Caught between Scylla and Charybdis? Regulating Bank Leverage When There Is Rent Seeking and Risk Shifting

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We develop a theory of optimal bank leverage in which the benefit of debt in inducing loan monitoring is balanced against the benefit of equity in attenuating risk shifting. However, faced with socially costly correlated bank failures, regulators bail out creditors. Anticipation of this generates multiple equilibria, including one with systemic risk in which banks use excessive leverage to fund correlated, inefficiently risky loans. Limiting leverage and resolving both moral hazards—insufficient loan monitoring and asset substitution—requires a novel two-tiered capital requirement, including a "special capital account" that is unavailable to creditors upon failure. (*JEL* G21, G28, G32, G35, G38)

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Introduction

Financial crises have occurred for centuries, have been studied extensively (e.g., Allen and Gale 2000a, 2000b, and 2008), and are typically

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followed by calls for regulatory reform. After the recent crisis, the prudential regulation of banks emerged as a pivotal issue. The key question being asked is what is the socially optimal amount of capital that banks should be required to hold on their balance sheets? Underlying this question is the premise that privately optimal bank capital levels may fall below the social optimum, thus necessitating regulation.

In this paper, we address this central question with a theoretical approach that recognizes the well-known moral hazard frictions in banking and seeks to generate an implementable policy prescription for regulating bank capital. The moral hazard problems that we focus on are (1) rent seeking by managers who underprovide loan monitoring effort and (2) asset-substitution moral hazard involving the bank choosing excessively risky, socially inefficient portfolios. Our analysis generates a capital regulation proposal to deal with these problems. Broadly, our proposal is aimed at increasing bank capital in a way that does not compromise bank discipline by uninsured creditors and yet keeps bank incentives to take excessive leverage and risks that are correlated with those of other banks in check.

It has been proposed that the market discipline of (uninsured) debt can ameliorate the first moral hazard—inadequate loan monitoring (Calomiris and Kahn 1991; Diamond and Rajan 2001).[1] The second moral hazard—risk shifting—can be dealt with by ensuring that the bank has sufficient equity capital (see, e.g., Bhattacharya, Boot, and Thakor 1998; Merton 1977; Thakor 2014).[2] A study of bank failures by the Office of the Comptroller of the Currency (1988) confirmed that these two moral hazard problems seem simultaneously relevant in understanding bank failures.[3] The evidence from the 2007–2009 crisis leads to a similar conclusion.[4]

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[1] The specifics of modeling differ across papers. For instance, Calomiris and Kahn (1991) model this as a problem of managerial fraud, whereas Diamond and Rajan (2001) model it as a holdup problem in the spirit of Hart and Moore (1994). See also Acharya and Viswanathan (2011).

[2] While Jensen and Meckling (1976) proposed this as a problem for nonfinancial corporations, it is exacerbated in the case of financial firms by implicit and explicit guarantees, such as deposit insurance (Bhattacharya and Thakor 1993) and the ease of risk manipulation (Myers and Rajan 1998).

[3] The OCC's study was based on an analysis of banks that failed, became problems and recovered, or remained healthy from 1979–1987. The study analyzed 171 failed banks and concluded "Management-driven weaknesses played a significant role in the decline of 90 percent of the failed and problem banks the OCC evaluated. Many of the difficulties the banks experienced resulted from inadequate loan policies, problem loan identification systems, and systems to ensure compliance with internal policies and banking law. In other cases, directors' or managements' overly aggressive behavior also resulted in imprudent lending practices and excessive loan growth that forced the banks to rely on volatile liabilities and to maintain inadequate liquid assets."

[4] For instance, on April 12, 2010, Senator Carl Levin, D-Mich., chair of the U.S. Senate Permanent Subcommittee on Investigations, issued a statement addressing some of the lending practices of Washington Mutual, the largest thrift in the United States until it was seized by the government and sold to J. P. Morgan Chase in 2008 (see U.S. Senate Press Release, "Senate Subcommittee Launches Series of Hearings on Wall Street and the Financial Crisis," April 12, 2010). The statement confirms evidence of poor lending, fraudulent documentation, and lack of disclosure.

We would ordinarily expect the privately-optimal capital structure choices of banks to deal efficiently with these moral hazard problems. However, there is an inherent conflict between how the two problems can be addressed: reducing risk shifting requires raising capital, and using market discipline to reduce managerial shirking requires raising leverage. Hence, it is not clear what the private optimum would look like, particularly relative to bank capital structures observed in practice, since the observed capital structures are also affected by the possibility of government bailouts.

Motivated by these observations, we address the following questions. First, how do the disciplining roles of bank capital and leverage interact? Second, what does this interaction imply about the bank's privately optimal capital structure? Third, how do ex post bank bailouts by regulators affect the bank's ex ante capital structure? Does the possibility of bailouts justify regulatory capital requirements? And, if so, what form should these requirements take?

To address these questions, we develop a model in which the market discipline of debt works via creditors threatening to liquidate a bank that has not monitored its loans. While shareholders could also use a similar threat, we show that they lack the incentive to do so. We then show that if leverage is too low, debt becomes so safe that creditors lack the incentive to impose the discipline that induces bank monitoring. At the other extreme, if leverage is too high, managers take excessive risk and bet the bank with the creditors' money. The privately-optimal capital structure of the bank is thus like a ship navigating carefully between the mythological sea monsters Scylla (rent-seeking moral hazard) and Charybdis (asset-substitution moral hazard).

Formally, there are parametric conditions under which the bank has a range of incentive-compatible leverage levels, and as long as bank leverage is within this range, both forms of moral hazard are resolved (case 1). In this case, the bank's privately-optimal capital structure maximizes its ex ante liquidity with a level of leverage that is low enough to eliminate asset substitution, but high enough to induce creditor discipline. This capital structure induces the choice of the first-best loan portfolio by the bank. However, there are other conditions (case 2) under which it is impossible to choose leverage that simultaneously induces creditor discipline and deters asset substitution. In this case, the bank's capital structure must tolerate either the inefficiency of loan monitoring shirking or the inefficiency of excessive risk.

In reality, asset substitution at banks is often correlated across banks, such as real estate investments (e.g., Reinhart and Rogoff 2008).[5] We

[5] In our model, risks are correlated both within banks and potentially (when asset-substitution moral hazard is unresolved) across banks. Thus, the kind of asymptotically vanishing-risk-via-diversification argument that operates in Ramakrishnan and Thakor (1984), for example, does not work here when asset-substitution moral hazard is not resolved, and a role for bank capital arises.

argue that this phenomenon is attributable to government-sponsored fiscal injections or central-bank-provided lender of last resort (LOLR), which arise from the fact that it is simply time inconsistent for regulators to refuse to bail out banks in the face of en masse failures.[6] In particular, when bank failures are correlated, all banks' creditors may be protected because of the prohibitive social costs perceived to be associated with a systemic collapse, like the one in 2008, following the failures of Lehman Brothers and other financial institutions. We initially take such regulatory forbearance as given and show that the anticipation of it generates another Nash equilibrium in banks' leverage choices. In this equilibrium, systemic risk is inefficiently increased via two channels—banks overlever and take on excessive correlated asset risk. Thus, regulatory forbearance itself becomes a source of systemic risk. As creditors anticipate being bailed out, their downside risk is "socialized," so increasing bank leverage is *not* met with a higher cost of debt financing, and there is no credit rationing. This situation enables banks to "loot" the taxpayer, in the sense of Akerlof and Romer (1994), by paying out dividends and eroding bank capital even as bank risk and leverage rise. Looting arises purely through shareholder value maximization by banks.

A regulatory capital requirement can potentially address this problem. Under conditions guaranteeing that the privately optimal capital structure in the absence of regulatory forbearance can fully resolve different forms of moral hazard (case 1), a simple minimum equity capital requirement restores the first-best asset choice and eliminates correlated risk taking and excessive leverage. But when private contracting cannot simultaneously resolve different moral hazards (case 2), such a capital requirement is not efficient. The amount of equity that renders asset substitution unattractive makes debt so safe that it eliminates market discipline related to loan monitoring. The optimal capital requirement that copes with this is more complex: it has a two-tiered structure with the following features.

First, the bank should be required to fund itself with a minimum amount of equity capital, which may be viewed as being similar to a leverage-ratio restriction or a tier-1 capital requirement. This capital faces no restrictions regarding assets in which it is invested.

6 Acharya and Yorulmazer (2007), Acharya (2009), and Farhi and Tirole (2012) build formal models of the regulator's time-consistency problem when banks fail together and of the induced herding behavior in banks. Besides herding, joint failure risk can also be created by banks through the use of short-term debt and credit-risk transfer mechanisms, as studied by Allen, Babus, and Carletti (2012) and Thakor (2012). The point that excessive systemic risk may ultimately be rooted in the time inconsistency of government regulation was recognized as early as Kindleberger (1978) and has been reinforced recently by Kane (2010), among others. The issue is further complicated when regulatory intervention pertains to multinational banks with cross-border deposit insurance (e.g., Calzolari and Loranth 2011).

Second, the bank must also keep an additional "special capital account" (SCA). This capital is "special" in the sense that (1) it must be invested in safe assets[7] and (2) it is subject to contingent distribution rights: It accrues to the bank's shareholders when the bank is solvent, like any other capital. But if there is an idiosyncratic failure of the bank, this capital is unavailable to cover the claims of (uninsured) creditors; it accrues instead to the regulator. This ensures that even when the bank has sufficiently high capital for shareholders to deter excessive risk taking, creditors have sufficiently high "skin in the game," and their incentives to liquidate inefficiently run banks are maintained.

Implicit in the design of the two-tiered capital requirement structure is the notion that there will be intertemporal transfers between the two capital accounts as they change in response to earnings shocks. We analyze a two-period version of the model that shows the dynamics of these adjustments. The key result is that a larger special capital account must be kept at the beginning than in the static case in order to accommodate negative shocks to the regular capital account, which must then be refurbished with a transfer from the special capital account. This design permits one to avoid issuing any equity, except at the outset. The benefit of such equity issuance avoidance in the context of an adverse-selection setting is also examined.

1. Model

We present a model that shows how the extent of leverage in a bank's financial structure determines the incentives provided and the discipline imposed by debt on the bank's portfolio choices. In doing so, the model also explains the economic role played by bank capital.

1.1 The economy

Consider an economy in which all agents are risk neutral and the risk-free rate of interest is zero. There are five dates: $t=0$, 1, 2, 3 and 4. We will refer to $t=0$ to $t=2$ as the first period and $t=2$ to $t=4$ as the second period. The economy has a large number of banks. At $t=0$, each bank is owned by shareholders and operated by a manager. The bank needs I units of funding to invest in a new loan portfolio in the first period. This investment can be financed with any combination of debt (D) and equity (E), so that $D+E=I$ at $t=0$. This loan portfolio matures at $t=2$, at which time the bank invests in another loan portfolio for the second

[7] This investment restriction makes the special capital account look like a cash-asset reserve requirement, but it goes beyond that because (as explained above) it stipulates a particular form of ownership or contingent distribution rights.

