Accounting Information Quality, Interbank Competition, and Bank Risk Taking

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Abstract

We study the interaction between interbank competition and accounting information quality and their effects on banks’ risk-taking behavior. We identify an endogenous false-alarm cost that banks incur when forced to sell assets to meet capital requirements. We find that when the interbank competition is less intense, an improvement in the quality of accounting information encourages banks to take more risk. Keeping the banks’ investments in loans constant, the provision of high-quality accounting information reduces the false-alarm cost of assets sales and improves the discriminating efficiency of the capital requirement policy. When considering the banks’ endogenous investment decisions, however, this improvement in discriminating efficiency causes
excessive risk-taking, because banks respond by competing more aggressively in the
deposit market and the increase in deposit costs motivates banks to take more risk.
Our paper shows that improving information quality increases risk taking with mild
competition, but has no effect under fierce competition.

1 INTRODUCTION

Limited liability in the form of, for instance, deposit insurance, provides an incentive for
financial institutions to increase risk via both capital structure and investment decisions.
Not surprisingly, concerns about such risk-taking are paramount for those who study, devise
and implement regulations for the financial system. Because competition within the financial
system is not perfect, one avenue of inquiry regarding risk has been to explore how the extent
of competition influences bank risk taking when the limited liability incentives are present.
Within the context of this exploration, some regulators and academics argue that to preserve
the stability of the banking and financial industry, competition needs to be restrained (Padoa-
Schioppa, 2001, 14; Keeley, 1990; Suarez, 1994; Matutes and Vives, 1996). We extend this
literature regarding the relation between bank risk taking and competition by exploring how
two other risk disciplining mechanisms alter the behavior of banks when competition ranges
from near-monopoly to perfect competition: minimum capital requirements and accounting
disclosure quality.

Within the context of an imperfect competition model, we show that the presence of an
accounting-based capital requirement, which is intended to reduce risks associated with high
leverage, creates an important role for accounting information quality in bank risk taking via
the opportunity costs of false negative signals from the accounting system. Most importantly, we show that the impact of disclosure quality on risk-taking depends directly on the level of competition in the banking market. Specifically, we find that when the competition in the deposit market is less intense, risk-taking incentives are increasing in the quality of disclosure. However, this positive relation between disclosure quality and risk-taking becomes more muted as competition increases such that when the competition is sufficiently fierce, disclosure quality has no impact on risk-taking incentives. We also show that requiring banks to hold a minimum amount of capital restrains their risk-taking behavior. However, this disciplining effect is weakened when information quality is increased. Thus, while the banking literature posits capital requirements, competition policy and disclosure as key policy tools to discipline bank risk-taking, we show that these policies cannot be examined in isolation because the interaction among them plays a key role in determining risk-taking incentives.

We examine a setting in which \( N \) banks compete in the deposit market. Each bank chooses the amount of capital to raise through deposits and the level of risk at which this capital is invested in loans. After banks take these decisions simultaneously, a public accounting signal issued by each bank provides information about the quality of its loan investment. This accounting information is used by a regulator to monitor whether banks meet a regulatory capital requirement. If a bank fails to meet the requirement, it is forced to sell a portion of its risky assets to boost its capital ratio. This setting allows us to examine the interaction between the two banking regulatory tools of capital requirements and accounting information. Because the capital-ratio requirement is calculated based on accounting information, the ability of a capital-requirement policy to deter banks’ risk-taking behavior should be examined jointly with the financial accounting information properties. We examine this in-
teraction assuming that banks improve their capital ratio through the sale of a portion of their risky assets. This is a frequently observed action taken by banks to fulfill the capital requirement. During the 2008–2009 financial crisis, following huge write-downs and severe capital impairments, banks were often forced to deleverage by selling a considerable amount of their risky assets in the secondary market, even at a distressed or fire-sale price (Shleifer and Vishny, 2011). For instance, First Financial Network, an Oklahoma City-based loan sale advisor on behalf of the FDIC, planned to sell $150 million in loan participation from four failed banks in October, 2009 (Business Wire, 2009). More recently, BNP Paribas, one of the largest French banks, sold $96 billion of assets to shore up capital and cut funding needs (Reuters, 2011).

