

# CAUGHT BETWEEN SCYLLA AND CHARYBDIS? REGULATING BANK LEVERAGE WHEN THERE IS RENT-SEEKING AND RISK-SHIFTING

## Abstract

We consider a model in which banking is characterized by asset substitution moral hazard and managerial under-provision of effort in loan monitoring. The privately-optimal bank leverage efficiently balances the benefit of debt in providing the discipline to ensure that the bank monitors its loans against the benefit of equity in attenuating asset-substitution moral hazard. However, when correlated bank failures impose significant social costs, regulators bail out bank creditors. Anticipation of this action generates multiple equilibria, including an equilibrium featuring systemic risk, in which all banks choose inefficiently high leverage to fund correlated, excessively risky assets. Leverage can be reduced via a minimum equity capital requirement, which can rule out asset substitution, but this also compromises debt discipline. Optimal capital regulation requires a two-tiered capital requirement, with a part of bank capital invested in safe assets, unavailable to creditors upon failure so as to retain market discipline, and made available to shareholders only contingent on solvency in order to contain risk-taking. We also consider a dynamic state-contingent bailout policy in which, rather than always bailing out all banks, the regulator optimally bails out banks only when a sufficiently large number of banks have failed. Used in conjunction with the two-tiered capital requirement proposed, this can contribute to *both* ex ante and ex post banking stability

*JEL:* G21, G28, G32, G35, G38

*Key words:* market discipline, asset substitution, systemic risk, bailout, forbearance, moral hazard, capital requirements

## I. INTRODUCTION

Financial crises have occurred for centuries, have been studied extensively (e.g. Allen and Gale (2000a, 2000b, 2008)), and are typically followed by calls for regulatory reform. After the recent crisis too, the prudential regulation of banks has 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 frictions in banking and seeks to generate an implementable policy prescription for regulating bank capital. Broadly, our proposal is aimed at increasing bank capital in a way that does not compromise bank discipline by uninsured creditors and yet keeps in check bank incentives to take excessive leverage and risks that are correlated with those of other banks.

We begin by noting two well-known moral hazard problems that banks face: (i) rent-seeking by managers who under-provide loan monitoring effort; and (ii) asset-substitution moral hazard involving the bank choosing excessively risky, socially-inefficient portfolios.

It has been proposed that the market discipline of (uninsured) debt can ameliorate the first moral hazard — inadequate loan monitoring (Calomiris and Kahn (1991) and Diamond and Rajan (2001)).<sup>1</sup> 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), and Merton (1977)).<sup>2</sup> 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.<sup>3</sup> The emerging evidence from the 2007-09 crisis of leads to a similar conclusion.<sup>4</sup>

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<sup>1</sup> 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 hold-up problem in the spirit of Hart and Moore (1994). See also Acharya and Viswanathan (2011).

<sup>2</sup> While Jensen and Meckling (1976) proposed this as a problem for non-financial 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)).

<sup>3</sup> The OCC's study was based on an analysis of banks that failed, that became problems and recovered, or that remained healthy during the period 1979-87. The study analyzed 171 failed banks to identify characteristics and conditions present when bank health deteriorated. The study concludes: "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

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—risk-shifting by raising capital and managerial shirking by 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 that combines both forms of moral hazard – shirking and risk-shifting. In our model, 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) and Charybdis (asset substitution).

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 I). 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 II)

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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.”

<sup>4</sup> 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.

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)). We 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.<sup>5</sup> 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 over-lever 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, nor is there any credit rationing. This situation enables banks to “loot” the taxpayer, in the sense of Akerlof and Romer (1993), by paying out dividends and eroding bank capital even as bank risk and leverage rise, looting that 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 I), 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 II), such a capital requirement is not efficient. The amount of equity that renders

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<sup>5</sup> 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 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)).

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.

Second, the bank must also keep an additional “special capital account.” This capital is “special” in the sense that (i) it must be invested in safe assets;<sup>6</sup> and, (ii) 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.

Once the two-tiered capital requirement is in place, the possibility of correlated asset choices is eliminated, and there is *no* rationale for a regulatory bailout. However, adding two features to the model generates an endogenous rationale for an arrangement in which the regulator needs *both* a bailout policy and the special capital requirement. One feature is that banks can set up shadow banks so a fraction of banks are locked into correlated asset choices, outside of the regulatory capital requirement, and there is a state in which the (correlated) failures of these banks can bring down the whole banking system, including capital-regulated banks. That is, setting up shadow banks may be a form of “regulatory arbitrage” for regulated banks to avail of government subsidies. Absent these shadow banks, capital requirements are designed to ensure that the equilibrium asset choices of banks are not correlated, so the regulator has no rationale to bail out banks; the presence of shadow banks generates a positive probability of correlated asset choices in equilibrium, and thus a case for regulatory intervention. The second feature is a dynamic element that all banks do not fail together. Some banks fail early

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<sup>6</sup> In particular, suppose free cash-flow diversion or perquisite consumption (Jensen (1986)) can also erode bank capital. To address this, we show that, though the first tier of capital can be used to fund any assets permissible for the bank, the special capital must be invested by the bank in pre-designated securities such as risk-free government bonds. 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.

and, if they are not bailed out, *may* possibly cause other banks to fail later. The regulator now faces a noisy inference problem – should the early failures of a subset of banks be prevented via a bailout or should these failures be treated as idiosyncratic and allowed to occur? We formally combine these two features – shadow banking and sequential bailouts – to derive the optimal regulatory intervention policy, thereby providing mutually reinforcing roles for both selective bailouts and capital requirements.

The rest of the paper is organized as follows. Section II develops the basic model with managerial shirking and risk-shifting problems. Section III contains the analysis of privately-optimal bank leverage, and how it is affected by induced regulatory forbearance. This section also discusses the optimal capital requirement featuring the special capital account. Section IV examines the extension that models sequential failures and endogenizes a bailout-*cum*-capital-requirements arrangement. Section V discusses the implications of our proposed scheme for current regulatory proposals. Section VI discusses the related literature. Section VII concludes. All proofs are in the Appendix.

## II. 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.

### The Economy

Consider an economy in which all agents are risk-neutral and the risk-free rate of interest is zero. There are three dates:  $t = 0$ ,  $1$ , and  $2$ . 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. This investment can be financed with any combination of debt ( $D$ ) and equity ( $E$ ), so that  $D + E = I$  at  $t = 0$ . We will refer to  $E$  as the bank's equity capital.

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 loan portfolio at  $t = 1$ ; no additional financing is required at  $t = 1$ . The time line is explained in Figure 1.

**Figure 1 here**

### 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 ( $A$ ) that 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. 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.<sup>7</sup>

We describe next 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  $A$  and  $G$  portfolio):*

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

*Cash flows at  $t = 2$ :*

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

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

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<sup>7</sup> There are many examples of signals that may be observable by the contracting parties in real time when they are realized but cannot be verified by a third party after the fact, and are thus inadequate for contract enforcement. For example, one party makes a verbal promise to another with no documentation.

If the bank does not monitor its loans, then the portfolios are rendered indistinguishable (and in equilibrium, we will show below will be liquidated, so that we use the subscript  $\ell$  for these outcomes):

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

For  $i \in \{A, G\}$ . We assume the following: (i) in terms of the likelihood of success in date-2 cash flow, given monitoring, the good loan portfolio,  $G$ , dominates the aggressive portfolio  $A$ , i.e.,  $p_G > p_A$ , and the aggressive portfolio  $A$  dominates the inefficiently monitored portfolio, i.e.,  $p_A > p_\ell$ ; (ii) in terms of the level of date-2 cash flow, given monitoring, portfolio  $A$  dominates portfolio  $G$  which in turn dominates the inefficiently monitored portfolio:  $H_A > H_G > H_\ell$ ; and (iii) in terms of expected cash flow at date 2, given monitoring,  $G$  dominates  $A$  and 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 good loan portfolio  $G$  and the aggressive loan portfolio  $A$  in (iii) 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.

*Asset Portfolio Correlations:*

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 the aggressive loan portfolio project  $A$ : an idiosyncratic state—say,  $\theta_i$ —and a systematic state—say,  $\theta_s$ . 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:

$$1 - p_A - q_s = 1 - p_G \quad (4)$$

or, in other words,  $q_i = 1 - p_G$ . This condition implies that the probability of the idiosyncratic state  $\theta_i$  is the same as the failure probability of the good loan portfolio  $G$ . We assume that in state  $\theta_i$  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  $\theta_t$ , the probability that *all* banks will fail is zero in the limit. In state  $\theta_S$ , however, these failures are perfectly correlated.<sup>8</sup>

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  $\Delta I$  is invested in  $S$  at  $t=0$ , and the security is sold or redeemed at  $t=1$  or  $t=2$ , it pays  $\Delta I$  with probability 1.