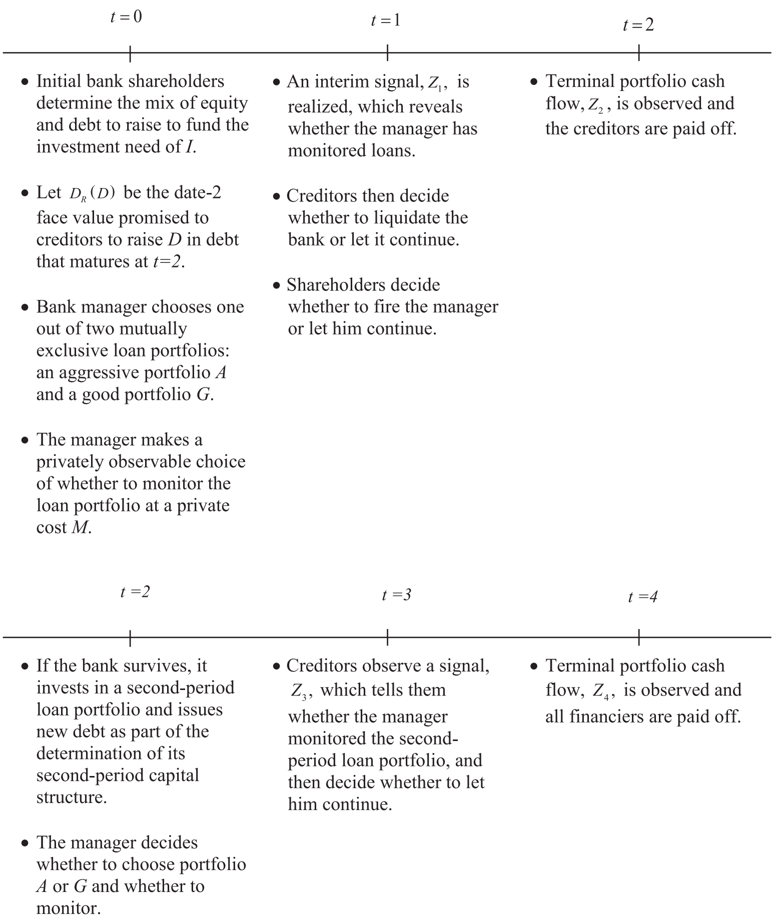

Figure 1
Sequence of events

period if it continues. We will refer to E as the bank's equity capital. The loan portfolio opportunity set for the bank in both periods is identical. We will solve the bank's capital structure and loan portfolio choice in each period. The time line of events is described in Figure 1.

It is simplest to think of the bank as being 100% owned by the manager at the outset, with the owner-manager first choosing the bank's capital structure, while raising external financing of I. Subsequent to this choice, the manager chooses the loan portfolio. The bank's owner-manager is wealth constrained, which is why he needs external financing. An alternative to this interpretation is that the bank manager is distinct from the initial shareholders who are wealth constrained, but the manager's incentives are aligned with maximizing the wealth of the initial shareholders.

We assume that the capital market is competitive so that the expected return that must be provided to investors purchasing the bank's securities is zero. Thus, the participation constraints of outside shareholders and creditors hold tightly in equilibrium and all financiers earn an expected return of zero. If the bank can raise financing up to I units, it can meet its investment need at $t=0$, which then allows it to choose a first-period loan portfolio at $t=0$.

1.2 Loan portfolio attributes

There are two mutually exclusive loan portfolios the bank can choose from at $t=1$: a "good" portfolio (G) and an "aggressive" portfolio (A), which may be preferred by bank shareholders, owing to asset-substitution moral hazard. Each loan portfolio generates a stochastic cash flow at $t=2$, denoted as Z_2, whose distribution depends on the monitoring effort of the bank's manager, a binary decision involving an effort choice from the set {monitor, do not monitor}. Moreover, each portfolio also produces an interim signal, $\tilde{Z}_1$, which reveals whether the bank engaged in monitoring at $t=0$. This signal is costlessly observable to all at $t=1$, but it is *not* verifiable for contracting purposes, so contracts cannot be conditioned on it.

Next, we describe the formal structure of the probability distributions of the cash flows of the two portfolios. Informally, the good portfolio (G) efficiently balances risk and return, whereas the aggressive portfolio (A) is excessively risky.

Signal at $t=1$ (for both the A and G portfolio):

$$\tilde{Z}_1 = \begin{cases} x>0 & \text{if the loan portfolio is monitored} \\ 0 & \text{otherwise} \end{cases} . \tag{1}$$

Cash flows at $t=2$:

For portfolio $i \in \{A, G\}$, if the bank monitors, then

$$Z_2^i = \begin{cases} H_i>0 & w.p.\ p_i \in (0,1) \\ H>0 & w.p.\ r \in (0,1) \\ 0 & w.p.\ 1-p_i-r \end{cases} , \tag{2}$$

where $p_G > p_A$ (so the G loan has a higher probability of success than A loan) and $H_A > H_G > H$ (so the A loan has a higher payoff than the G loan in the highest payoff state).

If the bank does not monitor its loans, then the A and G portfolios have the same date-2 cash-flow distribution (and in equilibrium, we will show below that creditors will liquidate the bank when it does not monitor its loans, so that we use the subscript ℓ for these outcomes):

$$Z_2^i = \begin{cases} H_\ell > 0 & w.p. \ p_\ell \in (0,1) \\ H > 0 & w.p. \ r \\ 0 & w.p. \ 1 - p_\ell - r \end{cases} \tag{3}$$

for $i \in \{A, G\}$. In (3), we capture the idea that lack of monitoring produces an economic loss, as $H_\ell < H_G$ and $p_\ell < p_G$.

To summarize, we assume the following: (1) If the bank monitors, then G has a higher probability than A of producing the highest date-2 cash flow, that is, $p_G > p_A$. But the probability of achieving the highest date-2 cash flow drops if the bank does not monitor, and it is p_ℓ with both A and G, where $p_\ell < p_A$. (2) When the bank monitors, the highest date-2 cash flow is higher with A than with G, but this cash flow drops if the bank does not monitor, that is, $H_A > H_G > H_\ell$, (3) $H_G > I > H$, which means that the investment in the good loan portfolio can be recovered only if the state with the highest date-2 payoff is realized, and (4) in terms of expected date-2 cash flow, when the bank monitors, G dominates A by a sufficient margin; in particular, $[p_G/(p_G - p_A)]H_G - [p_A/(p_G - p_A)]H_A > 1$. The "sufficient margin" between the G and A in (3) is easily met since we know that $p_G H_G - p_A H_A > 0$, implying that the condition above is satisfied if we were to simply assume $p_G H_G - p_A H_A > 1$, for instance. We will refer to the state in which the payoff is zero as the "failure state."

1.2.1 Asset portfolio correlations. Because the loan portfolio investment opportunities for the bank are the same in both the first and the second periods, we will describe only the first-period investment opportunity set for the bank. We will assume that, in the cross-section of banks, the date-1 signals, Z_1, for any loan portfolio, as well as the date-2 cash flows, Z_2^G, for loan portfolio G, Z_1^i, Z_2^i are independently and identically distributed (i.i.d.). The possibility of systemic risk is introduced by assuming that Z_2^A is cross-sectionally correlated. In particular, there are two failure states for loan portfolio A: an idiosyncratic state—say, θ_i—and a systematic state—say, θ_S. The probabilities of these states are q_i and q_s, respectively, such that $q_i + q_S = 1 - p_A$. Moreover, for simplicity, we assume that

$$1 - p_A - q_S = 1 - p_G \tag{4}$$

or, in other words, $q_i = 1 - p_G$. This condition implies that the probability of the idiosyncratic state θ_i is the same as the failure probability of G. We assume that in state θ_i bank failures are uncorrelated in the cross-section of banks and that there are arbitrarily many banks, so that, by the law of large numbers, in state θ_i, the probability that *all* banks will fail is zero in the limit. In state θ_S, however, these failures are perfectly correlated.[8]

In addition to A and G, the bank can invest any amount in a zero-NPV riskless security, S, whose expected return is equal to the risk free rate (zero). This is a safe security that yields a payoff equal to the investment at either $t=1$ or $t=2$. That is, if $\overline{\Delta \mathrm{I}}$ is invested in S at $t=0$, and the security is sold or redeemed at $t=1$ or $t=2$, it pays $\overline{\Delta \mathrm{I}}$ with probability one.

1.3 Liquidation possibility

In the first period, the bank can be liquidated at $t=1$ or the bank manager can be fired at $t=1$. Similarly, if the bank survives the first period, it can be liquidated at $t=3$ or the bank manager can be fired at $t=3$. To capture opacity and asset-specificity of bank assets, we assume that both actions are costly and lead to the same outcome—a bank value, L, that is lower than the continuation value of the bank without monitoring ($p_\ell H_\ell$):

$$p_\ell H_\ell + rH > L > 0. \tag{5}$$

The idea is that the bank has made relationship loans for which the incumbent bank manager has developed relationship-specific monitoring expertise that cannot be replaced costlessly by liquidating loans or selling them to other banks with alternate bank managers (see Boot and Thakor 2000 for an analysis of relationship lending).

A comment on our liquidation/firing specification is warranted. Unlike setups in which only the bank's creditors are given the right to pull the plug on the bank,[9] we are giving both the bank's shareholders and creditors the ability to terminate the manager. This symmetric allocation of control rights avoids the criticism of a nonlevel playing field in which debt has an assumed disciplining advantage over equity. With this symmetric allocation as our starting point, we endogenously establish that the disciplining incentive of equity is inherently weaker than that of debt due to the different contract designs that go with debt and equity (see lemma 2).

1.4 The bank manager's objective and the rent-seeking problem

In each period, the bank manager seeks to maximize the wealth of the initial shareholders, net of his private monitoring cost, $M>0$. Monitoring is a binary decision: either the manager monitors or not. Thus, a decision

[8] Assumptions weaker than (4) would suffice for our purposes, but (4) effectively implies that the entire asset-substitution component of portfolio A relative to portfolio G is due to its systematic risk. Also note that having arbitrarily many banks and i.i.d. portfolio cash flows for portfolio G also guarantees that the probability that all banks will fail together if they choose portfolio G is asymptotically zero.

[9] See, for example, Calomiris and Kahn (1991).

is made at $t = 0$. It is assumed that the bank manager's monitoring effort is unobservable. We will impose parametric assumptions to ensure social efficiency of the G loan portfolio with monitoring:

$$p_G H_G + rH - M > p_\ell H_\ell + rH > I. \tag{6}$$

Since $p_G H_G > p_A H_A$, (6) implies that portfolio G with monitoring dominates any other choice from a social efficiency standpoint. Further, it is assumed that

$$p_G H_G - p_\ell H_\ell - [p_G - p_\ell][p_G]^{-1}[I - rH] < M. \tag{7}$$

This restriction means that if the bank manager raises all of the external financing I from debt and financiers assume that the manager will choose the G loan portfolio and monitor it, the manager will find it privately optimal not to monitor. This restriction merely ensures that the external financing raised at $t = 0$ is large enough to precipitate moral hazard in bank monitoring (note that the left-hand side of (7) is strictly decreasing in I). It is this moral hazard that creates a potential role for creditor disciplining of the bank. We discuss this next.

1.5 Observability, control rights, and contracts

All cash flows are observable ex post, and any investment made by the bank in the safe asset (S) can be observed by all. However, as for the bank's investment in the risky portfolio, only the bank manager privately observes whether the chosen loan portfolio is G or A, and whether it is monitored. Moreover, in the case of portfolio A, no one can observe whether the failure state was θ_i or θ_S. Thus, external financiers cannot observe which loan portfolio they financed, but financiers have the right to fire the incumbent manager or liquidate the bank.

We consider two forms of external financing contracts: debt and equity.[10] The debt contract is such that creditors cannot demand more repayment than what was promised to them contractually nor impose some other penalty on the bank if the bank is able to fully repay its debt obligation.[11] The debt contract stipulates that creditors can demand full repayment of the first-period debt at face value, D_R, at $t = 1$, force liquidation of the bank at $t = 1$, and collect the proceeds if their demand of full repayment cannot be met at that time; they can take similar action on the second-period debt at $t = 3$. Creditors could also decide not to demand

[10] Numerous papers have provided the micro-foundations of debt and equity as optimal securities. See Boot and Thakor (1993a), among others.

[11] This is a ubiquitous feature of debt contracts that we take as a given. It rules out creditors writing debt contracts that would force the bank to repay creditors more if H_A, rather than H_G, was observed at $t = 2$. This assumption merely guarantees that asset-substitution moral hazard cannot be eliminated through a "forcing contract." An alternative assumption is that $H_A - H_G$ is unobservable to creditors and is nonpledgeable, so that creditors cannot distinguish between loan portfolios A and G even ex post.

full repayment of the first-period debt at $t=1$, to roll over the debt, and to be repaid at $t=2$. They could similarly decide not to demand full repayment of the second-period debt at $t=3$ and just to be repaid at $t=4$. In contrast, equity is not promised a specific repayment, that is, shareholders are residual claimants, but they can fire the incumbent manager at $t=1$ in the first period or at $t=3$ in the second period. At this stage, our focus is on optimal private contracting; regulatory intervention will be introduced later in Sections 3 and 4.