The results in our article stem mainly from the emergence of an endogenous “false-alarm” cost that banks incur when they are forced to sell their risky assets, even if they are sold at their fair price. This cost is borne only by a bank that receives a bad accounting signal but ultimately remains solvent. The false alarm cost arises because, when the bank sells its assets, neither the bank nor the market knows the future outcome. Consequently, the fair price that the market offers reflects the expected cash flows considering the possibility of both good and bad outcomes. In the case that a bad investment outcome is realized, the bank is insolvent and must use all of the proceeds to repay depositors. Since insolvency happens regardless of whether assets are sold, asset sales have no net effect on the final payoff, which is always zero. However, if a good investment outcome is realized, the cash flow the assets yield is larger than the proceeds obtained from their sale. Therefore, the “early” assets sales triggered by a false alarm from the imperfect accounting information system impose a cost ex ante.
We show that the false-alarm cost of assets sales plays an important role in the relation between accounting information quality and banks’ risk taking decisions. When the number of banks competing in the same market is not too large, we find that an improvement in accounting information quality induces more aggressive risk taking. More specifically, holding the amount of banks’ investments in loans constant, the provision of high-quality accounting information reduces the false-alarm cost of assets sales and improves the discriminating efficiency of the capital requirement policy, which is consistent with conventional wisdom. However, if the banks’ investment decisions are optimally determined, it is precisely this improvement in discriminating efficiency that may cause excessive risk-taking because the reduced endogenous false-alarm cost implies higher investment returns. As a result, banks respond by expanding investments which, through competition in the deposits market, leads to a higher deposit rate. The higher deposit rate, in turn, lowers the banks’ profitability, which induces them to take riskier loan investments to maintain their level of profitability.

In contrast, when there are a sufficiently large number of banks, we find that accounting information quality has no impact on banks’ risk-taking decisions. Upon a bad signal, a bank’s profit is outweighed by the false-alarm cost, and that results in the bank’s insolvency even if the bank’s investment yields a high outcome. As a result, the bank only cares about its payoff after a good signal, which is not affected by accounting information quality. This response makes the risk decision independent from information quality.

We also study an extension of our main setting that examines the effect of accounting conservatism on banks’ risk-taking decisions. We find that a more conservative accounting system restrains banks’ risk-taking behavior when the interbank competition is less intense. In contrast, when there are many banks competing, neither information quality nor conser-
vatism influences banks’ risk-taking decisions. Indeed, in our setting, accounting information is only relevant through the capital requirement examination. Therefore, the quality of information only plays a role in the case of a bad signal. Because conservatism makes bad signals less informative, increasing conservatism in our setting is equivalent to decreasing information quality.

Section 2 next provides a literature review. We describe the main model in Section 3 and explain the resulting equilibrium in Section 4. Section 5 provides an extension of our model to study the effects of accounting conservatism. Section 6 provides several robustness checks to our main results and discusses caveats. Section 7 concludes.

2 LITERATURE REVIEW

Prior literature has extensively examined the interaction between market competition and risk-taking behavior in the banking industry. Some studies argue that a less competitive environment allows banks to enjoy higher rents that they would lose in case of failure. Therefore, lowering competition might improve economic efficiency by inducing banks to be more cautious in their risk-taking behavior to avoid failure (Allen and Gale, 2000; Keeley, 1990; Suarez, 1994; Matutes and Vives, 1996). This argument is also shared by some banking regulators. However, other studies reach different conclusions. For example, Boyd and Nicolò (2005) study a setting in which a bank offers a menu of contracts to borrowers, and they argue that banks can be more aggressive in risk taking as the market becomes more concentrated. The related empirical evidence on this matter is mixed. Some studies show that bank crises are less common in more concentrated markets (Beck, Demirguc-Kunt, and Levine,
2003; Keeley, 1990; Dick, 2006), while some other studies reach the opposite conclusion (Jayaratne and Strahan, 1998). In the extant literature, the role of accounting disclosure on the interaction between market competition and risk-taking has been ignored. In our article, we shed light on this interaction by assuming that banks, after taking their investment size and risk decisions, are subject to a capital requirement examination that uses accounting information. We find that both harsher competition and more precise information increase risk, although the effect of information quality on risk vanishes when competition is too harsh.

A second stream of related literature examines the relationship between capital requirements and banks’ risk-taking behavior. Buser, Chen, and Kane (1981) provide insight on how raising capital requirements may restrict banks’ risk-taking behavior. Regulators apparently share this point of view and believe that a tightened capital requirement is an effective way to restrain aggressive leverage taking. However, there are also studies indicating that the effect of a capital requirement on a bank’s risk-taking behavior is not monotonic (Koehn and Santomero, 1980; Gennotte and Pyle, 1991). In addition, empirical studies on the relation between capital requirements and banks’ risk taking provide mixed evidence (Aggarwal and Jacques, 2001; Konishi and Yasuda, 2004; Calem and Rob, 1999; Laeven and Levine, 2009). In this article we focus on the interaction between capital regulation and accounting information quality, and we find that more precise information may weaken the disciplinary effect of capital regulation on risk-taking behavior.