### Liquidation Possibility

The bank can be liquidated at  $t = 1$  or the bank manager can be fired at  $t = 1$  and replaced with a *de novo* manager. Both actions produce the same outcome: the value of the bank assets take on a value of  $L > 0$ . To capture opacity and asset-specificity of bank assets, we assume that both actions are costly, and lead to a bank value,  $L$ , that is lower than the continuation value of the bank without monitoring ( $p_\ell H_\ell$ ):

$$p_\ell H_\ell > L > 0. \quad (5)$$

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 to alternate bank managers.

### The Bank Manager's Objective and the Rent-Seeking Problem

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, and thus decision 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:

$$p_G H_G - M > p_\ell H_\ell > I. \quad (6)$$

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:

$$p_G H_G - p_\ell H_\ell - [p_G - p_\ell][p_G]^{-1} I < M. \quad (7)$$

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<sup>8</sup> 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.

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.

### **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  $\theta_t$  or  $\theta_s$ . 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*.<sup>9</sup> 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.<sup>10</sup> The debt contract stipulates that creditors can demand full repayment of the debt face value,  $D_R$ , at  $t = 1$ , and can force liquidation of the bank at  $t = 1$  and collect the proceeds if their demand of full repayment cannot be met at that time. Creditors could also decide not to demand full repayment of the debt at  $t = 1$ , roll over the debt and be repaid at  $t = 2$ . In contrast, equity is not promised a specific repayment, i.e., shareholders are residual claimants, but they can fire the incumbent manager at  $t = 1$ . At this stage, our focus is on optimal private contracting; regulatory intervention will be introduced in Section IV.

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<sup>9</sup> Numerous papers have provided the micro-foundations of debt and equity as optimal securities. See, among others, Boot and Thakor (1993).

<sup>10</sup> 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 the creditors and non-pledgeable, so that creditors cannot distinguish between loan portfolios  $A$  and  $G$  even ex post.

## 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,  $\Lambda$ , associated with *all* banks failing together and their creditors making losses, but no cost associated with the failure of any individual bank.<sup>11</sup> Then, only when all banks fail together, the LOLR will 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  $\Lambda$  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. Assume also for now that *all* banks are bailed out if they fail together, e.g., due to “fairness” reasons.

Formally, the LOLR’s objective is to avoid the ex-post cost  $\Lambda$  of an industry collapse and, among different regulatory policies at  $t = 0$ , choose the one that leads to efficient portfolio choice at  $t = I$  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, etc.), 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.<sup>12</sup>

### III. ANALYSIS OF THE BENCHMARK MODEL

In this section, we analyze our base model. We solve the model by backward induction, starting with events at  $t = I$ , at which time the financiers of the bank choose whether to liquidate the bank (or fire the manager), or 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.

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<sup>11</sup> If only an individual bank fails, it can be readily acquired in practice since other banks are healthy. Such re-intermediation 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.

<sup>12</sup> 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.

## A. 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.

## B. The Second Best

### *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  $p_\ell [D_R \wedge H_\ell]$  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's claims is  $p_G D_R$  which assumes that  $D_R < H_G$ . We now have:

***Lemma 1:*** *When the bank raises external financing of  $I$ , 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  $\Delta I$  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  $I$  large enough, 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:

**Lemma 2:** *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 at  $t = 1$  if  $\tilde{Z}_1 = 0$  at  $t = 1$ , and will allow it to continue if  $\tilde{Z}_1 = x$  at  $t = 1$ , where:*

$$\hat{D} \equiv \frac{L}{p_G}, \quad (8)$$

$$D^0 \equiv \frac{L}{p_\ell}. \quad (9)$$

*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  $D_R \in [0, D^0]$ .*

*The creditors' decision is unaffected by how much  $\Delta I$  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 they prefer to liquidate and take the sure liquidation payoff at  $t = 1$  rather than gamble on the risky continuation payoff. At the other extreme is 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 up 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.

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 non-concave 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.

**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 for financiers a competitive expected return of zero, 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  $p_G[H_G - D_R] \geq p_A[H_A - D_R]$ , which can be written as:

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

We shall initially assume that:

$$\frac{[p_G H_G - p_A H_A]}{p_G - p_A} > \frac{L}{p_G} \quad (11)$$

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 that it holds:

$$\frac{L}{p_\ell} > \frac{[p_G H_G - p_A H_A]}{[p_G - p_A]}. \quad (12)$$

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  $p_\ell$  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  $\tilde{Z}_1 = 0$ , i.e., 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  $p_\ell$  is small enough. Note that (12) holds if  $p_\ell$  is small enough. We now state a useful result for later use.<sup>13</sup>

**Lemma 3:** *If the bank chooses loan portfolio  $G$  and monitors in equilibrium, then repayment,  $D_R$ , that the bank must promise creditors at  $t = 2$ , in order to raise an amount  $D$  at  $t = 0$  is:*

$$D_R(D) = \frac{D}{p_G}. \quad (13)$$

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

### C. 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:** *Suppose first that (11) holds. Then:*

(i) *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  $D_R^* \in [\hat{D}, \tilde{D}]$ , also choose the good 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  $D_{\max} = p_G D^0$  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  $t = 0$ .*

(ii) *The LOLR can eliminate the bad Nash equilibrium in (i) above and ensure that the bank chooses the loan portfolio  $G$  and provides monitoring by either credibly precommitting 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  $E = I - D$ .*

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<sup>13</sup> It is easy to verify that this lemma too is unaffected by how much  $\Delta I \geq 0$  the bank invests in  $S$ .

Suppose (11) does not hold. Then:

(i) Absent regulatory intervention, private contracting will have to tolerate either the inefficiency of no monitoring by the bank or the inefficiency of the bank choosing loan portfolio A.

(ii) 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 (11)) is  $D_R(D) = \hat{D}$ . 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, i.e., 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.

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  $t = I$ , 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  $t = I$  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*.

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**Figure 2 here**

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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 (1993).

In essence, the LOLR's intervention in state  $\theta_S$  “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 the conflict of interest between bank owners and taxpayers. That is, the taxpayers now become an “economic creditor” of the banking sector, and maximizing bank equity value can lead to highly-levered capital structures and correlated risky asset choices by bank owners.<sup>14</sup> 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 the 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 leverage is the conduit through which regulatory forbearance is transferred in value terms to the bank's shareholders through

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<sup>14</sup> Acharya, Gujral, Kulkarni, and Shin (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 incentives to the investment banks to *not* cut back on leverage and dividends even as their insolvency became imminent.

excessively risky portfolios. Although motivated by equity maximization, this is possible *only if* risky portfolios are funded through debt. Since shareholders do not get 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 to 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.

But 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 the aggressive portfolio  $A$  over  $G$ .

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**Figure 3 here**

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It might appear that a resolution of this problem would be to issue long-maturity debt with a date-2 face value of  $D_R^* \leq \tilde{D}$  and give creditors control rights to demand early repayment at  $t = 1$  only when  $\tilde{Z}_1 = 0$  is observed. This would take out of the hands of the creditors the power to unconditionally demand repayment and liquidate the bank at  $t = 1$ . 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  $\tilde{Z}_1$ .<sup>15</sup> 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  $\Lambda$ . In that sense, this 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

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<sup>15</sup> 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 non-contractible, 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.

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  $\Lambda$ , ensures selection of the loan portfolio  $G$ , and ensures that the manager monitors.

This is achieved with the regulatory policy laid out in Proposition 1. Under this policy, the LOLR demands that, in addition to the equity 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” and 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.<sup>16</sup> 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 1 is that the special capital account can be arbitrarily large (up to the point that bank shareholders’ and manager’s reservation utility is met).<sup>17</sup> 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, as it can choose the special capital account requirement to be quite large without worrying about diluting creditors’ monitoring incentives.

What does it mean for the creditors to *not* have access to the special capital account 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 special capital account a moot point in this state. However, if a particular bank experiences idiosyncratic failure when some

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<sup>16</sup> 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 can be “leveraged” by the bank to add assets, just like regular tier-1 capital. That is, with a 4 percent special capital requirement, every dollar of capital in this account allows the bank to put another \$25 of assets on its books.

<sup>17</sup> 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.

others succeed, its special capital account accrues to the LOLR rather than its creditors. This means that creditors take *some* haircut even if there is capital in the special account. Since credit remains risky, monitoring incentives are preserved.

Thus, it is the *combination* of what happens in the portfolio-success state (the special capital account is an additional equity input that accrues to the bank's shareholders) and the non-systemic failure state (the special capital account 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 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 special capital account — 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 get paid in full with or without this account. This makes the special capital account “invisible” to the creditors, and leaves market discipline unaffected.

One may argue that the special capital account 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.<sup>18</sup> 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 special capital account.<sup>19</sup> But if such a security were to

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<sup>18</sup> This is reminiscent of the resolution provided by relaxing the budget-balancing constraint in the model of moral hazard in teams in Holmstrom (1982).

<sup>19</sup> The special capital account 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

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 special capital account.

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 with which to pay the creditors, other than the safe asset. 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 over-ride of absolute priority in some states, the additional capital provided by 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.

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 will be confined to that subset, as will be the application of the capital-requirement regime in Proposition 1, we will say more about this later.