1.6 The bank regulator as a lender of last resort

There is a lender of last resort (LOLR) that regulates banks. The LOLR perceives a sufficiently large social cost, Λ, associated with all banks failing together and their creditors making losses, but no cost associated with the failure of any individual bank.[12] Then, only when all banks fail together, will the LOLR find it ex post efficient to intervene and bail out some or all banks. We assume that, in a bailout, the LOLR avoids the cost Λ by paying off only the creditors fully; the LOLR can wipe out equity, replacing it, for example, with a government stake that is unwound in due course. Indeed, if bank owners or shareholders are bailed out too, then the distortions induced by regulatory forbearance would be even larger. Also, assume for now that all banks are bailed out if they fail together, for example, for "fairness."

Formally, the objective of the LOLR is to avoid the ex post cost Λ of an industry collapse and choose the regulatory policy at $t=0$, from among different options, that leads to an efficient first-period portfolio choice at $t=0$ so that the ex ante value of the bank is maximized. The LOLR faces the same informational constraints as the bank owners and must respect the contractual features of debt and equity claims that the bank uses (e.g., limited liability of equity, priority of debt over equity), but it has the ability to restrict the bank's capital structure, dictate (observable) investment in the safe asset S by the bank, and potentially create and enforce "super priority" claims on the bank's assets that can take the form of (state-contingent) regulatory seizure of the bank's assets before they are disbursed to other claimants.[13]

[12] If only an individual bank fails, it can be readily acquired in practice since other banks are healthy. Such reintermediation is difficult when a large part of the banking sector fails. Equally likely are externalities from a full-scale run on the financial sector when many banks fail at the same time.

[13] An analogy can be made with respect to the objective function of the Federal Deposit Insurance Corporation (FDIC) in the United States. Its explicit mandate is to provide deposit insurance, charge the insured depositories an ex ante risk-based premium for the insurance, pay off insured claims if the insured institutions fail, resolve (merge or liquidate) the failed institutions, and intervene in an early fashion ("prompt corrective action") with a variety of restrictions on activities in case the insured institution's capital falls below a threshold.

1.7 Some remarks on the key features of the model

Since one of our goals is to introduce the two types of moral hazard that pull the bank's capital structure in opposite directions, the model has unavoidable richness. There are four key features. First, there are two types of loans (an aggressively risky loan A and a more prudently risky loan G), with different payoff distributions based on whether or not the bank manager monitored the loans. Having both A and G loan types is necessitated by the need to introduce asset-substitution moral hazard, which generates a (disciplining) role for bank equity to resolve this moral hazard. Having loan monitoring (with unobserved managerial effort) affect payoff distributions introduces a shirking moral hazard on the part of the bank manager that is (potentially) resolved by bank debt.

Second, we assume that the payoffs on G across banks are i.i.d., but those on A are correlated in the cross-section. This has the appealing implication that there is no systemic risk if banks choose the socially preferred loan, G, but systemic risk can arise from the pursuit of excessive risk (A). Thus, systemic risk arises endogenously in the model based on bank loan choices.

Third, we permit bank liquidations by creditors and managerial firing by shareholders, so that, from the standpoint of the bank manager, both groups of financiers are "symmetric" in their ability to exercise control rights that can end the manager's tenure. This feature enables us to show endogenously that the threat of termination is always stronger from creditors than from shareholders, thereby micro-founding the disciplining role of debt in resolving the shirking moral hazard.

Fourth, we introduce the LOLR as a government agency that may bail out banks to avoid the social cost of an industry meltdown. This engenders distortions in the capital structure and asset portfolio choices of banks and leads to the two-tiered capital requirement with the special capital account (SCA) that we characterize. The role of the LOLR as not just a provider of emergency liquidity for banks but also as an institution that is strategically deciding whether to bail out failing banks is well established historically and discussed extensively by Acharya and Thakor (2015).

2. Analysis of the static version of the model

In this section, we first analyze the single-period version of our model, that is, dates $t=0$, 1, 2. This makes subsequent analysis of the dynamics in the two-period (five dates) version of the model more transparent. We solve the model by backward induction, starting with events at $t=1$, at which time the financiers of the bank choose whether to liquidate the bank (or fire the manager) or to allow it to continue (with the same manager). We then move to $t=0$, at which time the bank manager chooses the bank's capital structure and its loan portfolio and also makes his monitoring decision. We begin by describing the first best.

2.1 The first best

If the manager's monitoring effort is contractible, then given (6) and the assumption that $p_G H_G > p_A H_A$, the loan portfolio G with bank monitoring is the first-best choice. In the first best, the bank is never liquidated, and the bank's capital structure is irrelevant.

2.2 The second best

2.2.1 Events at $t=1$. At this stage, the main issue of interest is the decision of the shareholders and the creditors of the bank about whether to let the bank continue with the incumbent manager or to liquidate the bank/fire the manager. Suppose the bank issued D in debt and E in equity to raise I at $t=0$. Let D_R be the date-2 repayment obligation on the debt raised at $t=0$. The bank's equilibrium choice of loan portfolio and the bank manager's choice of monitoring made at $t=0$ will determine the relationship between D and D_R.

If the manager chose not to monitor, then $\tilde{Z}_1 = 0$ is observed and creditors infer that the bank manager did not monitor at $t=0$. Given the assumption that all control transfers to creditors, they assess the expected value of their claim with continuation as $p_\ell[D_R \wedge H_\ell] + r[D_R \wedge H]$, where "$\wedge$" is the "min" operator. The liquidation value of their claim is L.

If the bank manager chooses to monitor, then $\tilde{Z}_1 = x$ is observed. Now the creditors know that the bank monitored its loan portfolio at $t=0$. Assuming that the bank chose the G loan portfolio at $t=0$, the continuation value of the creditor' claims is $p_G D_R + r[D_R \wedge H]$, which assumes that $D_R < H_G$. We now have Lemma 1.

Lemma 1. (Moral hazard without market discipline)
When the bank raises external financing of I, given that (7) holds, the bank manager will abstain from monitoring the loan portfolio regardless of the bank's capital structure (mix of debt and equity in I) as long as there is no threat of dismissal of the manager or liquidation of the bank. This result is unaffected by how much additional investment $\overline{\Delta I}$ is made in S by the bank at $t=0$.

The intuition is that external financing weakens the manager's incentive to monitor as the manager now has to share the benefits of monitoring (the enhancement in the portfolio value), but the cost of monitoring, M, is borne entirely by the manager. Thus, for large enough I (and (7) guarantees this), the manager prefers to shirk, as long as he is not threatened with dismissal or liquidation.

Investment in S does not affect managerial incentives because its payoff does not depend on the monitoring decision of the manager. Now we have Lemma 2.

Lemma 2. (Endogenous disciplining actions of the bank's creditors and shareholders)
If creditors assume that the bank has chosen the G loan portfolio, then as long as the bank issues debt D at $t=0$ such that $D_R \in [\hat{D}, D^0)$, the creditors will liquidate the bank if $\tilde{Z}_1 = 0$ at t = 1, and will allow it to continue if $\tilde{Z}_1 = x$ at t = 1, where

$$\hat{D} \equiv \frac{L}{p_G + r}, \tag{8}$$

$$D^0 \equiv \frac{L}{p_\ell + r}. \tag{9}$$

Even if $\tilde{Z}_1 = 0$ is observed at $t=1$, the shareholders will not fire the incumbent manager at $t=1$ and will choose to continue with him, for any debt repayment $D_R \geq D^0$.

The creditors' decision is unaffected by how much ΔI the bank invests in S at $t=0$.

The intuition is as follows. If the bank keeps too low a level of debt ($D_R < \hat{D}$), then the creditors will unconditionally demand full repayment at $t=1$ even if $\tilde{Z}_1 = x$, recognizing that this will force liquidation of the bank at $t=1$. This is because the net liquidation value is large enough relative to the expected value of their claim under continuation, so concavity of the creditor' claims ensures that creditors prefer to liquidate and take the sure liquidation payoff at $t=1$ rather than gamble on the risky continuation payoff. At the other extreme, when the amount of debt issued at $t=0$ is so large ($D > D^0$) that the creditors have de facto ownership of the bank and behave like shareholders, unconditionally passing on the opportunity to liquidate in the hope of a risky continuation gamble paying off in the future. It is only when the bank's debt repayment is between these two extremes ($D_R \in [\hat{D}, D^0]$) that creditors force liquidation at $t=1$ only if $\tilde{Z}_1 = 0$ and not if $\tilde{Z}_1 = x$. Since the difference between the creditors' liquidation payoff and their continuation payoff is unaffected by how much the bank invests at $t=0$ in S, the creditors' liquidation decision does not depend on this investment. So we will ignore S until we examine the role of the LOLR and then the dynamic model.

By contrast, the shareholders do not fire the manager because gambling on risky continuation has a higher expected payoff for the shareholders than taking the sure liquidation payoff, given the nonconcave payoff structure of the equity contract. Thus, debt disciplines the manager to monitor, while equity does not. This difference in behavior between debt and equity, highlighted by lemmas 2 and 3, stems entirely from the difference in the nature of these contractual claims on the bank's cash flows.

2.2.2 Events at $t = 0$. The key events at $t = 0$ are the initial shareholders' choice of capital and the bank manager's loan portfolio and monitoring choices. We begin with the observation that the manager will choose the capital structure that maximizes the value of the bank at $t = 0$. Since new securities are being issued to deliver a competitive expected return of zero for financiers, the beneficiaries of a value-maximizing loan portfolio choice at $t = 0$ are the initial shareholders, represented by the bank manager.

Clearly, the value-maximizing loan portfolio is G with monitoring. Since neither the bank manager's loan portfolio choice nor his decision to monitor are observable ex ante, indirect incentives must be provided to achieve the appropriate choices when external financing creates moral hazard in the bank's provision of loan monitoring. Conditional on monitoring, the incentive compatibility constraint for the manager to prefer G over A is $p_G[H_G - D_R] + r[H - D_R] \geq p_A[H_A - D_R] + r[H - D_R]$, which can be written as

$$D_R \leq \tilde{D} \equiv \frac{[p_G H_G - p_A H_A]}{p_G - p_A}. \tag{10}$$

We shall initially assume that

$$\frac{[p_G H_G - p_A H_A]}{p_G - p_A} > \frac{L}{p_G + r} \tag{11}$$

which will ensure that $\tilde{D} > \hat{D}$ (see (8)). Now recall from lemma 2 that if the debt repayment exceeds D^0 (given by (9)), then creditors unconditionally allow the bank to continue at $t = 1$. We will require that $\tilde{D}$ (given by (10)) is less than D^0. The following condition, obtained by comparing (9) and (10), guarantees that $\tilde{D} < D^0$, and we will assume throughout that it holds:

$$\frac{L}{r + p_\ell} > \frac{[p_G H_G - p_A H_A]}{[p_G - p_A]}. \tag{12}$$

Condition (12) is easy to interpret. Recalling that D^0 is the upper bound such that for a debt repayment less than D^0, creditors are willing to liquidate the bank if $\tilde{Z}_1 = 0$. As p_ℓ becomes smaller, the expected continuation value of a bank that has not monitored its loans declines, so it becomes more attractive for creditors to liquidate the bank and collect L if $\tilde{Z}_1 = 0$; that is, liquidation conditional on $\tilde{Z}_1 = 0$ occurs for a larger range of exogenous parameter values, which means D^0 goes up. Thus, a sufficient condition for $\tilde{D} < D^0$ is for D^0 to be large enough, for which a sufficient condition is that p_ℓ is small enough. Note that (12) holds if p_ℓ is small enough. We now state a useful result for later use.[14]

Lemma 3. (Bank's capital structure with private contracting)
If the bank chooses loan portfolio G and monitors in equilibrium, then repayment, D_R, that the bank must promise creditors at $t=2$, to raise an amount D at $t=0$ is

$$D_R(D) = \frac{D}{p_G + r}. \tag{13}$$

Assuming that (11) holds, the second-best equilibrium with private contracting involves the bank issuing debt such that $D_R \in \left(\hat{D}, D^0\right)$. The manager monitors and the creditors never liquidate at $t=1$ in equilibrium.