There are also several studies on the implications of accounting measurement for risk-taking behavior. For example, Li (2009) compares banks’ risk-taking behaviors under three different accounting regimes and finds that fair-value accounting may be less effective in
controlling banks’ risk level when compared to other regimes. Burkhardt and Strausz (2009) argue that lower-of-cost-or-market accounting may exacerbate the asset-substitution effect of debt. Bertomeu and Magee (2011) show that a shift of accounting information quality driven by an economic downturn may result in more bad loans. Bushman and Williams (2011) find evidence supporting the view that accounting discretion over loan-loss provisioning can have either positive or negative real consequences in disciplining of banks’ risk taking. In contrast to these papers, our model illustrates how accounting information, capital regulation and market competition interact in their effects on banks’ risk-taking behavior.

There are numerous previous studies on the effects of accounting information quality on firms’ internal decisions. Some studies show that more detailed information may not be efficient (Arya and Mittendorf, 2011; Arya, Glover, and Liang, 2004). Similarly, our article shows that the improvement of accounting information quality may not be beneficial. In a capital market setting, Dye and Sridhar (2007) examine the interaction between the choice of accounting information precision and investment decisions under different observability assumptions. In contrast, we examine the role of accounting information quality in a product market setting and we focus on accounting information’s effect on banks’ risk taking.

Fewer studies have examined the interactions between capital standards, risk taking and accounting rules. Among the few, Besanko and Kanatas (1996) study the effect of capital standards on bank safety in the presence of fair-value accounting rules. They assume that a bank satisfies the capital requirement by selling equities to outside investors and show that a more stringent capital requirement may raise the probability of bank failure. In contrast to our article, the key factor driving their results comes from a dilution effect, in which increasing capital standards dilutes insiders’ ownership which in turn reduces their incentive
to exert effort in improving loan quality.

3 MODEL

3.1 Setup

We examine a three-date setting in which $N \geq 2$ identical risk-neutral banks compete in a market for deposits. At date 0, each bank $i$ decides on how much deposit funds $D_i$ to obtain and chooses the risk level $S_i$ at which it invests these funds in loans. The outcome of all loans of bank $i$ is described by a binary state, $\theta_i \in \{H, L\}$, where $H$ stands for high and $L$ stands for low, and this state is realized at date 2. At date 1, an imperfect accounting signal, $\eta_i$, which is informative about the future outcome of the loans, is generated for each bank $i$ and observed publicly. The accounting signal is also binary, $\eta_i \in \{G, B\}$, where $G$ stands for good and $B$ stands for bad.\footnote{This binary assumption simplifies our analysis without much loss of generality; to verify this, we examined a setting with a continuum of states and accounting signals, and found that the main results still hold qualitatively. Detailed analysis of this continuous-state setting is available upon request.} In case of a bad signal, the bank must sell some of its assets (i.e., loans) to fulfill a capital requirement. Finally, at date 2, the outcome is realized.

The time line of the model is shown below.

At date 0 all banks make two decisions simultaneously: the total amount of deposit funds, $D_i$, and the risk level at which they invest those funds, $S_i \in [0, 1]$. We assume that the banks’ choices of $S_i$ and $D_i$ are not perfectly observed by outsiders. This assumption reflects circumstances in practice and makes the model tractable without driving our results. In the robustness checks section we illustrate that the model with observable decisions provides qualitatively similar results. The deposit market is represented by an upward sloping inverse
supply curve that yields the equilibrium gross deposit rate, \( r_D(D_A) \), as a function of the aggregate bank deposit amount, \( D_A = \sum_{j=1}^{N} D_j \). For simplicity, we assume that \( r_D \) has the linear functional form \( r_D(D_A) = bD_A + \varepsilon \), where \( b > 0 \), and \( \varepsilon \) is an unobservable random shock reflecting other factors that influence the deposit rate. We assume \( E[\varepsilon] = 0 \), and that \( \varepsilon \) has a support with a positive measure but sufficiently small. This expression implicitly assumes that deposit amounts are perfect substitutes and increase the gross deposit rate. Because all deposits are fully insured by the Federal Deposit Insurance Corporation (FDIC), the competitive gross deposit rate \( r_D \) is independent of the individual and aggregate risk of all banks.\(^2\)

We assume that each bank \( i \) invests all funds obtained from deposits in bank loans that in aggregate have an uncertain outcome, \( X_i \). The outcome of these loans is characterized by the state, \( \theta_i \in \{H, L\} \), such that the loans are either in a high state (\( H \)), in which they yield a high outcome, or in a low state (\( L \)), in which they yield a low outcome which we normalize to zero. Neither the bank nor outsiders observe the realized state and outcome.