#### **IV. SHADOW BANKS, SEQUENTIAL DEFAULTS AND REGULATORY BAILOUT POLICY**

The previous analysis shows that if capital requirements are properly designed *ex ante* — including the adoption of a “special capital” requirement — correlated failures will not occur in equilibrium. This obviates the need for any *ex post* bailouts. The question we now ask is whether capital requirements and bailouts can *co-exist* as part of a constrained-efficient arrangement.

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creditors are paid off regardless of whether bank failures are idiosyncratic or systemic. And second, contributions to the special capital account 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.”

To address this question, we bring in two related issues not considered in the previous analysis. One is that of “regulatory arbitrage” in the shadow banking system. That is, when the regulated banking system wishes to avail of regulatory subsidies—say in the form of bailouts—but is confronted with accompanying (perceived) costs, such as regulatory capital requirements and other regulatory proscriptions, then there may be incentives for entities to be set up in the shadow banking system that circumvent the regulatory costs but still tempt regulators to bail them out in case they fail. This can happen if the failure of the shadow banking system is perceived by the LOLR *ex post* to threaten the entire financial system, including regulated banks.

The second issue is the strong assumption in the analysis is that when banks choose portfolio *A* and there is a systematic shock, *all* banks fail together. In practice, the LOLR faces a more difficult task in determining whether a system-wide event has occurred, because banks do not all fail at the same time. That is, dynamic elements arise naturally by virtue of the fact that a subset of banks may fail at date  $t_1$ , with more banks possibly failing at say date  $t_2$  ( $> t_1$ ), and the number of banks that fail at  $t_2$  may depend not only on whether the failure-causing shock at  $t_1$  was systematic, but also on *how* the LOLR responded to that initial shock.<sup>20</sup> This means that the LOLR faces a noisy inference problem to decide whether to bail out a few early-failing banks. If it bails them out and the shock that caused them to fail was not systematic, then it is a waste of taxpayer resources. If it does not bail them out and the shock turns out to be systematic, then the whole system might collapse. The LOLR’s bailout policy needs to balance these two costs. An understanding of these costs enables us to move to the next step and ask: how should the regulator combine *ex- post* bailouts with *ex- ante* capital requirements in an environment in which there are incentives for shadow banks to circumvent regulation? In what follows, we provide formal structure and join these two ideas—sequential bailouts and shadow banking — together to address this question.

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<sup>20</sup> Also, due to asset commonality or creditor-induced contagion, there may be information or flow-of-funds linkage that connect shadow banks to regulated banks. For example, the Federal Reserve’s decision to help rescue Bear Stearns was driven by the fear that the shock that affected Bear Stearns’ fortunes had potentially systemic implications and that *not* rescuing the shadow bank could perhaps bring down other parts of the financial system. Allen, Babus and Carletti (2012) have formally examined how systemic risk arises through the interconnectedness of banks.

## A. The Emergence of Shadow Banks to Exploit the Bailout Subsidy

To formally integrate the ideas above into our analysis, we assume that the LOLR *cannot* tell whether the state  $\theta_l$  or the state  $\theta_s$  has occurred when there are bank failures. Moreover, there are two types of observationally indistinguishable banks: “normal” banks and “rogue (or shadow) banks”. The normal (referred to henceforth as type- $n$ ) banks are the regulated banks that we have examined in our previous analysis, whereas the rogue (referred to henceforth as type- $r$ ) banks are those that are locked into loan portfolio  $A$  and are incapable of monitoring borrowers.<sup>21</sup> However, they can masquerade as banks that have conducted monitoring by producing  $Z_t = x$  at  $t=1$  almost surely. These banks are not subject to the capital requirements imposed on regulated banks (or can “lever up” in hard-to-detect ways), and are thus free to choose whatever leverage they wish. Suppose the probability that a randomly-chosen bank is a type- $r$  bank is  $r \in (0,1)$ , and the probability that it is a type- $n$  bank is  $1-r$ .<sup>22</sup> Assume for now that regulatory capital requirements have been set to ensure that all type- $n$  banks choose portfolio  $G$  in equilibrium; this will be verified later. Since the type- $r$  banks invest in portfolio  $A$ , these two sets of banks differ in their portfolios.

To capture, in a simple way, the dynamics of the sequential-failures analysis in the next subsection, an additional date is introduced:  $t=3$ . The “innate” probability of failure of the  $A$  portfolio (with no monitoring) is  $1-p_l$  and that of the  $G$  portfolio (with monitoring) is  $1-p_G$ . These failures are revealed at  $t=2$ . However, if the systematic-risk state  $\theta_s$  occurs at  $t=2$  and the failing banks are not rescued by the LOLR, then *all* banks will fail at  $t=3$ , including banks with  $G$  loan portfolios that did not fail at  $t=2$ . That is, these delayed failures at  $t=3$  occur (regardless of portfolio choice) because of the interconnectedness of all banks in state  $\theta_s$ , the systematic-risk state. Even though the failing banks that are not rescued at  $t=2$  may be type- $r$  banks, their failures can induce spillovers that can bring down the otherwise-healthy banks at  $t=3$ , banks that did not experience failure at  $t=2$ . That is, even though the type- $r$  banks operate

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<sup>21</sup> The idea is that these are transaction-oriented banks that are not set up to engage in relationship banking activities like loan monitoring.

<sup>22</sup> Although our sequential bailout analysis requires that the type- $n$  and type- $r$  banks are observationally identical *a priori*, the key is that the LOLR cannot regulate an unborn entity. That is, even if the LOLR could distinguish between type- $n$  and type- $r$  banks, the type- $r$  bank can be created to avoid regulation, at least for a while, and our main results will obtain if these type- $r$  banks are systemically important. The main idea here is that regulation typically plays “catch up” when new instruments—like credit default swaps—and new entities are created; there is usually a lag between entity creation and its regulation.

more or less independently of the type- $n$  banks, they can ex-post become systematically important in the eyes of regulators if they engage in correlated bets and jeopardize the safety of the whole financial system with correlated failures. We assume, however, that this interconnectedness is state-specific, so if banks fail at  $t = 2$  because their  $G$  loan portfolios failed or because  $A$  loan portfolios failed in state  $\theta_i$ , then there are *no* spillover effects on other banks. This is meant to capture the fact that not all shocks are systematic and not all failures have systemic connotations. *Figure 4* depicts the sequence of events.

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**Figure 4 here**

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Earlier we defined  $q_i$  and  $q_s$  as the probabilities of states  $\theta_i$  and  $\theta_s$  respectively with portfolio  $A$  that is monitored. Let us now define  $\bar{q}_i$  as the probability of state  $\theta_i$  when  $A$  is not monitored, with

$$\bar{q}_i + q_s = 1 - p_\ell \tag{14}$$

as the probability of failure of the type- $r$  bank's (unmonitored)  $A$  portfolio. That is, monitoring does not affect the systematic-failure probability of the  $A$  portfolio. Since  $p_\ell < p_A$  (the success probability of  $A$  with monitoring), it follows that  $1 - p_\ell > 1 - p_A$ , and thus  $\bar{q}_i > q_i$ . This implies that monitoring helps to reduce the idiosyncratic failure probability of the  $A$  portfolio.

There are a couple of ways to interpret the type- $r$  banks. Perhaps the most direct is to think of these banks as representing exogenous uncertainty in the regulator's ability to gauge the effectiveness of capital requirements in producing the appropriate portfolio-choice incentives. Optimal capital regulation—especially the calibration aspect—is hard in part because the response of each regulated bank to a minimum capital requirement may be unpredictable. In a sense, this uncertainty is a reduced-form representation for a setting in which banks have a large number of attributes that impinge on their portfolio choices, and the regulator can observe only a subset of them, which introduces uncertainty in the regulator's assessment of the bank's portfolio choice for any capital requirement.

Another interpretation is that the type- $r$  bank is a shadow bank that can be set up by a regulated bank. The shadow bank's portfolio choice does not respond to capital requirements, but banks wish to avail of the regulatory bailout subsidy available to all banks in certain states of

the world. That is, shadow banks can be set up unobservably within capital-regulated banks, and regulated banking and shadow banking are connected implicitly or explicitly.

We now formalize sequential bailouts by the LOLR, taking  $r$  as given; the Appendix shows how  $r$  can be endogenized.<sup>23</sup> We will derive the LOLR's subgame perfect bailout policy and show that the type- $r$  banks may indeed get bailed out if sufficiently many of them fail, and this may, in turn, cause bailouts to be extended to type- $n$  banks as well. Thus, the shadow banking sector can emerge to engage in regulatory arbitrage of the bailout subsidy (as shown above). Our analysis will also show that the capital requirement for *regulated* banks must be adjusted to account for the bailout-subsidy spillover from shadow banks to regulated banks. That is, the *ex ante* design of capital requirements must anticipate the adoption of a subgame perfect bailout policy by the LOLR. Moreover, because it is easy to verify in this setting that, in the private-contracting case, the bank's investment in  $S$  makes no difference, we will ignore  $S$  until we introduce the LOLR.