2.3 Lender of last resort and the equilibrium

To examine the bank's capital structure decision in the presence of possibly correlated asset choices, we now analyze the impact of a lender of last resort (LOLR). As mentioned in the model description, the LOLR will bail out all banks if they fail together. This gives us the following result.

Proposition 1. (Equilibrium with LOLR when (11) holds)
Suppose that (11) holds. Then

a. If the LOLR is perceived by banks as adopting a policy of bailing out all banks if they fail together, then two Nash equilibria arise. One is a socially efficient Nash equilibrium in which all banks raise debt $D_R^* \in \left[\hat{D}, \tilde{D}\right]$, also choose loan portfolio G, and provide monitoring. The other is a socially inefficient Nash equilibrium in which all banks choose the maximum face value of debt consistent with loan monitoring, D^0 (see (9)), raise debt of $D_{max} = p_G D^O$ at$t = 0$, and choose loan portfolio A. The excess of D_{max} over I is paid to the bank's initial shareholders as a dividend at $t=0$.

[14] It is easy to verify that this lemma too is unaffected by how much $\overline{\Delta \mathrm{I}} \geq 0$ the bank invests in S.

b. The LOLR can eliminate the bad Nash equilibrium in (a) above and ensure that the bank chooses G and provides monitoring by either credibly precommiting not to bail out any bank or by imposing a capital requirement that restricts the bank to issue debt D with corresponding face value, $D_R(D)$, given by (13), satisfying $D_R(D) \in [\hat{D}, \tilde{D}]$. If $I > D$, then $I - D$ is covered with equity $E = I - D$.

The economic intuition is as follows. We know that when (11) holds, $\tilde{D} > \hat{D}$, so that $D_R^* \in [\hat{D}, \tilde{D}]$ is the private equilibrium of leverage choices. The anticipation of regulatory bailouts when all banks fail together (but not otherwise) generates two Nash equilibria. In one Nash equilibrium, all banks continue to raise debt, D, such that $D_R^* \in [\hat{D}, \tilde{D}]$ and choose i.i.d. portfolios. This is a Nash equilibrium because, conditional on all other banks choosing such a D, an individual bank knows that if it deviates and fails, it will not be bailed out since all the other banks will not fail at the same time.

Since $D_R^* > \hat{D}$, the bank's creditors find it subgame-perfect to avoid unconditionally liquidating the bank at $t = 1$, and the fact that it is lower than D^0 (since $D_R^* < \tilde{D} < D^0$) ensures that the creditors will indeed find it subgame-perfect to liquidate the bank when the signal $t = 1$ is zero. This is predicated on the assumption that the bank manager will choose the G loan portfolio. Since $D_R^* \leq \tilde{D}$, we guarantee that the manager prefers the G portfolio to the A portfolio. Further, since $\hat{D} \leq D_R^* < D^0$, we also guarantee that the manager prefers to monitor the loan portfolio, given a credible liquidation threat by the creditors. Thus, the beliefs of financiers about the manager's loan portfolio and monitoring decisions are validated in equilibrium. This situation is depicted in Figure 2.

But there is also another Nash equilibrium in which all banks asset-substitute in favor of the aggressive portfolio A (even though condition (11) can be met by a level of debt that would not trigger asset substitution) and raise the maximum possible leverage consistent with the creditors having the liquidation incentives to induce the manager to monitor loans. That is, $D_R^* = D^0$. We call this the "looting" equilibrium, as in Akerlof and Romer (1994).

In essence, the LOLR's intervention in state θ_S "socializes" the bank's incremental risk in choosing portfolio A relative to portfolio G. This induces all banks to choose A and also employ excessive leverage. Although creditors still provide some market discipline by ensuring that the bank monitors loans, the locus of the agency problem is now a conflict of interest between bank owners and taxpayers. That is, the taxpayers now become an "economic creditor" of the banking sector, and

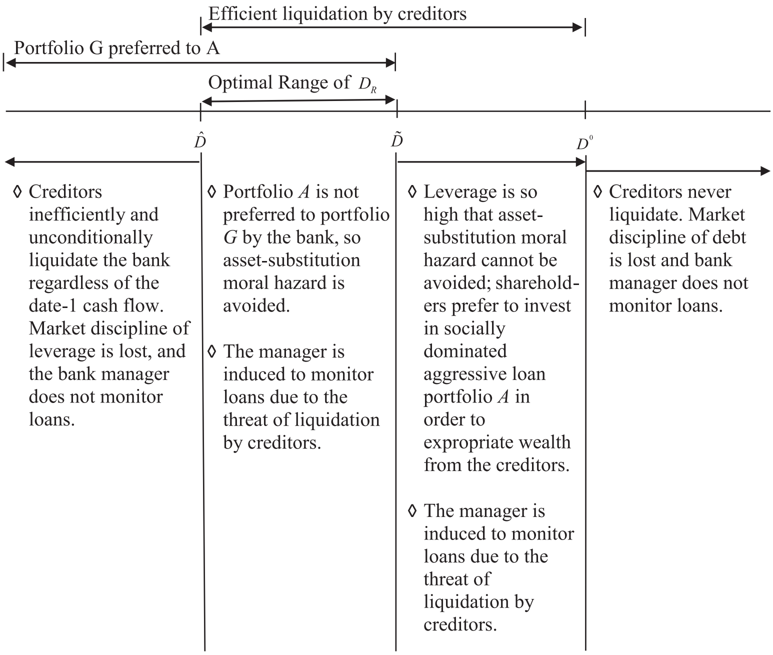

Figure 2
Optimal amount of debt raised by the bank at t = 0 when (11) holds

maximizing bank equity value can lead to highly levered capital structures and correlated risky asset choices by bank owners.[15] These actions "loot" the LOLR (effectively the taxpayers) by passing on all possible risks to the LOLR and paying out dividends from the proceeds of the extra debt issued at $t=0$. The reason why the bank's initial shareholders want the surplus funds raised in excess of I to be paid out as a dividend is that these funds would otherwise stay invested in S in the bank and limit creditor shortfalls when the bank fails, reducing the size of the ex post bailout, and in turn, reducing the ex ante transfer to the shareholders. The bank's creditors have no incentive to force the bank to invest surplus funds in S since they price the debt to break even. So the bank will act this way if permitted by the LOLR.

Bank debt now only curbs managerial shirking in monitoring, but its pricing fails to reflect the bank's risk-shifting problem. In effect, bank

[15] Acharya et al. (2009) show that while distressed depositories (such as Wachovia and Washington Mutual) subject to prompt corrective action by the FDIC cut their dividends a few quarters prior to their failure, similarly distressed investment banks (Lehman Brothers and Merrill Lynch) in fact raised their dividends in quarters prior to failure even as their leverage was rising. The latter evidence is consistent with anticipation of regulatory forbearance, especially following the rescue of Bear Stearns, providing an incentive to the investment banks to *not* cut back on leverage and dividends even as their insolvency became imminent.

leverage is the conduit through which regulatory forbearance is transferred in value terms to the bank's shareholders through excessively risky portfolios. Although motivated by equity maximization, this is possible only if risky portfolios are funded through debt. Since shareholders are not bailed out ex post, looting incentives do not exist absent leverage.

It is straightforward, however, for the LOLR to eliminate the bad Nash equilibrium. All that is needed to eliminate looting is a simple capital requirement that limits the bank's debt so that its promised date-2 repayment, D_R, is not more than $\tilde{D}$. Given that leverage, it becomes privately optimal for the bank to select portfolio G since the incentive compatibility constraint for the choice of G holds.

Proposition 2. (Equilibrium with LOLR when (11) does not hold)
Suppose (11) does not hold. Then

a. absent regulatory intervention, private contracting will have either the inefficiency of no monitoring by the bank or the inefficiency of the bank choosing loan portfolio A.
b. if there is regulatory intervention and the LOLR is perceived to have a policy of bailing out banks if they all fail together, then the LOLR can restore the efficiency of the bank choosing portfolio G and providing monitoring by allowing the bank to raise D in debt such that its date-2 repayment obligation (given by (13)) is $D_R(D) = \hat{D}$, where $\hat{D}$ is given by (8). The bank is then also required to raise equity of $\hat{D} - \tilde{D}$ that is in excess of what it needs to satisfy its investment need, that is, it must raise equity of $E_T = E + E_s$, where $E = I - D$ and $E_s \equiv \hat{D} - \tilde{D}$. The bank is then required to invest the "special capital" E_s in the safe security S, whose payoff, $\hat{D} - \tilde{D}$, accrues to the bank's shareholders if the bank does not fail. If the bank fails and it is not bailed out by the LOLR (i.e., idiosyncratic failure), then the special capital account is not available to the bank's creditors, but instead accrues to the LOLR.

When (11) does not hold, we have $\tilde{D} < \hat{D}$ (see Figure 3). In the absence of regulatory intervention, the original shareholders are now between a rock and a hard place: if D_R^* is chosen to be less than $\tilde{D}$ to avoid asset-substitution moral hazard, then the creditors will unconditionally liquidate the bank at $t = 1$, and if D_R^* is set above $\hat{D}$ to avoid unconditional liquidation, then the manager will risk-shift and prefer portfolio A over G.[16]

It might appear that a resolution to this problem is to issue long-maturity debt with a date-2 face value of $D_R^* \leq \tilde{D}$ and give creditors

[16] This shows that when (11) does not hold, the SCA has a role to play even if there are no regulatory bailouts that are creating incentive distortions that the LOLR is attempting to overcome through the design of capital requirements. Our focus, however, is on how capital requirements can be designed when the LOLR follows a specific ex post bailout policy.

$D < \tilde{D}$	$\tilde{D} < D < \hat{D}$	$\hat{D} < D < D^0$	$D > D^0$
◊ Leverage is so low that creditors unconditionally and inefficiently liquidate the bank. Market discipline of leverage is lost and bank manager does not monitor loans. ◊ Leverage is low enough to ensure that portfolio G is preferred to portfolio A by the bank manager, so asset-substitution moral hazard is avoided.	◊ Creditors unconditionally and inefficiently liquidate the bank. So market discipline of leverage is lost and bank manager does not monitor loans. ◊ Leverage is so high that asset-substitution moral hazard cannot be avoided; the bank manager prefers to invest in socially dominated portfolio A in order to expropriate wealth from the creditors.	◊ Leverage is high enough to ensure that creditors liquidate the bank conditionally and efficiently so the manager is induced to monitor due to creditor discipline. ◊ Leverage is so high that asset substitution moral hazard cannot be avoided; shareholders prefer to invest in portfolio A over portfolio G.	◊ Creditors never liquidate. Market discipline of debt is lost and bank manager does not monitor loans.

Figure 3
Optimal amount of bank debt at t = 0 when (11) does not hold
There does not exist an optimal D that simultaneously ensures that creditors monitor ($D_R(D) > \hat{D}$) and the bank prefers the G loan portfolio ($D_R(D) < \tilde{D}$).

control rights to demand early repayment at $t = 1$ only when $\tilde{Z}_1 = 0$ is observed. This would take the power to unconditionally demand repayment and liquidate the bank at $t = 1$ out of the hands of the creditors. However, this solution does not work here because $\tilde{Z}_1$ is not a verifiable signal for contracting purposes, so debt contracts cannot be written conditional on $\tilde{Z}_1$.[17] If there is regulatory intervention with a (perceived) bailout precommitment, a regulatory capital requirement such that $D_R(D) \leq \tilde{D}$ continues to dissuade banks from investing in loan portfolio A and hence eliminates the social cost Λ. In this sense, it is a feasible regulatory policy. However, with this policy, creditors follow an inefficient unconditional liquidation policy, so the market discipline of debt is lost altogether as the manager prefers not to monitor the loan portfolio in this case. The trick is to uncover a feasible capital requirement that eliminates the social cost Λ, ensures selection of the loan portfolio G, and ensures that the manager monitors.