\(^2\)The FDIC insurance assumption, without driving our main results, simplifies our analysis. Even if we assume that deposits are not insured and that \( r_D \) depends on the market’s conjecture of total risk, banks’ returns are only reduced in the \( H \) state, and our results remain valid.
until date 2. The risk level of the loans, $S_i$, affects the expected return of the loans in two ways. First, given the loan amount, $D_i$, a higher loan risk yields a higher return in the $H$ state. In particular, in the $H$ state the loans yield a cash flow of $(1 + S_i)D_i$, while the loans yield a zero cash flow in the $L$ state. Second, we follow Boyd and Nicolò (2005) in assuming that the probability that the loans end up in the $H$ state, $P(S_i)$, decreases with their risk. In particular, we assume that $P(S_i)$ follows a linear function $P(S_i) = 1 - S_i$, where $S_i$ lies in the unit interval. The outcome from the loan investment can be characterized as follows,

$$X_i = \begin{cases} (1 + S_i)D_i & \text{if } \theta_i = H, \\ 0 & \text{if } \theta_i = L. \end{cases}$$

At date 2, bank $i$ pays $r_D D_i = (bD_A + \varepsilon) D_i$ to depositors only in the $H$ state. In the $L$ state, the bank obtains a zero cash flow from the loan investment and does not pay depositors because banks have limited liability. Absent any capital requirement examination, bank $i$ would expect a net cash flow of

$$P(S_i)(1 + S_i - E[r_D])D_i.$$ (1)

This expression reflects the basic risk-return trade-off for the bank: a higher level of risk decreases the probability of the $H$ state, but increases the net loan cash flow if the $H$ state is realized. This trade-off makes the expected net cash flow strictly concave in $S_i$, and ensures an interior maximum at $\frac{E[r_D]}{2}$. Also, notice that if banks were forced to bear the burden

\[\text{We examined a more general functional form for the probability distribution in a continuous state setting, and we find that the main results qualitatively remain.}\]
of covering defaults (i.e., pay depositors in the \(L\) state), they would expect a net cash flow of \(P(S_i)(1 + S_i) - E[r_D])D_i = ((1 - S_i)(1 + S_i) - E[r_D])D_i\), and hence, would optimally choose a risk level of zero. In our model, as a result of limited liability, banks deviate from this “first-best” risk choice and take risk excessively.\(^4\)

At date 1, an imperfect accounting signal \(\eta_i\) on the loan performance is generated and observed publicly. The quality of this accounting information is represented by an exogenous parameter, \(\phi\), which is the probability that the signal generated is correct. That is, \(\Pr(\eta_i = G|\theta_i = H) = \Pr(\eta_i = B|\theta_i = L) = \phi\). We assume that the accounting signal is imperfectly informative: \(\frac{1}{2} < \phi < 1\).

In reality, banks face a capital requirement that is based on accounting measures. This capital requirement requires a bank to maintain a minimum capital ratio, which is calculated as the bank’s equity over its risk-weighted assets. In economic downturns, the bank’s assets are often impaired while the associated impairment losses reduce the bank’s equity value. These two effects jointly result in a lower capital ratio. To fulfill the capital requirement, banks frequently sell risky assets to boost their capital ratio.\(^5\) For instance, First Financial Network planned to sell $150 million in loan participation from four failed banks in October, 2009 (Business Wire, 2009) and BNP Paribas sold $96 billion of assets to shore up capital.

\(^4\)We thank an anonymous referee for bringing up this point. When there is no limited liability, the optimal choice of zero risk is in fact a normalization. By adjusting parameters in the model, we could potentially normalize the optimal risk choice to any arbitrary value.

\(^5\)For example, suppose a bank’s risky assets are worth $2 million, its equity is recognized to be $1 million and the weight for risky assets in the calculation of the risk-weighted assets is 100%. The capital ratio is then 0.5. Assume that, upon a bad accounting signal, the market value of the risky assets declines to $1.5 million. Then, the assets’ value is marked to market and the impairment loss reduces the equity book value to $0.5 million. The capital ratio after the accounting signal, therefore, declines to 0.33. If the bank then fails the capital examination, it must take steps to satisfy the regulatory capital requirement. In particular, the bank can sell a part of its risky assets for cash. Suppose the bank sells $0.5 million of its risky assets for cash. Because cash has zero weight in the calculation of risk-weighted assets, the new risk-weighted assets amount to $1 million and, as a result, the capital requirement ratio is boosted back to 0.5.
and cut funding needs (Reuters, 2011). Consistent with these observations, we assume in our model that if the accounting signal realization is \( B \), the bank violates the capital requirement and must sell a portion of its risky assets for cash. For simplicity, we assume that the proportion of assets that needs to be sold is a constant, \( \alpha \in (0, 1) \), which henceforth we refer to as the “assets sales portion.” The market price of the bank’s assets, \( \text{Asset}^B_i \), equals the market’s conditional expectation of the future value of the loans:

\[
\text{Asset}^B_i = E[X_i(S_i^e, D_i^e, D_{-i}) | B] = \left[ \frac{(1 - \phi)(1 - S_i^c)}{(1 - \phi)(1 - S_i^c) + \phi S_i^c} \right] (1 + S_i^c) D_i^e.
\]