## B. Formalizing Sequential Failures and Bailouts

Let  $\xi \in [0,1]$  be the probability that the LOLR will *not* bail out a bank that fails at  $t = 2$ , and  $1 - \xi$  the probability that there will be a bailout.<sup>24</sup> For now, we take  $\xi$  as a given; it will be endogenized in the next subsection. It is assumed that a bailout can occur only at  $t = 2$ , if the goal is to prevent contagion. If the LOLR waits until  $t = 3$ , and state  $\theta_s$  occurred at  $t = 2$ , then all banks will fail. Note also that the LOLR has no incentive to intervene in liquidations related to cash flows at  $t = 1$  since these occur before  $\theta_s$  is realized and thus have no contagion implications. The terms of the bailout are the same as before — the creditors of the bank suffer no haircuts, but the bank's shareholders are wiped out. With this, we see that conditional on its own loan portfolio succeeding, the probability that a bank will fail is  $q_s \xi$  and that it will succeed is  $1 - q_s \xi$ . The probability that a bank in danger of failure at  $t = 2$  due to default on its own loan portfolio will be bailed out by the LOLR is  $1 - \xi$ .

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<sup>23</sup> If  $r$  is endogenously determined, as shown in the Appendix, then it is affected by the LOLR's bailout policy and capital requirements, which means that the LOLR will adjust these policy variables taking into account their impact on  $r$ . We leave the solution of this rather complicated fixed-point problem as an interesting task for future research.

<sup>24</sup> Since banks are *ex ante* observationally identical, the LOLR will either bail out all failing banks at  $t = 2$  or none. Recall that the LOLR cannot distinguish between type- $n$  and type- $r$  banks *ex-ante*.

Finally, we impose the following restriction on the exogenous parameters:

$$H_\ell > \frac{L}{1-a_1}, \quad (15)$$

where  $a_1$  is the probability that the bank will fail and not be bailed out. Thus  $1-a_1$ , is the bank's survival probability, and (15) says that the expected value of the unmonitored loan exceeds its liquidation value. We then have the following result:

**Lemma 4:** *If creditors, who cannot distinguish between the type-n and type-r banks ex ante, assume that the type-n banks have chosen  $G$  loan portfolios, than as long as a type-n bank issues debt  $D$  at  $t=0$  such that the repayment  $D_R \in [\hat{D}, \underline{D}^o]$ , the creditors will liquidate the bank at  $t=1$  if  $Z_1 = 0$  at  $t=1$ , and will allow the bank to continue if  $Z_1 = x$  at  $t=1$ , where*

$$\underline{D}^o \equiv \frac{L}{1-a_1}, \quad (16)$$

$$\hat{D} \equiv \frac{L}{1-a_2}, \quad (17)$$

with  $a_1 \equiv p_\ell q_S \xi + [1-p_\ell] \xi$ ,  $a_2 \equiv p_r q_S \xi + [1-p_r] \xi$ , and,  $p_r \equiv (1-r)p_G + rp_\ell > p_\ell$ .

We now impose another restriction on the exogenous parameters.

$$0 < \min \left\{ \frac{[a_1 - a_2]}{[1 - a_2]} L, L - \left[ \frac{p_G H_G - p_A H_A}{p_G - p_A} \right] [1 - a_1] \right\}. \quad (18)$$

This restriction ensures that the incentive compatible debt level lies within an interval of positive measure defined by  $[\hat{D}, \underline{D}^o]$ . Note that for (18) to hold and for  $[\hat{D}, \underline{D}^o]$  to have positive measure, it is necessary for  $1-\xi$  to be large enough. This is readily apparent by setting  $1-\xi = 0$ , in which case  $a_2 > a_1$ , (18) does not hold, and  $\hat{D} > \underline{D}^o$ . Lemma 4 then leads to our next result:

**Lemma 5:** *As long as  $D_R \leq \tilde{D}$ , where*

$$\tilde{D} \equiv \left[ \frac{p_G H_G - p_A H_A}{p_G - p_A} \right], \quad (19)$$

*the type-n bank will prefer portfolio  $G$  with monitoring to portfolio  $A$  with monitoring.*

*Moreover, given (18),  $\tilde{D} < \underline{D}^o$  and  $\hat{D} < \underline{D}^o$ .*

As with our previous analysis, the question arises as to whether  $\hat{D}$  is bigger or smaller than  $\tilde{D}$ . For  $\hat{D} < \tilde{D}$ , we need  $\frac{L}{1-a_2} < \frac{[p_G H_G - p_A H_A]}{p_G - p_A}$ , which upon rearranging, yields the analog of

(11):

$$L < \left( \frac{p_G H_G - p_A H_A}{p_G - p_A} \right) [1 - a_2]. \quad (20)$$

As in the previous analysis, we can derive the relationship between the promised repayment  $D_r$  and the amount of debt financing raised,  $D$ . This is presented in the next result.

**Lemma 6:** *If the type- $n$  bank chooses loan portfolio  $G$  and monitors in equilibrium, then the repayment,  $D_r$ , that the bank must promise creditors at  $t = 3$ , in order to raise  $D$  at  $t = 0$  is:*

$$D_r(D) = \frac{D}{1 - a_2}. \quad (21)$$

One point to note is that the presence of the type- $r$  banks increases the repayment the type- $n$  banks have to promise creditors in order to raise a given amount. This is evident from (16) and definitions of  $a_2$  and  $p_r$  (see Lemma 4) which together imply that  $D_r(D)$  is increasing in  $r$ , for any given  $D$ . The intuition is that the type- $r$  banks are riskier and are observationally indistinguishable from the type- $n$  banks.

### C. Optimal Capital Requirements

Bailouts now have a somewhat different implication compared to the previous analysis. To see this, assume  $\xi = 1$ , so the bailout probability is zero. In this case, if  $q_s$  is high enough, the *ex ante* participation constraints of type- $n$  banks may be impossible to satisfy, even if there are no capital requirements and banks are free to choose privately optimal capital structures.<sup>25</sup> On the other hand, if the bailout probability is set high enough, we would return to the looting equilibrium of the previous analysis in which all banks choose portfolio  $A$  and maximum leverage. Thus, in the setting here, the LOLR faces a more delicate balancing act that will call for a *combination* of selective bailouts (probability less than 1) and capital requirements. This leads to our next result:

**Proposition 2:** *If the probability that a bank that fails at  $t = 2$  will be bailed out by the LOLR is  $1 - \xi$ , then the following describes the optimal regulatory policy:*

(i) *Suppose (20) holds. Then the regulator imposes a capital requirement that requires the bank to issue debt  $D$  such that the corresponding face value,  $D_r(D)$ , given by (21), satisfies*

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<sup>25</sup> Satisfaction of this participation constraint means that it is feasible for the bank to raise the financing it needs for its loan portfolio and keep enough surplus to give the manager incentives to monitor. With a sufficiently high likelihood of correlated failures and no bailout, the bank would be unable to generate an expected future payoff high enough to fund its loan portfolio.

$D_R(D) \in [\hat{D}, \tilde{D}]$ . Any financing need in excess of  $D$ , defined as  $E = I - D$ , is met with equity.

Moreover,  $\hat{D}$  and  $D^o$  are both decreasing in the probability of a bailout.

(ii) Suppose (20) does not hold. Then, the regulator allows the bank to raise debt such that its date -3 repayment obligation (given by (21)) is  $D_R(D) = \hat{D}$ . The bank is then required to raise equity of  $E_T = E + E_S$ , where  $E = I - D$  and  $E_S = \hat{D} - \tilde{D}$ . The bank is then required to invest the “special capital”  $E_S$  in the safe asset  $S$ , whose payoff  $\hat{D} - \tilde{D}$ , accrues to the bank’s shareholders if the bank does not fail. If the bank fails and is not bailed out by the LOLR, the special capital account is not available to the bank’s creditors but accrues instead to the LOLR.

We see then that, as in Proposition 1, a special capital account is needed in some circumstances. The key is that the LOLR now uses a state-contingent bailout policy, so that banks are sometimes bailed out and sometimes allowed to fail, in combination with capital requirements. Given that capital requirements are designed to keep leverage and asset choices from deviating from the social optimum, the LOLR uses bailouts as a mechanism to not only reduce (but not eliminate) the likelihood of contagion, but also to facilitate satisfaction of the participation constraints and the incentive compatibility constraints of banks that are making prudent asset choices. In other words, a selective bailout policy keeps the banking system from collapsing, *ex ante* as well as *ex post*, whereas capital requirements preserve socially-efficient leverage and portfolio choices as well as creditor discipline in the presence of the likelihood of bailouts.

Note the interaction between the minimum debt needed to ensure creditor discipline on the bank,  $\hat{D}$ , and the bailout probability. As the probability of a bailout increases, the minimum level of debt above which creditors permit the bank to continue if  $Z_1 = x$ , rather than unconditionally liquidating it, gets smaller. Similarly, the maximum debt,  $D^o$ , below which leverage needs to be in order to ensure that the creditors liquidate the bank if  $\tilde{Z}_1 = 0$  is also decreasing in the bailout probability. Thus, less leverage is needed for market discipline as the bailout probability increases. The intuition is that, conditional on the incentive compatibility conditions for bank monitoring and loan portfolio choice being satisfied, an increase in the bailout probability increases the value of the bank.