This is achieved with the regulatory policy laid out in proposition 2. Under this policy, the LOLR demands that, in addition to the equity

[17] But even if $\tilde{Z}_1$ were verifiable and contractible, it can be shown (details available upon request) that giving creditors only $\tilde{Z}_1$ conditional control rights may not work. The basic idea is that as long as creditors have access to some noncontractible, payoff-relevant private information in addition to $\tilde{Z}_1$, giving creditors unconditional control rights to demand full repayment at $t = 1$ may be desirable because it would enable them to use this private information to discipline the bank.

input E, which permits the bank to meet its investment need I when combined with new borrowing D, the bank must also raise an extra E_s in equity. This E_s is kept in a "special capital account" (SCA) and is invested in the safe assets, which could be a Treasury security. A key feature of this account is that, while it is available to enhance the bank's shareholders' payoff in the solvency state, it is not available to the bank's creditors in the event of idiosyncratic insolvency.[18] Assuming that the contractual constraint that shareholders cannot be paid anything if creditors are not paid in full is binding, the only resolution is for the capital account to go to the LOLR in the event of insolvency. The LOLR can, in turn, use the proceeds from the account to fund its administrative costs and potentially even transfer them to surviving banks and firms in the economy (e.g., by lowering taxes).

Another aspect of proposition 2 is that the SCA can be arbitrarily large (up to the point that bank shareholders' and manager's reservation utility is met).[19] The bank must raise at least as much special capital as $\hat{D} - \tilde{D}$, but if it raises more, none of the relevant incentives are affected in the sense that the bank's preference for the G portfolio is unchanged. This reduces the LOLR's calibration burden.

What does it mean for creditors not to have access to the SCA in the event of bankruptcy when we admit the possibility of a bailout by the LOLR? If all banks fail together (by choosing and experiencing the correlated-default state), then the LOLR bails them all out and creditors take no haircut, making the treatment of the SCA a moot point in this state. However, if a particular bank experiences idiosyncratic failure when some others succeed, its SCA accrues to the LOLR rather than its creditors. This means that creditors take some haircut even if there is capital in the SCA. Since credit remains risky, monitoring incentives are preserved.

Thus, it is the combination of what happens in the portfolio-success state (the SCA is an additional equity input that accrues to the bank's shareholders) and the nonsystemic failure state (the SCA accrues to the LOLR rather than the creditors) that allows asset-substitution moral hazard to be deterred without diluting creditors' monitoring incentives.

Formally, this works as follows. When (11) is violated, $\hat{D} > \tilde{D}$. So the repayment $D_R = \hat{D}$ must be chosen to ensure that creditors will only

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[18] The special capital account is in the spirit of cash-asset reserve requirements. However, it goes well beyond reserve requirements, given the restriction on its distribution to creditors. Another key difference is that a reserve requirement simply locks up a fraction of deposits in the form of cash or deposits at the Federal Reserve. By contrast, the special capital account is computed as a fraction of assets and can be "leveraged" by the bank to add assets, just like regular tier-1 capital. That is, with a 4% special capital requirement, every dollar of capital in this account allows the bank to put another \$25 of assets on its books.

[19] Of course, it is constrained by future cash flows available for backing the issued equity and transaction costs involved in the issuance, which for simplicity we have assumed to be zero.

threaten conditional liquidation to induce the bank manager to monitor loans. Because this violates the IC constraint for the bank to prefer portfolio G to A, we need to restore the incentives of shareholders to eschew the higher risk in A. Providing additional equity—via the SCA—helps to do this since this amount is invested in the safe asset, S. This increases the bank shareholders' payoff in the solvency state and thus reduces asset-substitution moral hazard. But it does not affect creditors' incentives since it is unavailable to bank creditors in the event of failure; note that creditors do not care about this account in the solvency state or in case of correlated failures since they are paid in full with or without this account. This makes the SCA "invisible" to the creditors and leaves the market discipline unaffected.

One may argue that the SCA gives the LOLR contracting possibilities that were otherwise unavailable to the bank and its financiers. In particular, this account represents a kind of security that differs from debt and equity. This security achieves efficiency by breaking the "budget-balancing constraint," which requires that the sum of the claims of shareholders and bondholders must be equal to the total claims on the bank.[20] The reason why such a security was not permitted in the absence of the regulator is that we limited the set of securities available for contracting to debt and equity. We do not know of any existing securities that correspond exactly to the SCA.[21] But if such a security were to be designed, then the inefficiency associated with the second best (when (11) does not hold) may be eliminated, and the regulator may be able to rely on this security instead of the SCA.

As a possible example of such a security, one might think that state-contingent (indexed) debt, where payoff for an individual bank's creditors depends on whether or not the bank's failure was accompanied by the failures of all other banks—could replicate the special capital account outcome even with private contracting. This is not the case, however, since the failure of the bank leaves it with nothing, other than the safe asset, with which to pay the creditors. This safe asset can accrue to either the creditors or the shareholders, the only two groups of claimants. If absolute priority is respected, the creditors receive it, in which case their monitoring incentives are diluted. If the debt contract allows for an override of absolute priority in some states, the additional capital provided by

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20 This is reminiscent of the resolution provided by relaxing the budget-balancing constraint in the model of moral hazard in teams in Holmstrom (1982).

21 The SCA also differs from a deposit insurance premium. First, creditors are not guaranteed in all instances of bank failures, but only in case of systemic failures. Thus, the regulator imposes a "haircut" on creditors in case of such failures, whereas with deposit insurance, insured creditors are paid off regardless of whether bank failures are idiosyncratic or systemic. And second, contributions to the SCA belong to bank shareholders in success states, and are therefore not like once-and-for-all payments to the deposit insurance fund. That is, the capital-account contributions are more like a "deductible" than a "premium."

the shareholders loses its incentive effect and asset-substitution moral hazard is triggered. Thus, private contracting fails because it lacks a way to break the “budget-balancing” constraint.

There may be contracts based on derivatives that could replicate the payoff on the SCA, albeit with some design modifications. For example, under existing regulations, derivative contracts are privileged in bankruptcy and are effectively senior to all other claims if they are collateralized. Thus, a collateralized CDS contract that pays the regulator in the event of the bank’s bankruptcy would be in the spirit of the SCA. But it would need to be adjusted for the dynamic transfers from the SCA—via sales of the underlying collateral—to the regular capital account that are part of our design, and the contract would need to be dissolved and ownership of the collateral transferred to the buyer if the bank is acquired by another entity.

Note also that we have assumed that when banks fail en masse, the LOLR bails out all the banks. If only a subset of banks—say the largest or systematically most important—were to be bailed out, then the looting problem would be confined to that subset, as would be the application of the capital-requirement regimes in propositions 1 and 2.

3. The Dynamic Case

While the single-period analysis in the previous section brings out the intuition about how capital requirements should be set, it has one major limitation, which is that it is hard to see the dynamics of adjustments in the regular capital account and the SCA from that analysis. That is, if the bank suffers a negative earnings shock that depletes its regular capital account, how does the transfer from the SCA occur without violating the constraint on the minimum amount needed in that account to satisfy incentive compatibility? That is, in the dynamic case, the setting of the SCA must anticipate the state-contingent transfers in future states of the world in which the bank’s regular capital account is depleted but the bank is allowed to continue. The two-period analysis in this section shows how the SCA is determined with this consideration.

3.1 The two-period model

From an implementation perspective, we seek a dynamic regime of capital requirements, in which the bank is asked to raise the prescribed amount of capital for its regular capital account, as well as its SCA at the outset ($t=0$), and all subsequent additions to capital come from dividend restrictions that help to augment retained earnings. The idea is that to the extent that there are adverse selection costs associated with raising equity (e.g., Myers and Majluf 1984), these can be avoided by having the bank build equity through retained earnings, whenever it needs additional capital.[22] Of course, in our model we have assumed no such costs associated with equity; that is, although they have different incentive effects, equity is no more costly than debt. Nonetheless, within the set of capital requirements schemes that are incentive compatible and also maximize the value of the bank, we seek a scheme that does not require the bank to issue equity except possibly at the outset (if current shareholders lack their own funds).

Since our focus is on the dynamics related to the SCA, we will assume that (11) does not hold. The analysis of the second period is exactly the same in this case as in the static case, so proposition 2 applies as far as the second-period capital requirements are concerned. Moreover, at $t=4$, the LOLR will have the same optimal intervention policy that is described in proposition 2, namely, banks are bailed out only if they all fail together, so the equilibrium probability of a bailout in the second period is zero. The following result characterizes the regulatory bailout policy over two periods.

Proposition 3. (Optimal regulatory bailout policy, and first-period capital structure and SCA)

Suppose (11) does not hold. Then among the class of regulatory schemes that do not require any equity input, except at $t=0$, the scheme that maximizes the ex ante value of the bank over two periods has the following features:

a. The LOLR bails out banks at $t=2$ only if they all fail together in the first period, and at $t=4$ only if they all fail together in the second period.
b. In the first period, at $t=0$ the bank is allowed to raise D in debt such that its date-2 repayment obligation (given by (13)) is $D_R(D)=\hat{D}$, where $\hat{D}$ is given by (8). The bank is required to raise equity of $E^*_{\mathcal{I}}=E+E^*_S$, where $E=I-D$ as in proposition 2 and $E^*_S=\hat{D}-\tilde{D}+\Delta$, where

$$\Delta \equiv I-\hat{D}[1-p_G-r][p_G+r]^{-1}-H. \tag{14}$$

The bank is then required to invest the special capital E^*_S in the safe security S, with a payoff at t = 2 of $\hat{D}-\tilde{D}+\Delta$.

[22] If equity has special costs relative to debt—either due to adverse selection or taxes—then there is the question of the cost of asking the bank to put up more equity capital at the outset to fill up its regular capital account and the SCA. However, the design of the dynamic scheme is intended to make this a one-time cost, with reliance on retained earnings for subsequent adjustments. Adverse selection costs for banks tend to be minimal when they are raising capital in response to regulatory capital requirements (e.g., see Cornett and Tehranian 1994), but in any case, if the bank faces daunting costs in raising equity even initially, then it could rely on an initial equity infusion by the government (in exchange for ownership) that is paid off by the bank over time as retained earnings are accumulated. Alternatively, if the bank is a subsidiary of a bank holding company (BHC), then the BHC can use debt financing (thus avoiding the adverse selection cost of equity) and then "downstream" the funds by using them as an equity input into the subsidiary.

The LOLR's bailout policy is similar to that in the static case. Not bailing out banks when they experience idiosyncratic failures continues to be optimal since it is needed for creditor discipline and efficient loan portfolio choice by the bank. We now describe what happens at $t = 2$ and the bank's second-period capital structure.

Proposition 4. (Bank closure, dividend payouts and second-period capital structure: Events at $t = 2$)
Under the policy described in Proposition 3,

a. at $t = 2$, if the realized payoff on the bank's first-period loan portfolio is H_G, then the bank repays its first-period creditors D_R, and is allowed to pay a dividend of $H_G - D_R - E + \Delta$ to its shareholders. In the second period, the bank raises D in debt such that its second-period debt obligation (given by (13)) is $D_R(D) = \hat{D}$, and its equity (through retained earnings) is $E_T = E + E_S$ where $E = I - D$ as in proposition 2 and $E_S = \hat{D} - \tilde{D}$ is invested in the safe security, S.
b. if at t = 2 the realized payoff on the bank's first-period loan portfolio is H, then the bank repays its first-period creditors D_R and is not allowed to pay a dividend. The amount Δ from the proceeds of its first-period investment in S is transferred to the bank's equity so that $E = H - D_R + \Delta$, whereas the rest of the proceeds $\hat{D} - \tilde{D}$ are reinvested in S for the second period, so $E_S = \hat{D} - \tilde{D}$ and $E_T = E + E_S$. The bank raises D in debt such that its second-period debt obligation (given by (13)) is $D_R(D) = \hat{D}$.
c. if at $t = 2$ the realized payoff on the bank's first-period loan portfolio is zero and all banks did not realize a payoff of zero, then the bank is shut down at $t = 2$ and not allowed to operate in the second period. The proceeds from the first-period investment in S accrue to the LOLR.