In this expression, the term in square brackets is the conditional probability of the \( H \) state given a \( B \) signal, and the rest is the loan outcome in the \( H \) state. Note that the assets price \( \text{Asset}^B_i \) is only a function of the investors’ risk conjectures and, therefore, it is ex-ante independent of the bank’s actual choices. To avoid trivial cases, we assume that once a capital-deficient bank ends up in the \( L \) state, the cash proceeds from the assets sale are not sufficient to repay depositors. However, by the virtue of limited liability, the bank is not liable for the outstanding balance. It can be shown that this assumption is satisfied if \( \alpha < \frac{1}{2} \), and thus we henceforth assume \( \alpha \in (0, \frac{1}{2}) \). In addition, for expositional purposes, we disregard the bank’s option to sell assets after a good signal realization. This is without loss of generality because, as we will show, the bank incurs an endogenous cost when selling the assets and therefore it is not willing to sell unless it is forced.

We can now specify the bank’s objective function. At date 0, each bank \( i \) chooses the
deposit quantity $D_i$ and the loan risk $S_i$ to maximize its expected net cash flow:

$$\max_{S_i, D_i} P_G E[\pi_i|G] + (1 - P_G) E[\pi_i|B],$$

(2)

where $P_\eta$ denotes the probability of signal $\eta, \eta \in \{G, B\}$, and $\pi_i$ denotes the bank’s cash flow net of payments to depositors. Conditional on a $G$ signal, $\pi_i$ has an expected value of $E[\pi_i|G] = P_{H|G} Max\{(1 + S_i - E[r_D])D_i, 0\}$, where $P_{H|G}$ denotes the conditional probability of the $H$ state given a $G$ signal. The expressions for all conditional probabilities can be found in Appendix I. In this expression, the maximum operator reflects the fact that the bank has limited liability and therefore cannot have a negative terminal value. If the realization of the net cash flow in the $H$ state is positive, it reflects the loan outcome, $(1 + S_i)D_i$, net of expected payments to depositors, $E[r_D]D_i$. Upon a $B$ signal, $\pi_i$ has an expected value of $E[\pi_i|B] = P_{H|B} Max\{(1 - \alpha)(1 + S_i)D_i + \alpha Asset_i^B - E[r_D]D_i, 0\}$. In this expression, the maximum operator reflects the fact that the bank has limited liability. The bank obtains a positive value only when the $H$ state is realized and the net cash flow is positive. In this expression, the term $(1 - \alpha)(1 + S_i)D_i$ is obtained from the unsold portion of the loans, the term $\alpha Asset_i^B$ is obtained from the sold portion of the loans, and the term $E[r_D]D_i$ is the payment to depositors.

4 EQUILIBRIUM

We define the equilibrium in our model as follows:

**Definition 1** *Equilibrium:* a Perfect Bayesian Equilibrium in this game is a triple $\{S_i^*, D_i^*, Asset_i^\eta\}$
for each bank $i \in \{1, \ldots, N\}$ such that:

- At date 0, each bank $i$ chooses the optimal risk and loan amount, $\{S_i^*, D_i^*\}$, to maximize its expected future cash flow, $E[\pi_i] = P_G E[\pi_i|G] + (1 - P_G) E[\pi_i|B]$.

- The market price of bank $i$'s assets at date 1 contingent upon the accounting signal, $\text{Asset}_i^n$, is equal to the market’s updated expectation of the loans’ outcome:

$$\text{Asset}_i^n = E[X_i(S_i^c, D_i^c, D_{-i}^c)|\eta], \quad \eta \in \{G, B\},$$

where $S_i^c, D_i^c, D_{-i}^c$ represent the market’s conjectures of bank $i$’s risk level, bank $i$’s deposit amount, and the total deposit amount of all other banks, respectively.

- In equilibrium, the market’s conjectures of each bank $i$’s risk-taking and investing decisions equal the bank’s actual decisions; i.e., $(S_i^c, D_i^c) = (S_i^*, D_i^*)$ for all $i \in \{1, \ldots, N\}$.