In Proposition 2, if (20) holds, then the capital requirement stipulates only a range within which the bank’s capital must lie, given a fixed  $r$ . However, if we interpret  $r$  as the fraction of a

bank's total resources devoted to unregulated (shadow) banking activities, then the regulator may need to be cognizant that higher capital requirements create incentives for the bank to increase  $r$ . In this case, the optimal capital requirement will correspond to the smallest number in the range of permissible values implied by Proposition 2.

#### D. Endogenizing the Bailout Probability

We now endogenize the bailout probability,  $1-\xi$ . The basic idea in this analysis is as follows. With sequential failures, the LOLR's decision to intervene with a bailout depends on trading off the benefit and cost of intervention. The benefit is that an industry collapse can be prevented if the observed failures are indeed a true harbinger of the occurrence of the systematic-failure state. The cost is that the failures may just be idiosyncratic and there would not be an industry collapse in the absence of an intervention, so intervening results in an inefficient use of taxpayer money. The LOLR may associate specific values to the benefit and the cost that may go beyond dollars and include "political costs" and reputation-related-benefits as well.<sup>26</sup> After determining these values, the LOLR's tradeoff hinges critically on the regulator's posterior belief that the systematic failure state has occurred, conditional on observing the number of banks that fail initially. The larger the size of the initial group of failing banks, the more likely it is that this state has occurred. Hence, the LOLR intervenes when sufficiently many banks fail. These ideas are formalized below.

Formally, we follow a Bayesian statistical inference approach in which the LOLR determines the bailout probability based on tradeoff between the type-I error of incorrectly rejecting the null hypothesis  $\{\mathcal{H}_0 : \theta = \theta_s\}$  and not bailing out when the true state at  $t = 2$  is  $\theta = \theta_s$  and the type-II error of falsely accepting the null hypothesis and bailing out when the true state at  $t = 2$  is not  $\theta = \theta_s$ . Since the only observable for the LOLR is the number of failing banks at  $t = 2$ , the choice of whether to bail out any bank will depend on how many banks are observed to have failed at  $t = 2$ . Let the total number of banks in the economy be  $\bar{N}$  and view  $r$  now as the fraction of (observationally identical) banks that are type- $r$  banks.

In Section III, we assumed the social cost of all banks failing was  $\Lambda$ . We now adopt a more general social loss function that the LOLR faces (from an incorrect inference and bailout

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<sup>26</sup> For example, Boot and Thakor (1993) emphasize reputational benefits for bank regulators in delaying closures of troubled banks in order to put off *observable* failures.

decision), given by  $\lambda(d_k; \theta_j), k, j \in \{f, s\}$  where  $d_k$  is the decision to bail out or not and  $\theta_j$  is the state. Here  $j = s$  in  $\theta_j$  indicates that the systematic-risk state,  $\theta_s$ , has occurred and  $j = f$  indicates that  $\theta_s$  has *not* occurred. Similarly,  $d_k = d_s$  indicates that the LOLR has decided to bail out all failing banks at  $t = 2$ , whereas  $d_k = d_f$  indicates that the LOLR has decided *not* to bail out failing banks at  $t = 2$ . Thus,  $\lambda(d_f; \theta_s)$  is the social cost perceived by the LOLR when it permits banks to fail at  $t = 2$  and this then leads to a collapse of the banking system at  $t = 3$  because the state is  $\theta_s$ , whereas  $\lambda(d_s; \theta_f)$  is the social cost of the regulator bailing out banks at  $t = 2$  even though the true state is  $\theta = \theta_f$  and thus a bailout was unnecessary to prevent an industry collapse.

The precise inference process by which the LOLR determines whether to bail out failing banks at  $t = 2$  is the *Bayes test*, which is described in detail in Mood, Graybill and Boes (1974). Given the null hypothesis  $\theta_j = \theta_s$  and taking as given the prior beliefs that the probability of state  $\theta_s$  is  $q_s$ , the expected social loss associated with the Bayes test is

$$q_s \Pr(\text{decision} = d_f | \theta_s) \lambda(d_f; \theta_s) + [1 - q_s] \Pr(\text{decision} = d_s | \theta_f) \lambda(d_s; \theta_f). \quad (22)$$

The Bayes test determines  $\Pr(\text{decision} = d_j | \theta_k)$  by providing a critical testing region  $\Omega(q_s)$ , so that the null hypothesis can be rejected if the observed number of bank failures falls in this critical region.

The critical testing region is obtained by minimizing the expected loss in (27). This critical region for the Bayes test is:

$$\Omega(q_s) = \left\{ N : \pi < \frac{[1 - q_s] \lambda(d_s; \theta_f)}{q_s \lambda(d_f; \theta_s)} \right\}. \quad (23)$$

where  $N$  is the number of banks observed to have failed at  $t = 2$  and  $\pi$  is the likelihood ratio given by:

$$\pi = \frac{\psi(N | \theta_s)}{\psi(N | \theta_f)}. \quad (24)$$

Here  $\psi(N | \theta_s)$  is the probability density function of  $N$  conditional on state  $\theta_s$ , and  $\psi(N | \theta_f)$  is the probability density function of conditional on state  $\theta_s$  not having occurred.

*Assumption: Monotone Likelihood Ratio Property (MLRP):* The ratio  $\psi(N | \theta_s) / \psi(N | \theta_f)$  is increasing in  $N$  for all  $N < \bar{N}$ .

The MLRP will hold in this case if  $q_i$  is small enough and  $p_G$  is large enough. The proof of Proposition 3 in the Appendix explicitly characterizes  $\psi(N|\theta_s)$  and  $\psi(N|\theta_f)$ .

The MLRP is thus effectively a restriction on the exogenous probabilities. We now have our next result.

**Proposition 3:** *Given the MLRP, the critical region  $\Omega(q_s)$  such that  $\theta = \theta_s$  should be rejected by the LOLR if the number of observed bank failures at  $t=2$  is  $N \in \Omega(q_s)$  is given by*

$\Omega(q_s) = \{N : N < N^*\}$ , where  $N^*$  is decreasing in  $\lambda(d_f; \theta_s)$ , the social cost of not bailing out failing banks when  $\theta = \theta_s$  and thus letting the system collapse.

The result that the critical region is such that the LOLR bails out all banks if the observed number of bank failures exceeds a critical number and abstains from bailing out banks otherwise is consistent with the intuition described earlier. One can now interpret  $\xi$ , the probability that the LOLR will not bail out failing banks at  $t=2$  as:

$$\begin{aligned} \xi &= \Pr(N < N^*) \\ &= \sum_{N=0}^{N^*-1} \{q_s \psi(N|\theta_s) + [1-q_s] \psi(N|\theta_f)\} \end{aligned} \quad (25)$$

Since  $\xi$  is increasing in  $N^*$ , we see that the probability of a bailout at  $t=2$  goes up as the social cost of an industry collapse,  $\lambda(d_f; \theta_s)$ , goes up. This is intuitive. To conclude, even though the LOLR can design capital requirements to ensure that the type- $n$  banks choose loan portfolio  $G$  and avoid correlated asset choices, the presence of the type- $r$  banks means that correlated failures can occur in equilibrium, rationalizing a policy of sequential bailouts in equilibrium.

## V. REGULATORY IMPLICATIONS

Our analysis has several important implications for regulatory capital requirements. We discuss below the implementation of the two-tiered capital requirement in Proposition 1 (when (11) does not hold) and 2 (when (25) does not hold).

Suppose that banks are at their “regular” tier-1 capital requirement at the outset. The regulator could ask each bank to retain all earnings and not pay any dividends, have the bank put the retained earnings in a “special” capital account, and require a separate minimum capital ratio for this kind of capital. Once the special capital ratio exceeds that particular level, the bank can resume dividend payments. The retained earnings can be invested only in predetermined

securities such as Treasuries. When a negative shock hits (either bank-specific or systemic) and the bank's tier-1 capital diminishes, it would be allowed to sell these Treasury securities and transfer cash from the special capital account 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 built back up to its required ratio.<sup>27</sup>

Note that this 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 and incorporates both the market discipline of debt as well as 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 special capital account is *additional* capital that would have otherwise been 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 pre-crisis 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 at a time when the bank is not in imminent danger of failure. Specifically, *no* adverse information is communicated by dividend restrictions kicking in when

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<sup>27</sup> 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 has to be moved from the special capital account 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 special capital account into the regular capital account on a continuous and mechanical basis, the issue of designing “crisis triggers” does *not* arise. The bank’s regular capital never gets depleted (absent unexpected shocks), nor is the bank required to raise additional equity by issuing stock.