Finally, the characterization of the dynamic case is completed by analyzing the events at $t = 4$, the end of the second period.

Proposition 5. (Distribution of payoffs at $t = 4$)
Given the policies described in propositions 3 and 4, if the bank operates in the second period and realizes a payoff of H_G at $t = 4$, it repays its second-period creditors D_R, and pays its shareholders a terminal dividend of $H_G - D_R + E_S$. If it realizes a payoff of H at $t = 4$, it repays its second-period creditors D_R and pays its shareholders a terminal dividend of $H - D_R + E_S$. If it realizes a payoff of zero on its second-period loan portfolio at $t = 4$ and not all banks fail, then the bank's creditors and shareholders receive nothing and the LOLR takes the proceeds E_S from the investment in S. If all banks fail together at $t = 4$,

then the LOLR collects the proceeds E_S from the investment in S, pays D_R to the bank's creditors and the shareholders get nothing.

The dynamic policy described in Propositions 3 and 4 stipulates different capital requirements in the first and second periods. The second-period capital requirements are the same as in the previous static analysis. However, in the first period the bank has to keep an additional amount Δ in its SCA, compared to the SCA in the second period. We can view this as a "dynamic capital surcharge." Its role is to ensure that the bank's SCA never dips below the level needed to guarantee incentive compatibility in the state in which the bank is allowed to continue but its normal capital account takes a hit (because the value of that capital account falls below E after paying off debt when the loan portfolio pays off H) and a transfer has to be made from the SCA to the normal capital account to bring it to the level needed for incentive compatibility.

Note that in our model, bank failure is defined as the realization of a zero payoff on the loan portfolio. It is the state in which the bank's regular capital account is the most impaired. It is the realization of this state (not the H state) that is the most informative about the choice of the aggressive portfolio A rather than the good portfolio G.[23] In practice, this implies that the regulator will wish to set some critical value of the regular capital account, so that as long as the bank's regular equity capital stays above that value, the bank is considered solvent and a transfer is made from the SCA to the regular capital account. However, if the regular equity capital account falls below the critical value—say, like the 2% capital threshold stipulated by the FDICIA of 1991—then the bank is declared insolvent and the ownership of the SCA transfers to the LOLR.

Corollary 1
Once the SCA is set high enough to satisfy the necessary incentive compatibility constraints, an increase in the SCA leads to a lower ex ante NPV to the initial shareholders of the bank.

The intuition is that the SCA represents an investment by the bank's shareholders that does not affect the value of the bank's debt, but it may have to be surrendered to the LOLR if the bank's earnings experience a sufficiently negative shock. This reduces the NPV of the bank's shareholders.

[23] Given that the incentive compatibility constraints are satisfied in equilibrium, the choice of portfolio A occurs only in an off-the-equilibrium-path sense (zero probability). In equilibrium the bank chooses G and the LOLR knows it. However, precommiting to allowing the bank to fail is important for incentive compatibility. Thus, even though our analysis does not consider the "customer-protection" benefits of safety nets like deposit insurance proposed by Merton and Thakor (2015), the fact that the bank does not choose A along the path of play means that the bank's customers are not exposed to unnecessary risk in equilibrium.

3.2 Model extension with adverse selection costs

Proposition 3 characterizes the dynamic capital surcharge, Δ, that must be set in the two-period case. An obvious question is why ask the bank to raise this additional capital at $t=0$, rather than letting it raise this capital, if needed, at $t=2$? One commonly given reason for not insisting on high capital requirements in banking is that there are adverse-selection costs associated with equity that make compliance with high capital requirements costly for banks.[24] There are no such adverse selection costs in our model, but we now develop an extension of the model with adverse selection costs; this extension helps us to see why it may be necessary for the bank to raise Δ at $t=0$ and avoid any equity issuance after that. The basic idea behind this extension is that there may be a future state in which the adverse selection problem is so severe that funding cannot be raised through an equity issue, causing a shortfall in the capital account and precipitating moral hazard. However, the probability of this future state may be low enough to permit capital to be raised ex ante before the state is realized. Thus, raising equity upfront to fund the dynamic capital surcharge Δ may be a good idea.

We will continue to assume that the bank's owner-manager is wealth constrained and must externally raise financing, as in the base model. We introduce the adverse-selection problem as follows. Suppose that we treat the state in which the first-period (G) project pays off H_G at $t=2$ as a "favorable" macroeconomic state and the states in which the first-period project pays off either H or 0 as "unfavorable" macroeconomic states. Thus, the project payoff has systematic risk.[25] In the unfavorable state, at $t=2$ the probability is $\beta \in (0, 1)$ that the bank is locked into a loan B that has a cash flow of L with probability 1. Although it is common knowledge whether the realized macroeconomic state is favorable or unfavorable, only the bank knows at $t=2$ whether it is locked into loan B or it has a choice between A and G in the unfavorable state; others only know that, given the occurrence of the unfavorable state, the probability that the bank has loan B is β. Assume that the bank's owner-manager has a private benefit $b>0$ associated with making a loan.

Now suppose the bank did not raise enough capital at $t=0$ to accommodate the dynamic capital surcharge, Δ, and H is realized at $t=2$, that is, the unfavorable state is realized and commonly observed. A bank that is locked into loan B and raises D such that the repayment obligation is $D_R(\hat{D}) = D$ is raising L in debt since $\hat{D} = L[p_G + r]^{-1}$. In other words, $D = L$. Thus, if the market was aware that the bank was locked into loan B, the bank would be unable to raise anything beyond D from either debt

[24] Imagine a setting like the one in Myers and Majluf (1984).

[25] It also has idiosyncratic risk since the payoff in the unfavorable macroeconomic state can be either H or 0.

or equity. This means that the additional amount Δ cannot be raised to refurbish the bank's equity.

With uncertainty about the bank's "type" at $t=2$ stemming from the market's lack of knowledge of whether the bank is locked into loan B, it is easy to see that continuity implies that the bank will be unable to raise Δ at $t=2$ if β is high enough. That is, adverse selection causes financing to be unavailable at $t=2$ in the unfavorable state of the world. Now, if p_G is high enough (implying that the ex ante probability of the unfavorable state, $1-p_G-r$, is low enough), then the bank will be able to raise Δ at $t=0$. To see this, note that if $p_G=1$, then clearly Δ can be raised at $t=0$, so by continuity, Δ can be raised at t$=0$ for $p_G=1-\varepsilon$, where $\varepsilon>0$ is arbitrarily small.

We see then that if p_G and β are sufficiently high, then the bank will be able to raise Δ ex ante at $t=0$, but not ex post at $t=2$ in the state in which it is really needed, that is, when the realized first-period loan payoff is H. This is one way to rationalize having the bank raise the dynamic capital surcharge for the special capital account at $t=0$.

4. Regulatory Implications

Our analysis has several important implications for regulatory capital requirements. Below, we discuss the implementation of the two-tiered capital requirements in propositions 2 and 3 (when (11) does not hold).

Proposition 4 indicates how intertemporal adjustments would be made in the "regular" (tier-1) capital account and in the SCA after the regulator has set two distinct capital requirements. The SCA can be invested in only predetermined securities, such as Treasuries. When a negative shock hits (either bank-specific or systemic) and the bank's tier-1 capital diminishes, the bank would be allowed to sell these Treasury securities and transfer cash from the SCA to the regular capital account; indeed, this would be a requirement if banks do not replenish tier-1 capital through other means, such as equity issuances. However, the dividends would be frozen until the special capital is rebuilt to its required ratio.[26]

Proposition 3 indicates the dynamic capital surcharge, Δ, that must be set in the two-period case. If there were multiple periods $T>2$, then imposing the restriction that the bank should not be required to issue equity after $t=0$ will cause Δ to increase with T. With a large value of T, Δ may become "unacceptably" high (see corollary 1). In practice, therefore, the regulator may set Δ only high enough to ensure that it covers the

[26] Banks will not choose to impose such dividend restrictions on their own because the associated benefit of avoiding the systemic externality of en masse bank failures is *not* a private benefit to any bank. Moreover, how banks adjust their ratios also depends on their asset portfolio activities (see Memmel and Raupach 2010).

capital requirements for incentive compatibility in the face of some sequence of consecutive H realizations, $\{H^t; t = 2, 4, -, n\}$, where H^t is the realization at date t (with $t \geq 2$ being even) and n is some even number less than T. After the H consecutive realizations at some $t < n$, an equity infusion beyond retained earnings would be required, and the bank would be required to do this in the favorable macroeconomic state in which the bank has realized H_G (since by our previous discussion, doing this in the unfavorable macroeconomic state may be infeasible). Thus, in practice, if a bank survives sufficiently many negative earnings shocks in succession, it may need to issue equity to refurbish its SCA. Doing this will limit the size of Δ.

Note that this two-tiered capital requirements approach can deal not only with the challenge of replenishing capital but also with potential liquidity shortages, since selling Treasuries provides liquidity. This proposal to preserve capital—or in other words, to prevent capital erosion—has numerous advantages.

First, the two-tiered capital proposal deals simultaneously with the various forms of moral hazard most commonly studied in banking—shirking in loan monitoring, managerial perquisites consumption, and shareholders' risk shifting—in an integrated way it incorporates both the market discipline of debt and the risk-attenuation benefit of equity. For instance, the proposal gets around the criticism that having a large capital cushion may make bank managers lazy or reduce market discipline. This is because the SCA is additional capital that would have been otherwise paid out as dividends, so it does not replace the debt that provides discipline. Moreover, the bank cannot invest the retentions as it pleases; the investments have to be in Treasury securities.

Second, the fact that the shareholders/managers will lose the special capital in bad states ensures that the positive aspect of high capital is maintained. This precludes the gradual precrisis erosion of bank capital during the good times (through dividend and cash distributions to shareholders and bank managers) that can convert an adverse asset-side shock into a crisis. More importantly, our scheme eliminates bank behavior that makes adverse asset shocks endogenously more likely owing to correlated choices of poor investments with other banks.

Third, the proposal has the advantage of not requiring shareholders to infuse additional cash capital at a time when confidence in bank management is at its nadir and liquidity is very low. Dividends can be retained for a time during which the bank is not in imminent danger of failure. Specifically, no adverse information is communicated by dividend restrictions kicking in when capital has to be moved from the SCA into the regular capital account because a negative shock to earnings has depleted the regular capital account. This is because the "automatic" nature of the transfer involves no management/regulatory discretion and hence communicates no information beyond that already contained in the negative earnings shock.

Fourth, since capital is transferred from the SCA into the regular capital account on a mechanical basis, the issue of designing "crisis triggers" does not arise.

Fifth, if this scheme is limited to only the systemically important banks, then the SCA could be viewed as a "special surcharge" on those banks.[27]

Finally, the scheme is relatively easy to harmonize internationally, or at least as easily as the current tier-1 capital requirements.

Our proposal has elements in common with the "capital conservation" idea proposed by the Bank for International Settlements (BIS). Our proposal is also somewhat similar to a new model for capital regulation proposed by former U.S. Treasury Secretary Timothy Geithner:[28] "Under the framework now being built, firms will be subject to two tiers of capital requirements. All firms will need to hold a substantial minimum level of capital. And they will be required to hold an added buffer of capital set above the minimum. If a firm suffers losses that force it to eat into that buffer, it will have to raise capital, reduce dividends, or suspend share repurchases." A key difference between this proposal and ours is that our scheme has contingent distribution rights in addition to a two-tiered capital requirement.

5. Related Literature

Our paper builds a model of bank capital structure in which both effort-shirking in loan monitoring and asset substitution have portfolio risk ramifications.[29] Dewatripont and Tirole (1994) consider optimal regulation of bank capital structure in a model in which too much debt can lead to excessive creditor intervention, whereas too much equity can lead to managerial shirking. Our model shares some of their seminal insights, but

[27] Acharya et al. (2012) discuss how to calibrate special capital accounts in a variety of ways using market data and regulatory stress tests in a manner that is robust to model errors. See also Acharya (2009).