We derive the equilibrium as follows. At date 0, each bank $i$ chooses the deposit quantity $D_i$ and the loan risk $S_i$ to solve

$$\max_{S_i, D_i} P_G P_{H|G} \text{Max}\{(1+S_i-bD_A)D_i, 0\} + (1-P_G) P_{H|B} \text{Max}\{(1-\alpha)(1+S_i)D_i+\alpha \text{Asset}_i^B-bD_A D_i, 0\}. \quad (3)$$

For expositional purposes, we assume that the realization of the net cash flow in the $H$ state after a $G$ signal is always positive. That is,

$$(1 + S_i - bD_A)D_i > 0. \quad (4)$$
Nevertheless, this condition is always satisfied in the equilibrium \((S^*, D^*)\) characterized in Proposition 1, where \(1 + S^* > bND^* = bD^*_A\). We consider two cases. In the first case, the bank obtains a positive net cash flow in state \(H\) after a bad accounting signal; In the second case this net cash flow is negative. In the appendix we prove that there exists a threshold \(\hat{N}\) such that, if \(N < \hat{N}\), the first case applies, and otherwise the second case applies.\(^6\) Formally, we must take into consideration the condition,

\[
(1 - \alpha)(1 + S_i)D_i + \alpha Asset^B_i - bD_AD_i > 0 \text{ for all } N < \hat{N}.
\] (5)

We first consider the case in which \(N < \hat{N}\). The bank’s program can be expressed as:

\[
\max_{S_i, D_i} P_G P_{H|G} [(1 + S_i - bD_A)D_i] + (1 - P_G)P_{H|B} [(1 - \alpha)(1 + S_i)D_i + \alpha Asset^B_i - bD_AD_i].
\] (6)

Taking derivatives with respect to the two choice variables, we obtain two first-order conditions:

\[
b(D_{-i} + D_i)D_i - 2[\phi + (1 - \phi)(1 - \alpha)]S_iD_i + \alpha(\phi - 1)Asset^B_i = 0, \quad (7)
\]

\[
\left(1 + S_i - \frac{b(D_{-i} + 2D_i)}{1 - \alpha(1 - \phi)}\right)(1 - S_i) = 0. \quad (8)
\]

\(^6\)As we discuss later in the article, a bank bears a false-alarm cost when forced to sell assets upon a \(B\) signal. As the number of banks increases, the more intense competition erodes the profit margin; when \(N \geq \hat{N}\), the profit margin becomes so small that it cannot cover the false-alarm cost, resulting in the bank’s insolvency even if the bank ultimately ends up in the \(H\) state.
In equilibrium, the market’s conjectures are true; i.e., \((S_i^c, D_i^c) = (S_i, D_i)\) for all \(i \in \{1, 2, \ldots, N\}\).

Therefore, the above equations become:

\[
D_i \left( b (D_{-i} + D_i) - 2 [\phi + (1 - \phi)(1 - \alpha)] S_i + \alpha(\phi - 1) \left( \frac{(1 - \phi)(1 - S_i)}{(1 - \phi)(1 - S_i) + \phi S_i} \right) (1 + S_i) \right) = 0,
\]

\[
\left( 1 + S_i - \frac{b (D_{-i} + 2D_i)}{1 - \alpha(1 - \phi)} \right) (1 - S_i) = 0.
\]

Solving the system of equations for all banks simultaneously, one can derive the decisions for each bank in equilibrium. Notice that \(D_i = 0\) and \(S_i = 1\) are obvious solutions to equations (10) and (9) respectively. However, these solutions do not satisfy the second-order conditions and therefore are discarded. Also, from equation (10), it is apparent that there is a linear relation between the optimal risk and investment choices. Indeed, solving for \(S_i\) we have \(S_i = \frac{b(D_{-i} + 2D_i)}{1 - \alpha(1 - \phi)} - 1\). Therefore, if the size of the loan assets were exogenous, an increase in the size of a bank’s loan assets would imply an increase in their risk. The resulting equilibrium expressions for the assets market price and banks’ decisions are stated below in Proposition 1. The equilibrium derivation for the case of \(N < \hat{N}\) can be found in the appendix.

On the other hand, in the second case for \(N \geq \hat{N}\), upon a \(G\) signal, condition (4) suggests that the bank is solvent. However, upon a \(B\) signal the bank receives a non-positive cash flow even if it ends up in the \(H\) state; therefore, a \(B\) accounting signal announces the bank’s
insolvency. The bank’s program thus reduces to:

$$\max_{S_i, D_i} P_G P_{\text{H}\mid G}(1 + S_i - bD_A)D_i.$$  \hspace{1cm} (11)

Taking derivatives with respect to the two choice variables, we obtain two first-order conditions:

$$[b(D_{-i} + D_i) - 2S_i]D_i = 0,$$  \hspace{1cm} (12)

$$(1 + S_i - bD_{-i} - 2bD_i)(1 - S_i) = 0.$$  \hspace{1cm} (13)

As in the previous case, solving the system of equations for all banks simultaneously, we obtain the expressions for the equilibrium deposit amounts and loan risks. We can show that the equilibrium is always unique and symmetric. Henceforth, we omit the firm index and denote the equilibrium strategy profile by $\{S^*, D^*, \text{Asset}^B\}$. Proposition 1 describes the equilibrium.