Fifth, if this scheme is limited to only the systemically important banks, then the special capital account could be viewed as a “special surcharge” on those banks.<sup>28</sup>

Sixth, the judicious use of two-tiered capital requirements in conjunction with a *state-contingent* bailout policy facilitates satisfaction of the participation constraints of regulated banks as well as incentive compatibility constraints on their leverage choices. It may also help to limit the temptation of setting up (unregulated) shadow banks that circumvent capital regulation but take advantage of ad hoc ex post bailout subsidies. That is, some desirable—albeit second best—combination of *ex ante* capital requirements and *ex post* bailouts can be deployed.

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 U.S. Treasury Secretary Timothy Geithner<sup>29</sup>: “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

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<sup>28</sup> Acharya, Mehran, Schuermann and Thakor (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).

<sup>29</sup> 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 account of systematic or correlated risk of assets rather than their total or absolute risk. See Acharya (2009), and Acharya, Pedersen, Philippon, and Richardson (2010a, 2010b), among others who have proposed measurement of such correlated risks and tying capital requirements to such “systemic risk weights.”

difference between this proposal and ours is that our scheme has contingent distribution rights in addition to a two-tiered capital requirement.

## VI. 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.<sup>30</sup> Dewatripont and Tirole (1994) consider optimal regulation of bank capital structure in a model where 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 focuses on the leverage distortions and correlated risk-taking<sup>31</sup> induced by government guarantees and LOLR and the role of state-contingent bailouts.<sup>32</sup>

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), and Admati, DeMarzo, Hellwig and Pfleiderer (2010)). This is a familiar argument in bank capital regulation, and a formal justification for it can be traced back 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 I where a simple minimum capital requirement. However, our analysis shows that this proposal does not work when we are in Case II, where our proposed two-tiered capital requirement structure is needed to restore efficiency.

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<sup>30</sup> 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 (2010), Guembel and White (2007), Hellwig (2009), and Stulz (1990). In particular, Biais and Casamatta also argue that effort investment requires more leverage, whereas risk-shifting containment requires less leverage. These papers do not, however, consider the correlated risk-taking across banks and the related regulatory distortions that we analyze in this paper.

<sup>31</sup> Other papers on correlated failures include Acharya and Yorulmazer (2007, 2008) and Phillipon and Schnabl (2010).

<sup>32</sup> Acharya and Thakor (2012) 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.

A slew of more complex proposals have also been put forth. These include Flannery's (2005) contingent capital certificates (CCC),<sup>33</sup> forced equity issuances by bank during periods of deteriorating performance (e.g. Hart and Zingales (2009), and Duffie (2010)), expanding the limited liability of equity (Admati and Pfleiderer (2009), "capital insurance" (Kashyap, Rajan and Stein (2008)),<sup>34</sup> and taxing the systemic risk of financial institutions (Acharya, Pedersen, Phillipon, and Richardson (2010a)). 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 equity by banks. Rather, banks can build up 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 up 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 be high enough from a shareholder standpoint to deter excessive risk taking, but low enough from a creditor standpoint to induce monitoring and discipline—is novel. Moreover, while the literature has focused on the ex post palliative effects of bailouts but their *ex ante* distortive effects, we show how state-contingent bailouts can foster both *ex ante* and *ex post* banking stability.

## VII. 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 creditor 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

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<sup>33</sup> For a detailed discussion of contingent capital, see also Albul, Jaffee, and Tchistyi (2010), Basel Committee on Bank Supervision (2009), Dudley (2009), McDonald (2010), Squam Lake Working Group on Financial Regulation (2009), Pennacchi (2010), Sundaresan and Wang (2010), and Vermaelen and Wolff (2010). Admati, DeMarzo, Hellwig, and Pfleiderer (2010) provide a critique of contingent capital proposals.

<sup>34</sup> 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.

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 over-levering 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 “special capital account” 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, which preserves the market discipline of debt even in the presence of the regulatory safety net. Such a two-tiered capital requirement may be used in conjunction with a more nuanced, state-contingent bailout policy when banks fail sequentially and early failures may be a harbinger of a possible systemic collapse.

## 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  $p_G[H_G - D_R] - M$ . Competitive capital market pricing means that  $D_R$  is given by  $I = p_G D_R$ . Substituting for  $D_R$ , we can write the bank manager’s expected payoff as  $p_G H_G - I - M$ . 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  $t=I$ , is  $p_\ell[H_\ell - D_R]$ . The condition for the manager to not 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:

$$p_G H_G - p_\ell H_\ell - [p_G]^{-1} [p_G - p_\ell] I < M. \quad (\text{A-1})$$

Since (A-1) is the same as (7), it holds under our working assumptions.

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

$$I + \Delta I = p_G D_R + [1 - p_G] \Delta I,$$

which implies

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

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

$$p_G [H_G + \Delta I - D_R] - M < p_\ell [H_\ell + \Delta I - D_R],$$

which means

$$p_G [H_G + \Delta I - I [p_G]^{-1} - \Delta I] - M < p_\ell [H_\ell + \Delta I - I [p_G]^{-1} - \Delta I]$$

which is the same as (A-1). 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:

$$[1 - \alpha] p_G H_G - M < [1 - \alpha] p_\ell H_\ell \quad (\text{A-2})$$

where  $\alpha$  satisfies the competitive pricing condition:

$$\alpha = I [p_G H_G]^{-1}. \quad (\text{A-3})$$

Substituting (A-3) in (A-2) and rearranging yields:

$$p_G H_G - p_\ell H_\ell - I [p_G H_G]^{-1} [p_G H_G - p_\ell H_\ell] < M. \quad (\text{A-4})$$

It can be verified that, given (A-1), the inequality in (A-4) holds since

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

As in the case of all-debt-financing, it can be verified that the bank's investment  $\Delta I$  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, i.e., 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 to not 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

$$p_\ell [D_R \wedge H_\ell] \tag{A-5}$$

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

$$L. \tag{A-6}$$

For the creditors to find it subgame perfect to liquidate to  $t = 1$  upon observing  $\tilde{Z}_1 = 0$ , the incentive comparability (IC) constraint is (A-5)  $\leq$  (A-6). Suppose first that  $D_R \geq H_\ell$ . Then (A-5) becomes  $p_\ell H_\ell$ , and we know by (5) that  $p_\ell H_\ell > L$ , so the IC constraint will not hold in this case. So choose  $D_R < H_\ell$ , so the IC constraint becomes  $p_\ell D_R \leq L$ , which can be written as  $D_R \leq D^0 \equiv \frac{L}{p_\ell}$ . 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  $p_G D_R$ . Thus, the IC constraint for the creditors to find it subgame perfect to let the bank continue is

$$p_G D_R \geq L, \text{ which becomes } D_R \geq \hat{D} \equiv \frac{L}{p_G}. \text{ Note also that if the bank raises an additional } \Delta I \text{ and invest it}$$

in  $S$ , the creditors' liquidation payoff at  $t=1$  increases by  $\Delta I$ , and its payoff from continuation until  $t=2$  also increases by  $\Delta I$ . 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  $p_\ell [H_\ell - D_R]$ , 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  $p_\ell [H_\ell - D_R] \geq 0$ , which holds.

In the second case, the bank is all-equity financed. Then, the IC constraint for the shareholders to find it sub-game 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,  $D = p_G D_R$  which yields (13) upon rearranging. ■

Moreover, when  $D_R \in [\hat{D}, D^0]$ , the bank manager invests in the  $G$  loan and monitors. Consequently,  $\tilde{Z}_1 = 1$  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  $t = I$  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  $t = I$ . 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  $G$ , their all failures are i.i.d. and as long as  $D_R^* \in [\hat{D}, \tilde{D}]$ , the bank manager will prefer monitoring over no monitoring. The expected payoff for the bank manager with portfolio  $G$  is (denoting  $D^G$  as the amount of debt raised at  $t = 0$  and  $\alpha$  as the share of ownership sold to raise equity  $I - D^G$ ):

$$[1 - \alpha] p_G [H_G - D_R^*] - M = p_G [H_G - D_R^*] - [I - D^G] - M \quad (\text{A-7})$$

since  $\alpha p_G [H_G - D_R^*] = I - D^G$ . 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

$$p_A [H_A - D_R^*] - [I - D^G] - M \quad (\text{A-8})$$

Given that the IC constraint (10) holds with  $D_R^* \in [\hat{D}, \tilde{D}]$ , we know that (A-7) exceeds (A-8). 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:

$$p_A [H_A - D_R^A] - [I - D^A] - M, \quad (\text{A-9})$$

where  $D_R^A > \tilde{D}$  designates the repayment obligation and  $D^A$  the amount of debt raised. Then, using (13), we can write (A-9) as:

$$p_A H_A + p_A D_R^A - \{I - p_A D_R^A\} - M = p_A H_A - I - M. \quad (\text{A-10})$$

Similarly, (A-7) can be written as:

$$p_G H_G - I - M. \quad (\text{A-11})$$

Clearly, (A-11) exceeds (A-10). 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:

$$p_A [H_A - D_R] - [I - D] - M = p_A H_A + [p_G - p_A] D_R - I - M \quad (\text{A-12})$$

We want to show that the expression in (A-12) is greater than  $p_G H_G - I - M$ . That is, we want to show

$$[p_G H_G - p_A H_A] < [p_G - p_A] D_R \quad (\text{A-13})$$

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 (i).