[28] The calibration issue of what the percentages should be in the two types of capital requirements proposed by Secretary Geithner is outside the scope of our model. By all accounts, however, current Basel risk weights might need to be revisited to take into account systematic or correlated risk of assets rather than their total or absolute risk. See Acharya (2009) and Acharya et al. (2012), and Acharya et al. (2013), among others, who have proposed measurement of such correlated risks and tying capital requirements to such "systemic risk weights."

[29] For other papers that combine the rent-seeking and risk-shifting moral hazard problems, see Jensen and Meckling (1976), Biais and Casamatta (1999), Edmans and Liu (2011), Guembel and White (2007), Hellwig (2009), and Stulz (1990). In particular, Biais and Casamatta (1999) also argue that effort investment requires more leverage, whereas risk-shifting containment requires less leverage. Besanko and Thakor (1987) show how collateral can reduce adverse-selection costs, but it can also be viewed as reducing risk shifting. These papers do not, however, consider the correlated risk-taking across banks and the related regulatory distortions that we analyze in this paper.

focuses on leverage distortions and correlated risk taking[30] induced by government guarantees, the LOLR, and the role of state-contingent bailouts.[31]

We also briefly discuss the relationship of our work to the many capital regulation proposals currently on the table. Perhaps the most direct approach to dealing with bank capital shortages is to require banks to keep more equity capital (e.g., Bhattacharya and Thakor 1993; Bhattacharya, Boot, and Thakor 1998; Admati et al. 2010; Thakor 2014). This is a familiar argument in bank capital regulation, and a formal justification for it can be traced to Merton (1977), who showed that banks can enhance the value of the deposit insurance put option by keeping lower capital. This proposal is similar to our case 1 in which (11) holds and a simple minimum capital requirement suffices. However, our analysis shows that this proposal does not work when (11) does not hold, and our proposed two-tiered capital requirement structure is needed to restore efficiency. The dynamic version of our model shows how the special capital requirement can be set to avoid having the bank issue equity after the initial date in order to satisfy its capital requirements.

A slew of more complex proposals have also been put forth. These include Flannery's (2005) contingent capital certificates (CCC),[32] forced equity issuances by bank during periods of deteriorating performance (e.g., Hart and Zingales 2009; Duffie 2010), expanding the limited liability of equity (Admati and Pfliederer 2009; "capital insurance"; Kashyap, Rajan, and Stein 2008),[33] and taxing the systemic risk of financial institutions (Acharya et al. 2013); see Thakor (2014) for an extensive discussion of these proposals and their link to financial stability. Our proposal differs from these in that it does not rely on the creation of new securities to be sold in the market, new forms of insurance, or the issuance of

[30] Other papers on correlated failures include Acharya and Yorulmazer (2007, 2008) and Phillipon and Schnabl (2013).

[31] Acharya and Thakor (2015) highlight that, while bank liquidity is enhanced by short-term debt, such debt can endanger financial stability by increasing the likelihood of contagious asset liquidations by creditors. While they model the micro-foundations of contagious creditor liquidations, we focus instead on the design of capital regulation that can ameliorate the distortions induced by correlated risk-taking and bailouts.

[32] For a detailed discussion of contingent capital, see also Albul, Jaffee, and Tchistyi (2010), Basel Committee on Bank Supervision (2009), Dudley (2009), McDonald (2013), Squam Lake Working Group on Financial Regulation (2009), Pennacchi, Vermaelen, and Wolff (2014), and Sundaresan and Wang (2010). Admati et al. (2010) provide a critique of contingent capital proposals.

[33] It is intuitive to think of bank capital as a hedge against (relatively continuous) profitability shocks, and insurance as protection against large (discontinuous) shocks. This intuition is related to the analysis of a firm's choice between hedging through derivatives and purchasing insurance provided by Rochet and Villeneuve (2011). Note, however, that the empirical evidence provided by Berger and Bouwman (2013) shows that capital improves the survival probability of a bank even during a crisis. Mehran and Thakor (2011) provide a theory and empirical evidence that higher capital is correlated with higher bank values in the cross-section.

equity by banks. Rather, banks can build the capital they need in good times by accumulating retained earnings in an account to be used in difficult times when capital is needed. These dynamics could be mechanical so that there is no news or stigma associated with drawing down or building capital. The key distinguishing feature of our theoretical framework, however, is that banks are compelled to internalize the consequences of having inadequate capital. Overall, the feature of our proposed capital requirement—that capital should be high enough to deter excessive risk taking from a shareholder standpoint, but low enough to induce monitoring and discipline from a creditor standpoint—is novel. Moreover, while the literature has focused on the ex post palliative effects of bailouts and their ex ante distortive effects, we show how state-contingent bailouts can foster both ex ante and ex post banking stability.

6. Conclusion

We have developed a theory of optimal bank capital structure with private contracting based on the idea that bank leverage should be high enough to create incentives for creditors to threaten liquidation and deter managerial shirking in monitoring and low enough to induce the bank's shareholders to avoid excessive risk. We then extend the model to introduce correlated default risk, so that bank failures generate negative social externalities. This result creates a rationale for regulatory intervention when banks fail en masse. But such discretionary regulatory forbearance itself counterproductively becomes a source of systemic risk. It leads to multiple Nash equilibria for ex ante bank capital structures, one of which involves banks overlevering themselves, selecting socially inefficient, excessively risky, and cross-sectionally correlated portfolios and paying out surplus debt as dividends. Indeed, riskier portfolios may be funded only with debt and not equity, as it is the creditors that enjoy the ex post forbearance.

By funding excessively risky correlated portfolios, however, bank owners effectively extract rents from regulators and taxpayers. Under some conditions, a simple minimum equity capital requirement solves the problem and eliminates the bad Nash equilibrium. But, in general, this approach can make bank debt too safe and erode market discipline, necessitating that a part of the capital requirement be in the form of a "SCA" that does not accrue to creditors, except in the case of en masse bank failures. Such capital regulation ensures that bank shareholders have enough skin in the game not to take aggressive risks and also ensures that bank creditors have enough skin in the game too, thereby preserving the market discipline of debt even in the presence of the regulatory safety net.

Appendix

Proof of lemma 1

If the bank raises all of I from debt financing (i.e., $D=I$), then with a repayment obligation of D_R, the bank manager's expected payoff with loan portfolio G and monitoring is $p_G[H_G - D_R] - M$, since when the payoff is $H < I = D$, the shareholders receive nothing. Competitive capital market pricing means that D_R is given by $I = p_G D_R + rH$. Substituting for D_R, we can write the bank manager's expected payoff as $p_G H_G + rH - I - M$. The bank manager's expected payoff without monitoring (when creditors price the bank's debt assuming G will be chosen and monitored), absent any threat of liquidation at $t=1$, is $p_\ell[H_\ell - D_R]$. The condition for the manager not to wish to monitor is $p_G[H_G - D_R] - M < p_\ell[H_\ell - D_R]$. Upon substitution for D_R and rearranging, this inequality can be written as

$$p_G H_G - p_\ell H_\ell - [p_G]^{-1}[p_G - p_\ell][I - rH]I < M. \tag{A1}$$

Since (A1) is the same as (7), it holds under our working assumptions.

Now suppose the bank invests an additional $\bar{I}$ in S. Then the creditors know that the creditors will ask for a repayment of D_R if the bank raises debt $D = \mathrm{I} + \bar{I}$. Thus, D_R solves

$$I + \bar{I} = p_G D_R + [1 - r - p_G]\bar{I} + r\big[H + \bar{I}\big],$$

which implies

$$D_R = [I - rH][p_G]^{-1} + \bar{I}.$$

Thus, borrowing an additional $\bar{I}$ to invest in S generates an additional repayment burden of $\bar{I}$ on the bank. The condition for the manager not to wish to monitor is now

$$p_G\big[H_G + \bar{I} - D_R\big] - M < p_\ell\big[H_\ell + \bar{I} - D_R\big],$$

which means

$$p_G\big[H_G + \bar{I} - [I - rH][p_G]^{-1} - \bar{I}\big] - M < p_\ell\big[H_\ell + \bar{I} - [I - rH][p_G]^{-1} - \bar{I}\big],$$

which is the same as (A1). Thus, the investment in S makes no difference.

Now assume that all of I is raised from outside equity. Then the condition for the manager to prefer *not* to monitor can be written as

$$[1 - \alpha][p_G H_G + rH] - M < [1 - \alpha][p_\ell H_\ell + rH], \tag{A2}$$

where α satisfies the competitive pricing condition:

$$\alpha = I[p_G H_G + rH]^{-1}. \tag{A3}$$

Substituting (A3) in (A2) and rearranging yields

$$p_G H_G - p_\ell H_\ell - I[p_G H_G + rH]^{-1}[p_G H_G - p_\ell H_\ell] < M. \tag{A4}$$

It can be verified that, given (A1), the inequality in (A4) holds since

$$I[p_G H_G + rH]^{-1}[p_G H_G - p_\ell H_\ell] > [p_G]^{-1}[p_G - p_\ell][I - rH].$$

As in the case of all-debt-financing, it can be verified that the bank's investment $\overline{\Delta I}$ in S does not make any difference.

We have shown therefore that the manager will not monitor the loan portfolio regardless of whether the bank raises all of its external financing with debt or equity. It can also be verified that this is true for any convex combination of these two extremes, that is, for any capital structure. Thus, as long as there is no threat of liquidation or dismissal at $t = 1$, the manager will not monitor when the investors price the debt or equity believing he will choose portfolio G and monitor. It can be verified similarly that the manager will also not monitor in the absence of a liquidation threat for any capital structure even if investors believe that he will not monitor and price the debt and equity accordingly. Thus, the only Nash equilibrium in the absence of a liquidation or dismissal threat at $t = 1$ is for the manager not to monitor. ■

Proof of lemma 2

Creditors assume that the bank has chosen the G loan portfolio. If the creditors observe $\tilde{Z}_1 = 0$, then they can infer that the manager did not monitor at $t = 0$. With a date-2 repayment obligation of D_R, the expected value of the creditors' loan if they continue at $t = 1$ is

$$p_\ell[D_R \wedge H_\ell] + r[D_R \wedge H], \tag{A5}$$

where "$\wedge$" is the "min" operator. The value of the creditors' claims if there is liquidation is

$$L. \tag{A6}$$

For the creditors to find it subgame prefect to liquidate to $t = 1$ upon observing $\tilde{Z}_1 = 0$, the incentive comparability (IC) constraint is (A5) $\leq$ (A6). Suppose first that $D_R \geq H_\ell$ and $D_R \geq H$. Then (A5) becomes $p_\ell H_\ell + rH$, and we know by (5) that $p_\ell H_\ell + rH > L$, so the IC constraint will not hold in this case. So choose $D_R < H_\ell$ and $D_R < H$ (we will see later that $D_R < H$ holds in the rest of the analysis), so the IC constraint becomes $[r + p_\ell]D_R \leq L$, which can be written as $D_R \leq D^0 \equiv \frac{L}{[p_\ell + r]}$. It is easy to verify that $D^0 < H_\ell$, which validates the assumption that $D_R < H_\ell$.

Now suppose $\tilde{Z}_1 = x$ is observed at $t = 1$. Then the creditors' expected payoff from continuation is $rH + p_G D_R$. Thus, the IC constraint for the creditors to find it subgame perfect to let the bank continue is $rH + p_G D_R \geq L$, which becomes $D_R \geq \hat{D} \equiv \frac{L}{p_G + r}$. Note also that if the bank raises an additional $\overline{\Delta I}$ and invest it in S, the creditors' liquidation payoff at $t = 1$ increases by $\overline{\Delta I}$, and its payoff from continuation until $t = 2$ also increases by $\overline{\Delta I}$. Thus, the creditors' liquidation policy is not affected.

Next, we examine the shareholders' firing policy. Suppose shareholders observe $\tilde{Z}_1 = 0$ at $t = 1$. For any D_R, their expected payoff from liquidation is $\{L - D_R\} \wedge 0$. Their expected payoff from continuation is $p_\ell[H_\ell - D_R] + r[H - D_R]$, which we know is strictly positive for any $D_R \leq D^0$.