**Proposition 1** There exists a unique and symmetric equilibrium in which,

i. each bank makes the optimal risk taking decision $S^*$ and loan decision $D^*$ given
by:

\[
S^* = \begin{cases} 
\frac{-k_2 - \sqrt{k_2^2 - 4k_1k_3}}{2k_1} & \text{if } N < \hat{N} \\
\frac{N}{N + 2} & \text{if } N \geq \hat{N}
\end{cases}, \quad \text{and}
\]

\[
D^* = \begin{cases} 
\frac{1 - \alpha(1 - \phi)}{b(N + 1)}(1 + S^*) & \text{if } N < \hat{N} \\
\frac{2}{b(N + 2)} & \text{if } N \geq \hat{N}
\end{cases},
\]

where the coefficients \((k_1, k_2, k_3)\) are defined as functions of \(\phi, \alpha, \) and \(N:\)

\[
k_1 = (N + 2)(1 - 2\phi) + \alpha(1 - \phi)[(N + 3)\phi - 1],
\]

\[
k_2 = [1 - \alpha(1 - \phi)][(3N + 2)\phi - 2(N + 1)],
\]

\[
k_3 = (1 - \phi)[N - \alpha(1 - \phi)(2N + 1)],
\]

and \(\hat{N} > 0\) is a threshold such that at \(N = \hat{N}\) we have in equilibrium \((1 - \alpha)(1 + S^*)D^* + \alpha \text{ Asset}^B_i - bND^{*2} = 0;\)

- upon a bad accounting signal, the bank’s assets market price, \(\text{Asset}^B\), is given by:

\[
\text{Asset}^B = \frac{(1 - \phi)(1 - S^*)}{(1 - \phi)(1 - S^*) + \phi S^*(1 + S^*)}D^*.
\]

The unique and symmetric equilibrium adopts two different characterizations, depending on whether the number of banks is below or above a threshold, \(\hat{N}\). When \(N < \hat{N}\), the equilibrium investment and risk decisions are contingent on the accounting information quality, \(\phi\), and the assets sales portion, \(\alpha\). However, when \(N > \hat{N}\), \(\phi\) and \(\alpha\) do not affect
the equilibrium investment and risk decisions. In the following subsections, we will examine
and explain the results in these two cases.

4.1 Case of $N < \hat{N}$

When the number of banks is sufficiently small ($N < \hat{N}$), banks’ risk-taking decisions are
contingent on both the accounting information quality and the capital requirement. By
examining the comparative static properties of the equilibrium presented in Proposition 1,
we find that a bank’s risk-taking incentives are disciplined by a higher asset sale portion,
$\alpha$. This is consistent with the intention of bank regulators in setting a capital requirement
to induce less aggressive risk decisions. However, our analysis also demonstrates that an
improvement in the quality of accounting information actually heightens a bank’s risk-taking
incentives. We summarize these results in the following proposition:

**Proposition 2** When $N < \hat{N}$, we have $\frac{\partial S^*}{\partial \phi} > 0, \frac{\partial S^*}{\partial \alpha} < 0$, and $\frac{\partial^2 S^*}{\partial \phi \partial \alpha} > 0$.

The results in Proposition 2 are driven by the trade-off between two effects: a *false-
alarm-cost* effect and a *deposit-market* effect. To understand these effects and the trade-off
between them, recall the bank’s objective function in equation (3):

$$P_G P_{H|G} \max\{(1+S_i-bD_A)D_i, 0\} + (1-P_G) P_{H|B} \max\{(1-\alpha)(1+S_i)D_i+\alpha \text{Asset}^B_i-bD_AD_i, 0\},$$
which can be rewritten as,\(^7\)

\[
P_H(X^H_i - E[r_D]D_i) - P_BP_{H|B} \alpha(X^H_i - \text{Asset}^B_i)\]

Bank’s expected cash flow with no assets sales false-alarm cost of assets sales

where for convenience we denote the outcome of the loans in the \(H\) state, \((1 + S_i)D_i\), as \(X^H_i\). The first component in the bank’s objective function coincides with expression (1), the expected net cash flow the bank would obtain if there were no forced asset sales. This term shows that the bank expects to repay \(E[r_D]D_i\) to depositors only if the \(H\) state is realized. As a consequence, the optimal level of risk implied by this first component is affected by an asset-substitution problem between the bank and the depositors. A larger expected payment \(E[r_D]D_i\) reduces the marginal benefit of increasing the probability of the \(H\) state, \(P_H\). As a result, banks turn to riskier investments to achieve a higher loan margin (i.e., a larger \(X^H_i - E[r_D]D_i\)).

