situation of TMTF. If the regulator believes that this will happen, he will not choose the high value of $d$ in period 0; rather, he will lower $d$ to a level that guarantees...
that TMTF cannot be triggered by banks’ passivity. Even though in this case banks are sure to choose passivity, the regulator can implicitly commit to applying intervention to all detected passive banks.

A question of interest is how the results would change with a more general model in which some troubled banks are insolvent but others are solvent. (In addition to the previous assumption that the regulator knows the number of troubled banks \( M \), we would add the assumption that the regulator knows the ratio of insolvent to solvent troubled banks.) The behavior of insolvent banks would not change in the general version of the model: an insolvent banker’s utility would always be higher with passivity than with bankruptcy. Similarly, the best response of solvent, troubled banks would still be to choose passivity for low values of \( d \) or whenever the expected policy is rescue, but to become active for high values of \( d \) (\( d \geq \tilde{d} \)), provided that intervention is the expected policy choice. What would likely change is the regulator’s ability to discipline troubled solvent banks by setting \( d = \tilde{d} \). For example, suppose that the proportion of insolvent to solvent troubled banks is high. Consider a value of \( M \) and a value of \( d \) such that \( d > d^*(M) \). Suppose, in addition, that \( d^*(M) < \tilde{d} \). If the number of troubled solvent banks is so low relative to the number of insolvent banks that TMTF would still be triggered (due to the passivity of insolvent banks) even if the solvent banks were to choose to be active, then the troubled solvent banks will choose passivity in response to \( \tilde{d} \). TMTF could thus be triggered for a larger range of parameter values in the general model than in the less general version; therefore, the equilibrium would involve the regulator setting more often a low value of \( d \) in order to avoid the triggering of TMTF.

How do the predictions of the model fit with reality? Section 1 cited a number of examples of banking crises in which bank rescues have been adopted, primarily in response to the perception by regulators that the crisis was systemic. Propositions 1 and 2 of Section 4 describe these cases, where as a result of the large number of banks that are troubled, the expected costs of closing the banks exceed the costs of bank rescues.

Japan and the U.S. offer a different type of experience. In both of these countries regulators responded to the onset of crisis by softening banking regulation. One possible interpretation of the regulators’ response (Boot and Thakor, 1993, and Kane, 1990) is that regulators acted in their own self interest, engaging in forbearance in the hope that banks’
financial states would improve and that the regulators’ ability to properly supervise banks would not be brought into question. Another possible explanation can be obtained with a slightly modified version of the model of this paper. Although the regulator’s choice of \( d \) has been modeled as occurring in period 0, prior to the onset of a crisis, it is possible to expand the model to allow for a relaxation of \( d \) in period 1. Note first that in period 1 the cost associated with having established the monitoring level \( d \) in period 0 is sunk. If upon perceiving the onset of a crisis, the regulator believes that the detection probability is so high that many banks will be discovered to be troubled and TMTF will be triggered, and if the regulator can costlessly relax banking regulation or reduce the quality of monitoring (e.g., by relaxing the definition of bank solvency), then the regulator will do so in order to lower \textit{ex post} policy costs. The outcome will be that fewer troubled banks are detected and intervention will be applied to those that are.\(^{27}\)

Finally, it is often observed that in developing and transition economies, banking regulations are weak. This would seem to aggravate banking sector problems in these countries, which are already vulnerable to crises.\(^{28}\) Yet, the model of this paper suggests that if regulators anticipate a high probability of a banking crisis, the total expected costs associated with defaulting loans on banks’ balance sheets may actually be lower if a low enough monitoring capability is set, so that regulators avoid being trapped in the situation of having to bail out the entire banking sector.

\(^{27}\)An alternative explanation put forth by Dewatripont and Tirole (1994) regarding U.S. regulators’ relaxation of solvency regulations in the face of the S&L crisis was that the budget available to the regulators was insufficient to cover the costs of so many S&L liquidations. Relaxing solvency requirements allowed the regulators to close fewer S&Ls and avoid having to request more money from the U.S. Congress. This type of regulatory budget constraint could also easily be added to the model of this paper.

\(^{28}\)Caprio and Honohan (1999) note the increased vulnerability to banking crises in developing relative to industrialized economies and attribute it to aggregate volatility and to increased political interference in bank lending. See Filer et al (1999) and Mitchell (2001) for a discussion of the added vulnerability of transition economies to banking crises.
7 Appendix

Motivation for Assumption 6.

The regulator will prefer some intervention to complete forbearance if costs of intervention decline for at least some range of positive $d$. Assumptions 4 and 5 guarantee that there exists a range of values of $dM$ for which $\omega(\cdot) = 0$. A necessary condition, then, for intervention costs to decline for some positive range of $dM$ is that $R_A(\alpha) < Z(\alpha)$, or

$$\max[0, (L - I_0 - (1 - \alpha)B - \alpha\hat{B})] < (1 - q)[L - I_0 - (1 - \alpha)B].$$

(19)

Note that this condition is automatically satisfied if banks that have been discovered and had their loan rollovers reversed are solvent. If the banks are still insolvent, this condition translates into the requirement that

$$\alpha\hat{B} > q[L - I_0 - (1 - \alpha)B].$$

This is Assumption 6 in the text.