Two cases need to be considered. In the first case, suppose $D_R \in [\hat{D}, D^0]$. In this case, it follows that $D_R = p_G D_R + [1 - p_G]D_R > p_G D_R \geq L$. Hence, $\{L - D_R\} \wedge 0 = 0$ and the IC constraint simply becomes $r[H - D_R] + p_\ell[H_\ell - D_R] \geq 0$, which holds.

In the second case, the bank is all-equity financed. Then, the IC constraint for the shareholders to find it subgame perfect to continue becomes $p_\ell H_\ell \geq L$, which holds given (5). Thus, the shareholders will always avoid firing the bank manager. ■

Proof of lemma 3

The proof follows immediately by showing that the initial amount D raised from debt must equal the expected value of the creditors' claims conditional on loan portfolio G being chosen and monitoring by the manager. That is, $D = p_G D_R + r D_{R,}$ which yields (13) upon rearranging. Moreover, when $D_R \in [\hat{D}, D^0]$, the bank manager invests in the G loan and monitors. Consquently, $\tilde{Z}_1 = 1$ and creditors never liquidate the bank. ■

Proof of proposition 1

We begin by examining the outcome without capital requirements. If (11) holds, then $\hat{D} < \tilde{D}$. By asking the manager to choose $D_R^* \in [\hat{D}, \tilde{D}]$, the initial shareholders ensure that the creditors will liquidate at $t = 1$ if $\tilde{Z}_1 = 0$ and permit continuation if $\tilde{Z}_1 = x$. By choosing to monitor the loan portfolio, the manager guarantees $\tilde{Z}_1 = x$ at $t = 1$. Moreover, as long as $D_R^* \leq \tilde{D}$, the value of the equity of the bank is maximized by choosing loan portfolio G.

Thus, with $D_R^* \in [\hat{D}, \tilde{D}]$ the manager chooses G and monitors the loan portfolio. If $D(D_R^*) < I$, then the rest of the bank's investment need, $I - D(D_R^*)$, is covered by issuing equity. If $D(D_R^*) > I$, then $D(D_R^*)$ is raised as debt, no equity is issued, and initial shareholders are paid a dividend of $D(D_R^*) - I$. It is then an equilibrium for creditors to infer that the bank will choose loan portfolio G and monitor it, so D_R^* is given by (13).

If $D_R^* \in [\hat{D}, \tilde{D}]$, to prove that it is a Nash equilibrium for all banks to choose G and monitor their portfolios, suppose all banks, except bank i, choose G. If bank i chooses G, all their failures are i.i.d., and as long as $D_R^* \in [\hat{D}, \tilde{D}]$, the bank manager will prefer monitoring to no monitoring. The expected payoff for the bank manager with portfolio G (denoting D^G as the amount of debt raised at $t=0$ and α as the share of ownership sold to raise equity $I - D^G$) is

$$[1-\alpha]\{p_G[H_G - D_R^*] + r[H - D_R^*]\} - M = p_G[H_G - D_R^*] + r[H - D_R^*] - [I - D^G] - M \tag{A7}$$

since $\alpha[p_G[H_G - D_R^*] + r[H - D_R^*]] = I - D^G$. If the manager chooses portfolio A with $D_R^* \in [\hat{D}, \tilde{D}]$ and the creditors believe that he has chosen G, his expected payoff is

$$p_A[H_A - D_R^*] + r[H - D_R^*] - [I - D^G] - M. \tag{A8}$$

Given that the IC constraint (10) holds with $D_R^* \in [\hat{D}, \tilde{D}]$, we know that (A7) exceeds (A8). So, as long as the manager of bank i chooses $D_R^* \in [\hat{D}, \tilde{D}]$, he will indeed choose portfolio G when all other banks are choosing G.

To complete the proof, we need to show that the manager will indeed choose $D_R^* \in [\hat{D}, \tilde{D}]$. Suppose not. Let $D_R > \tilde{D}$. Now, in the single-bank case, the manager prefers A over G. Given that all the other banks are choosing G, the failure of bank i will be uncorrelated with the failures of other banks. Thus, the manager's expected payoff from choosing $D_R \in [\tilde{D}, D^0]$ can be written as

$$r[H - D_R^A] + p_A[H_A - D_R^A] - [I - D^A] - M, \tag{A9}$$

where $D_R^A > \tilde{D}$ designates the repayment obligation and D^A the amount of debt raised. Then, using (13), we can write (A9) as

$$rH + p_A H_A - p_A D_R^A - rD_R^A - \{I - p_A D_R^A - rD_R^A\} - M = p_A H_A + rH - I - M. \tag{A10}$$

Similarly, (A7) can be written as

$$rH + p_G H_G - I - M. \tag{A11}$$

Clearly, (A11) exceeds (A10). Hence, it is a Nash equilibrium for all banks to issue debt such that $D_R^* \in [\hat{D}, \tilde{D}]$ and then choose portfolio G and monitor it.

But suppose all other banks are choosing $D_R^* \in [\hat{D}, D^0]$. Now if the manager of (each) bank i chooses A, with some probability the failure of bank i will be perfectly correlated with the failures of all the other banks. However, creditors will price the debt *as if* the repayment probability is p_G, not p_A, due to the systemic bailout in the state of correlated defaults. Thus, the manager's expected payoff from choosing $D_R^* \in [\hat{D}, D^0]$ and therefore being expected to choose portfolio A is

$$r[H - D_R] + p_A[H_A - D_R] - [I - D] - M = p_A H_A + rH + [p_G + r - p_A - r]D_R - I - M. \tag{A12}$$

We want to show that the expression in (A12) is greater than $rH + p_G H_G - I - M$. That is, we want to show

$$[p_G H_G - p_A H_A] < [p_G - p_A]D_R. \tag{A13}$$

Now, by (10), we have $[p_G - p_A]\tilde{D} = [p_G H_G - p_A H_A]$, which since $D_R > \tilde{D}$ implies that

$$[p_G H_G - p_A H_A] = [p_G - p_A]\tilde{D} < [p_G - p_A]D_R.$$

Thus, it is also a Nash equilibrium for every bank to issue debt such that $D_R \in [\tilde{D}, D^0]$ and choose portfolio A and monitor it. Note, however, that the ex ante value of each bank is maximized by issuing debt of D^0 as this maximizes debt proceeds and the bailout subsidy (which is transferred ex ante to shareholders via a dividend). This completes the proof of part (a).

To complete the proof of part (b), we note that since the regulator's objective is to maximize the ex ante value of each bank and avoid the social cost Λ, the regulator will want each bank to choose portfolio G and monitor it. If (11) holds, we have proved that this is achieved by requiring the bank to issue enough debt to ensure $D_R \in [\hat{D}, \tilde{D}]$. ■

Proof of Proposition 2

Now suppose (11) does not hold. Then $\hat{D} > \tilde{D}$. Suppose the regulator asks the bank to issue debt such that $D_R > \hat{D}$, and also issue equity $E_T = E + E_s$, where $E = I - D(\hat{D})$ and $E_S = \hat{D} - \tilde{D}$, with E_S being kept in a SCA. Consider the portfolio choice of a bank manager assuming all other banks choose project A. The bank manager's payoff with portfolio G and monitoring now becomes $[1-\alpha]\{p_G[H_G - \hat{D} + E_S] + r[H - \hat{D} + E_S]\} - M$, where $\alpha\{p_G[H_G - \hat{D} + E_S] + r[H - \hat{D} + E_S]\} = I - D(\hat{D}) + E_S$. In turn, this expression can be written as

$$[1-\alpha]\Big\{p_G\Big[H_G - \hat{D} + \hat{D} - \tilde{D}\Big] + r\Big[H - \hat{D} + \hat{D} - \tilde{D}\Big]\Big\} - M = [1-\alpha]\{p_G[H_G - \tilde{D}] + r[H - \tilde{D}]\} - M. \tag{A14}$$

If the manager chooses portfolio A instead, his expected payoff is

$$[1-\alpha]\{p_A[H_A - \tilde{D}] + r[H - \tilde{D}]\} - M. \tag{A15}$$

From our previous analysis (see (10)), we know that for $D_R = \tilde{D}$, (A14) and (A15) are equal. Hence, the manager will choose portfolio G. Indeed, if all managers choose portfolio G, then the manager will be worse off choosing A, as there are no correlated defaults to benefit from and hence it is dominant to choose portfolio G instead. ■

Proof of proposition 3

Part (i) of the proposition follows from the previous analysis. Incentive compatibility requires that the LOLR bailout banks only if they all fail together.

Now consider the rest of the proposition. It is clear that since loan portfolio decisions in the two periods are separate, the incentive compatibility conditions developed in the static case must apply in each period. Note that if the bank's payoff on the first-period loan at $t=2$ is H_G, then the amount left over after paying off creditors is

$$H_G - D_R + E_S^*. \tag{A16}$$

Satisfaction of the incentive compatibility constraints in the second period requires that the bank's debt be D, where D corresponds to a repayment obligation $D_R(D) = \hat{D}$, with $D_R(D)$ given by (13) and $\hat{D}$ given by (8). The equity in the regular capital account that is needed for incentive compatibility is $E = I - D$. This means the bank can pay out a dividend of

$$H_G - D_R + E_S^* - \Big[\hat{D} - \tilde{D}\Big] - E. \tag{A17}$$

to its shareholders at $t=2$, use its retained earnings to keep E in the regular capital account and $\hat{D} - \tilde{D}$ in the SCA, and raise D in new debt financing for the second period. This way the bank will have D in debt $E = I - D$ in equity in the regular capital account and $E_S = \hat{D} - \tilde{D}$ in the SCA, and all of the incentive compatibility conditions will be satisfied in the second period.

If the bank's payoff on the first-period loan portfolio is H, then the amount left over after repaying D_R to the first-period creditors at $t = 2$ (excluding the SCA investment payoff) is

$$
\begin{aligned}
H - D_R &= H - \hat{D} \\
&< H - D \text{ (Since } D < D_R(D) = \hat{D} \text{ by (13))} \\
&< I - D \text{ (since } H < I) \\
&= E \text{ needed for incentive compatibility in the second period.}
\end{aligned}
$$

In this case, the bank is not allowed to pay a dividend and is allowed to raise D in new debt with $D_R(D) = \hat{D}$ given by (13). The actual equity it needs in its regular capital account for incentive compatibility is $E = I - D$. Thus, the additional equity needed on top of $H - D_R$ is

$$
\begin{aligned}
& E - \left[H - \hat{D}\right] \\
&= I - D - \left[H - \hat{D}\right] \\
&= I - \frac{\hat{D}}{p_G + r} - \left[H - \hat{D}\right] \\
&= \Delta.
\end{aligned}
\tag{A18}
$$

■

Proof of proposition 4

The proof of proposition 3 showed that Δ can be transferred to the regular equity account from the proceeds of the investment of the first-period SCA in the riskless asset, leaving E_S,which can be kept in the SCA for the second period. This will ensure that all the second-period incentive compatibility constraints can be satisfied.

Clearly, if the payoff on the bank's first-period loan portfolio is zero and all banks have not failed together, at $t = 2$, then the bank is not rescued by the LOLR and is shut down.

This, and the proof of proposition 3, proved (i)–(iii). ■

Proof of corollary 1

The NPV to the bank's initial shareholders is

$$
\begin{aligned}
NPV = & \, p_G\left\{H_G + \Delta + p_G[H_G + E_S] + r[H + E_S] - M - I\right\} \\
& + r\left\{H + p_G[H_G + E_S + \Delta] + r[H + E_S + \Delta] - M - I\right\} \\
& - M - I - E_S - \Delta.
\end{aligned}
\tag{A19}
$$

Clearly,

$$
\begin{aligned}
\partial NPV/\partial\Delta &= -[1 - p_G - r[p_G + r]]. \\
&< 0
\end{aligned}
$$

■

Proof of Proposition 5

The proof follows from the observation that the second period is identical to the static case covered in Proposition 2, if the bank is allowed to continue. ■

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