To complete the proof of part (ii), we note that since the regulator's objective is to maximize the *ex-ante* value of each bank and avoid the social cost  $\Lambda$ , 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  $D_R \in [\hat{D}, \tilde{D}]$ . 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 special capital account. 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  $[1 - \alpha]p_G [H_G - \hat{D} + E_s] - M$  where  $\alpha p_G [H_G - \hat{D} + E_s] = I - D(\hat{D}) + E_s$ . In turn, this expression can be written as:

$$[1 - \alpha]p_G [H_G - \hat{D} + \hat{D} - \tilde{D}] - M = [1 - \alpha]p_G [H_G - \tilde{D}] - M. \quad (\text{A-14})$$

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

$$[1 - \alpha]p_A [H_A - \tilde{D}] - M. \quad (\text{A-15})$$

From our previous analysis (see (10)) we know that for  $D_R = \tilde{D}$ , (A-14) and (A-15) 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. ■

**Endogenous Derivation of  $r$  Through Incentives to Set Up Shadow Banks:** Formally, suppose each bank that is endowed with 1 unit “of stays” (physical, human and financial) resources, and can allocate a fraction  $r \in [0, 1]$  to setting up a shadow (type- $r$ ) bank and the remaining  $1 - r$  to setting up a regulated (type- $n$ ) bank. These two types of banks then operate independently of each other. Now, the value of the type- $r$  bank can be written as:

$$\begin{aligned}
V_r &= [1 - \bar{q}_i - q_s] \left[ H_\ell - \frac{I}{[1 - \bar{q}_i]} \right] \\
&= p_\ell H_\ell - [1 - \bar{q}_i - q_s] \frac{I}{[1 - \bar{q}_i]} \\
&= p_\ell H_\ell + q_s I [1 - \bar{q}_i]^{-1} - I
\end{aligned} \tag{A-16}$$

where we recognize that  $p_\ell = 1 - \bar{q}_i - q_s$  is the success probability of the unmonitored loan portfolio  $A$  (chosen by the type- $r$  bank), the type- $r$  bank finances entirely with debt (so the amount of initial debt raised =  $I$ ), and the debt is priced as if the success probability was  $1 - \bar{q}_i$  (assuming the number of type- $r$  banks failing in the systematic failure states is such that a bailout occurs with probability 1).

The value of the type- $n$  bank, which abides by the regulatory capital requirement stipulated in Proposition 1 and thus chooses loan portfolio  $G$ , is (see (A-11) in the proof of Proposition 1):

$$V_n = p_G H_G - I - M \tag{A-17}$$

Now, an incentive to set up a type- $r$  bank will exist as long as  $V_r > V_n$ . Comparing (A-16) and (A-17), we see that this will be the case if:

$$q_s I [1 - \bar{q}_i]^{-1} > p_G H_G - M - p_\ell H_\ell \tag{A-18}$$

We know from (6) that the right-hand side of (A-18) is positive. Thus, (A-18) will hold if  $\bar{q}_i$  is large enough. Let us assume that this condition holds. Of course, setting up a shadow bank by splitting up the bank's activities into different organizations will entail costs. Suppose the cost function is  $\kappa r^2 / 2$ , where  $\kappa > 0$  is a constant. Then the optimal fraction,  $r^*$ , of resources devoted to setting up a type- $r$  bank is:

$$\begin{aligned}
r^* &\in \arg \max_{r \in [0,1]} \{ r V_r + [1 - r] V_n - (\kappa r^2 / 2) \} \\
& \tag{A-19}
\end{aligned}$$

The optimal solution is:

$$\begin{aligned}
r^* &= [V_r - V_n] \kappa^{-1} \\
&= \frac{\{ q_s I [1 - \bar{q}_i]^{-1} - [p_G H_G + M - p_\ell H_\ell] \}}{\kappa}
\end{aligned} \tag{A-20}$$

Thus, the larger the benefit of regulatory arbitrage  $[V_r - V_n]$ , the higher is the value of  $r^*$ , the equilibrium size of shadow banking activity. ■

**Proof of Lemma 4:** If creditors observe  $\tilde{Z}_1 = 0$ , then they infer that the bank has not monitored, and thus type- $n$  and type- $r$  banks have identical payoff distributions from the standpoint of creditors. Creditors' IC constraint for liquidating the bank is:

$$p_\ell [1 - q_s \xi] D_R + [1 - p_\ell] [1 - \xi] D_R < L, \tag{A-21}$$

where the LHS is the creditors' continuation payoff and the RHS is their liquidation payoff. This inequality assumes that  $D_R < H_\ell$ , which is guaranteed by (15). Rearranging, we get:

$$D_R < \underline{D}^o \equiv \frac{L}{1-a_1}. \quad (\text{A-22})$$

Next, we examine what happens when  $\tilde{Z}_1 = x$ . Now the IC constraint for the creditors to wish to continue is

$$[1-r]\{p_G[1-q_s\xi]D_R + [1-p_G][1-\xi]D_R\} + r\{p_\ell[1-q_s\xi]D_R + [1-p_\ell][1-\xi]D_R\} \geq L, \quad (\text{A-23})$$

where the first term on the LHS refers to the type- $n$  bank (that has chosen portfolio  $G$  and monitored), and the second term refers to the type- $r$  bank. Rearranging yields:

$$D_R \geq \hat{D} \equiv \frac{L}{1-a_2}. \quad (\text{A-24})$$

■

**Proof of Lemma 5:** The IC constraint for the type- $n$  bank's manager to prefer portfolio  $G$  to portfolio  $A$  (both with monitoring) is  $p_G[H_G - D_R] \geq p_A[H_A - D_R]$ , since the bank's shareholders do not receive any payoff when the bank is bailed out. Thus, the condition for the bank to prefer  $G$  is the same as before:

$$D_R \leq \tilde{D} \equiv \frac{[p_G H_G - p_A H_A]}{[p_G - p_A]}. \quad (\text{A-25})$$

To show that  $\tilde{D} < \underline{D}^o$ , we need  $\left[ \frac{p_G H_G - p_A H_A}{p_G - p_A} \right] < \frac{L}{1-a_1}$ . Rearranging and simplifying yields:

$$\left[ \frac{p_G H_G - p_A H_A}{p_G - p_A} \right] [1-a_1] < L. \quad (\text{A-26})$$

To show that  $\hat{D} < \underline{D}^o$ , we need  $\frac{L}{1-a_2} < \frac{L}{1-a_1}$ , or that  $0 < [a_1 - a_2]L$ . Note that since  $\xi > q_s \xi$  and  $p_G > p_\ell$ , we have  $1-p_\ell > 1-p_r$ , which implies  $a_1 > a_2$ . Thus, it follows that if (18) holds, then  $\tilde{D} < D^0$  and  $\hat{D} < \underline{D}^o$ . ■

**Proof of Lemma 6:** The breakeven pricing condition is  $D_R[1-a_2] = D$ , from which (21) follows immediately. ■

**Proof of Proposition 2:** The proof is similar in structure to that of Proposition 1 and is therefore not fully repeated here. What remains is to show that  $\partial \hat{D} / \partial \xi > 0$  and  $\partial \underline{D}^o / \partial \xi > 0$ . First, note that

$\frac{\partial \hat{D}}{\partial a_2} = \frac{L}{[1-a_2]^2} > 0$  and  $\frac{\partial a_2}{\partial \xi} = 1 - p_r[1-q_s] > 0$ . Thus,  $\frac{\partial \hat{D}}{\partial \xi} > 0$ . Next,  $\frac{\partial \underline{D}^o}{\partial a_1} = \frac{L}{[1-a_1]^2} > 0$  and  $\frac{\partial a_1}{\partial \xi} = p_r q_s + 1 - p_\ell > 0$ . Thus,  $\frac{\partial \underline{D}^o}{\partial \xi} > 0$ . ■

**Proof of Proposition 3:** Let us begin by writing down  $\psi(N|\theta_s)$  and  $\psi(N|\theta_f)$  explicitly. As per (23), we know that the critical region for the Bayes' test is given by:

$$\psi(N|\theta_s) = \begin{cases} 0 & \text{if } N < r\bar{N} \\ p_G^{\bar{N}-N} [1-p_G]^{N-r\bar{N}} & \text{if } N \geq r\bar{N} \end{cases} \quad (\text{A-27})$$

$$\psi(N|\theta_f) = \sum_{j=0}^N \left\{ q_f^j [1-q_f]^{r\bar{N}-j} p_G^{[1-r]\bar{N}-N+j} [1-p_G]^{N-j} \right\}. \quad (\text{A-28})$$

$$\Omega(q_s) = \left\{ N : \lambda < \frac{[1-q_s]\lambda(d_s; \theta_f)}{q_s \lambda(d_f; \theta_s)} \right\}.$$