Assumptions 4-6 imply that for any $M$, intervention costs are initially declining for low values of $d$ but may begin to increase with $d$ if $\omega(\cdot)$ becomes large enough. We may distinguish between two cases.

Case 1: $M \leq \lambda(N - M)$, which implies that $\omega(\cdot) = 0$ for all $d$.

In this case the number of troubled banks is low enough relative to the total number of banks in the system, and the capacity of nonfailing banks to take on new borrowers is high enough, so that there are never any losses in the value of good borrowers. Displaced borrowers of failing banks will always be able to obtain new finance at a nonfailing bank. This implies that intervention costs $C_{Int}(N, M, d|Pass)$ are declining for all $d > 0$.

Case 2: $M > \lambda(N - M)$.

In this case external costs become positive for $d$ high enough. In addition, as $d$ increases, if the value of $\omega(dM, N)V$ becomes high enough relative to $Z(\alpha) - R_A(\alpha)$, then $C_{Int}(N, M, d|Pass)$ will turn increasing in $d$.

Proof that regulator always fires the bank manager with intervention.

We need to prove that it is optimal for the regulator to replace the bank manager (i.e., set $\rho = 0$) with a policy of intervention. Suppose, to the contrary, that intervention involves only reversal of loan rollovers, and the bank manager is not replaced. Then, it is possible to show that the bank will always prefer passivity to being active.
**Insolvent banks:**

When the banker is not replaced with intervention, her utility if she is passive becomes

\[ U(\text{Pass}|\text{Int}, d) = (1 - d) \cdot \{q[I_0 + B - L]\} + \rho. \]

This utility is greater than the utility in the bank manager is active, in which case

\[ U(\text{Act}|\text{Int}, d) = \rho. \]

The banker clearly prefers to be passive. So, in the case where all troubled banks are insolvent, allowing the bank manager to continue operating the bank with a policy of intervention does not induce troubled banks to choose to be active.

**Solvent banks:**

If the banker is not replaced with intervention, her utility if she is passive is

\[ U(\text{Pass}|\text{Int}, d) = (1 - d) \cdot \{q[I_0 + B - L]\} + d[I_0 + (1 - \alpha_g)B + \alpha_g\tilde{B} - L] + \rho. \]  \hfill (20)

The banker’s utility if she is active is

\[ U(\text{Act}|\text{Int}, d) = I_0 + (1 - \alpha_g)B + \alpha_g\tilde{B} - L + \rho \]  \hfill (21)

By Assumption 11, \( q[I_0 + B - L] > I_0 + (1 - \alpha_g)B + \alpha_g\tilde{B} - L \); therefore,

\[ U(\text{Pass}|\text{Int}, d) > I_0 + (1 - \alpha_g)B + \alpha_g\tilde{B} - L + \rho = U(\text{Act}|\text{Int}, d). \]

The solvent banker would also choose passivity given a policy of intervention.

**Proof of Lemma 6:**

Consider the optimal value of \( d \) given that TMTF has been triggered. This value is the solution to

\[ \min_{d \in [d^*(M), 1]} g(d) + C_{\text{Res}}(d, M|\text{Pass}). \]

Since both terms are increasing in \( d \), the solution to this problem is \( d^*(M) \). Yet, the fact that \( g(\cdot) \) and \( C_{\text{Res}}(d, M|\text{Pass}) \) are increasing in \( d \), together with \( g(0) = 0 \) implies that

\[ C_{\text{Res}}(0, M|\text{Pass}) < g(d^*(M)) + C_{\text{Res}}(d^*(M), M|\text{Pass}). \]

**Proof of Lemma 7:**

For the case where \( M < \lambda(N - M) \), this result follows immediately, since in this case \( C_{\text{Int}}(\cdot|\text{Pass}) \) is declining for all \( d \).
Note that the F.O.C. of problem (16) is given by

\[ g'(d) + M\{[\omega(dM, N)V] + [R_A(\alpha)] - [Z(\alpha)]\} + \gamma[0 - d] = 0, \quad (22) \]

where \( \gamma \) is a Lagrange multiplier relating to the constraint that \( d \geq 0 \). Let \( d^I \) be the value of \( d \) which satisfies (22). If \( d^I = 0 \), the lemma holds. Now consider the case where \( d^I > 0 \). Then, \( \gamma = 0 \), and \( g'(d^I) + M\{[\omega(\alpha)M, N)V] + [R_A(\alpha)] - [Z(\alpha)]\} = 0 \). That \( g'(\cdot) \) is positive require that \( M\{[\omega(\alpha)M, N)V] + [R_A(\alpha)] - [Z(\alpha)]\} \) be negative, which in turn requires that \( C_{int}(\cdot|Pass) \) is declining. Thus, \( d^I < \hat{d} \).

**Proof of Lemma 8:**

In order to prove the lemma, it suffices to identify the condition in which \( d^I = 0 \) in the problem (16). The convexity of \( g(\cdot) \) implies that this will be the case whenever \( g'(0) + M\{[\omega(0, N)V] + R_A(\alpha) - Z(\alpha)] > 0 \), which is equivalent to \( g'(0) + M\{R_A(\alpha) - Z(\alpha)\} > 0 \), since \( \omega(0, N) = 0 \).
References