Let  $N^*$  be such that

$$\lambda(N^*) = \frac{[1-q_s]\lambda(d_s; \theta_f)}{q_s \lambda(d_f; \theta_s)}. \quad (\text{A-29})$$

By (24) we see that

$$\lambda(N^*) = \frac{\psi(N^*|\theta_s)}{\psi(N^*|\theta_f)}, \quad (\text{A-30})$$

and the MLRP condition implies that  $\lambda(n)$  is increasing in  $n \forall n < N$ . Combining (A-27) and (A-28), we see that the critical region is

$$\Omega(q_s) = \{N : \lambda(N) < \lambda(N^*)\} \quad (\text{A-30})$$

which means the LOLR should reject the null hypothesis that  $\theta = \theta_s$  and avoid a bailout whenever  $N < N^*$  (since  $\lambda(N)$  is increasing in  $N$ ), and bail out all failing banks at  $t=2$  when  $N \geq N^*$ . Note further that the RHS of (A-29) is decreasing in  $\lambda(d_f; \theta_s)$ . Thus,  $\frac{\partial N^*}{\partial \lambda(d_f; \theta_s)} < 0$ . ■

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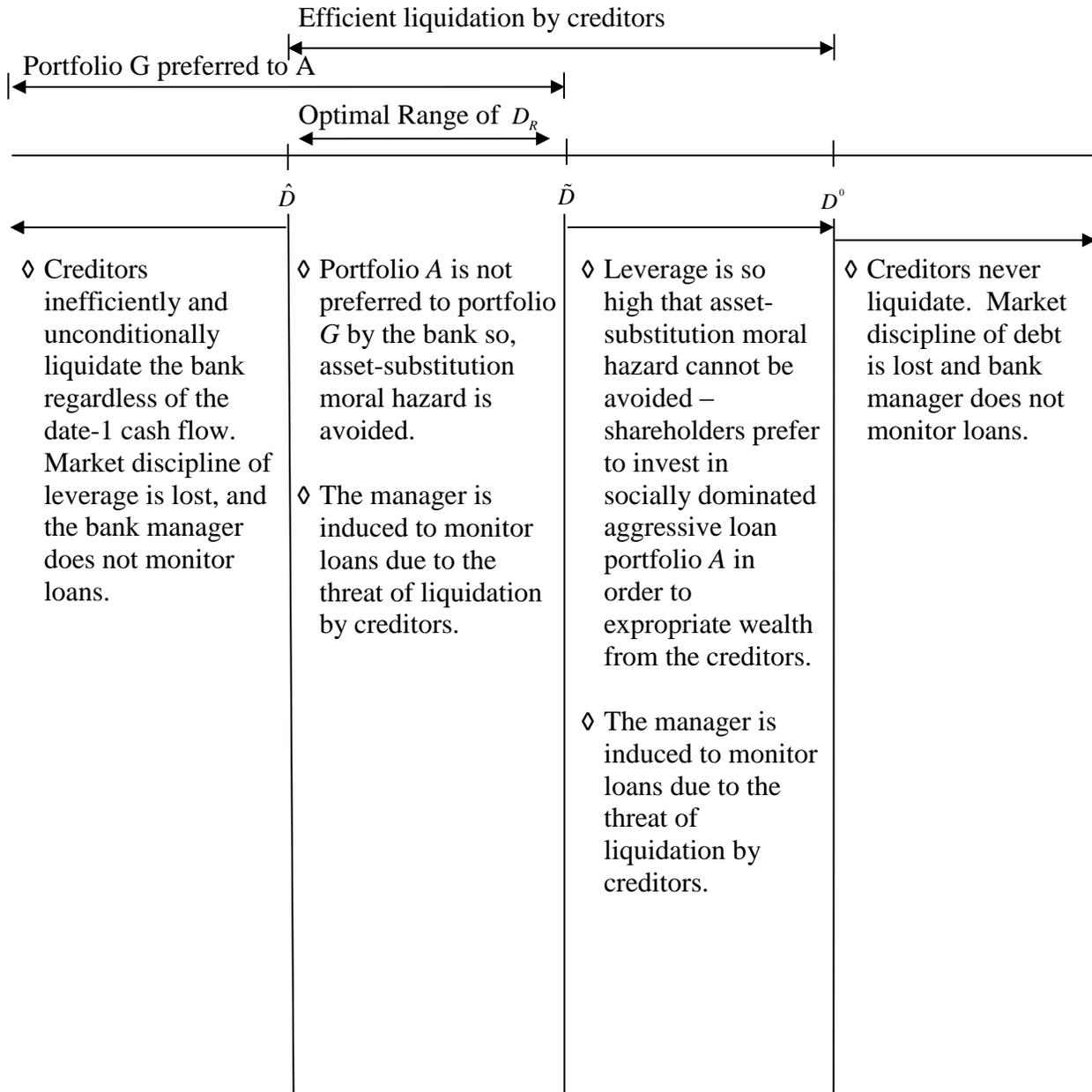
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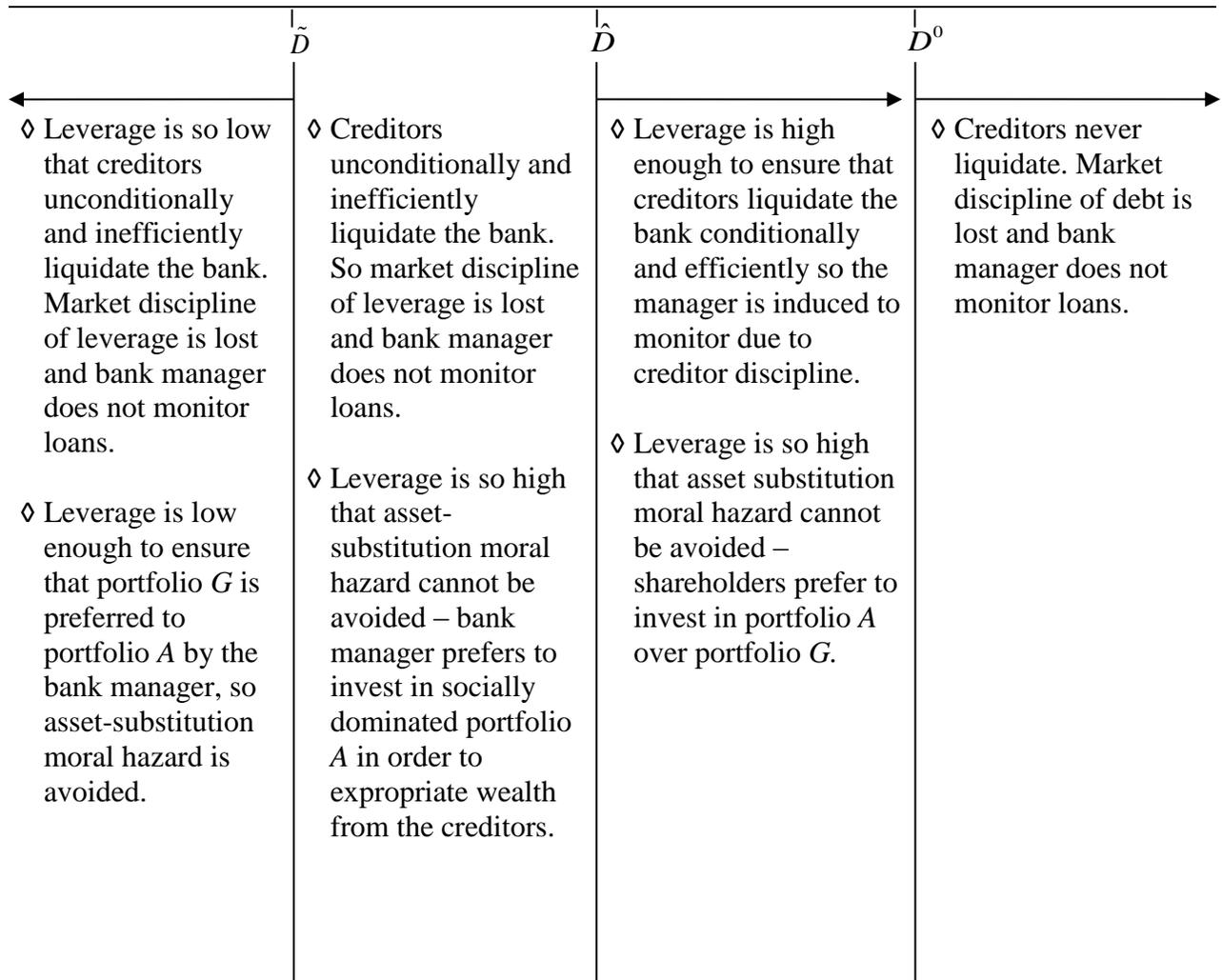


**FIGURE 2: OPTIMAL AMOUNT OF DEBT RAISED BY THE BANK AT  $t = 0$  WHEN (11) HOLDS**



**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 ( $D_R(D) < \tilde{D}$ ).



**FIGURE 4: SEQUENCE OF EVENTS WITH DYNAMIC BAILOUT POLICY**