The second component in the bank’s objective function represents an endogenous cost stemming from the sale of assets. The magnitude of the cost corresponds to the difference between the proceeds from assets sales, \(\alpha \text{Asset}^B_i\), and the cash flows from the loan assets obtained in the \(H\) state, \(\alpha X^H_i\). This cost is not due to the illiquidity in the assets market as the assets in our model are sold at their fair price. It is borne only by a bank that

---

\(^7\) According to equation (4), the realization of the net cash flow in the \(H\) state upon a \(G\) signal is always positive. In addition, when \(N < \hat{N}\), the bank obtains a positive net cash flow in state \(H\) upon a \(B\) signal. Therefore, the bank's objective function becomes

\[
P_GP_{H|G}(1 + S_i - bD_A)D_i + (1 - P_G)P_{H|B}\{(1 - \alpha)(1 + S_i)D_i + \alpha \text{Asset}^B_i - bD_A D_i\}
\]

\[
= P_GP_{H|G}(1 + S_i - bD_A)D_i + (1 - P_G)P_{H|B}\{(1 + S_i - bD_A)D_i - \alpha[(1 + S_i)D_i - \text{Asset}^B_i]\}
\]

\[
= P_GP_{H|G}(X^H_i - E[r_D]D_i) + (1 - P_G)P_{H|B}(X^H_i - E[r_D]D_i) - (1 - P_G)P_{H|B}\alpha(X^H_i - \text{Asset}^B_i)
\]

\[
= P_H(X^H_i - E[r_D]D_i) - P_BP_{H|B}\alpha(X^H_i - \text{Asset}^B_i).
\]
receives a pessimistic accounting signal but ultimately stays solvent. It arises because when the bank sells its assets, neither the bank nor the market knows the future outcome. The fair price that the market offers, therefore, reflects the expected cash flows considering the possibility of both good and bad outcomes. If a bad outcome is realized, the bank becomes insolvent, all the sale proceeds are paid to the depositors, and therefore the net value of the assets sale proceeds for the bank is zero. However, if a good outcome is realized, the cash flow generated by the investment, \( \alpha X_i^H \), is actually larger than the proceeds obtained from selling the assets, \( \alpha \text{Asset}_i^B \). Therefore, the “early” assets sale results in an endogenous cost. This cost is incurred only if both a bad signal and the \( H \) state are realized (i.e., when the accounting system generates a false alarm); from the perspective of the banks, it reflects an economic inefficiency arising from the imperfect accounting information. We call this cost the false-alarm cost and denote it by \( c_S \), where \( c_S = \alpha(X_i^H - \text{Asset}_i^B) \).

To illustrate how the false-alarm-cost affects the optimal risk choice, we rewrite the objective function in the following way:

\[
P_H(X_i^H - E[r_D]D_i) - P_H(1 - \phi)c_S.
\]

Like the expected deposit payment \( E[r_D]D_i \), the false-alarm cost is only incurred in the \( H \) state. Therefore, it plays an analogous role to the one played by \( E[r_D]D_i \) in influencing the bank’s risk decision. That is, an increase of \( c_S \) lowers the bank’s net cash flow in the \( H \) state, which encourages the bank to pursue risky projects more aggressively.

Improving the quality of accounting information affects a bank’s risk-taking decision in two ways. On one hand, improving the information quality reduces the size of the expected
false-alarm cost, \( P_H (1 - \phi) c_s \), which is a convergence of two opposing forces: an increase in information quality increases the size of the false-alarm cost but reduces the probability that false alarm actually incurs. Indeed, as accounting information quality improves, the chance that a bank ends up in the \( H \) state after obtaining a bad signal decreases, which makes the false-alarm cost less likely to be incurred. However, the lower \( H \)-state chance also reduces the assets-sales price, and that in turn yields a higher false-alarm cost. On balance, the decrease in probability dominates, resulting in a lower expected false-alarm cost. This lower false-alarm cost mitigates the asset-substitution problem between the bank and the depositors and, as a result, induces the bank to take less risk. That is, keeping the bank investment decision fixed, increasing \( \phi \) directly restrains the bank’s risk-taking behavior. We call this disciplinary role of accounting information the false-alarm-cost effect.

On the other hand, increasing the quality of accounting information also affects the bank’s investment decisions. The decrease of the expected false-alarm cost induced by an increase in information quality increases the bank’s marginal investment return. As a result, each bank responds by increasing its investment amount, \( D_i \). The resulting increase in aggregate investment leads to a higher deposit rate. The higher deposit rate, in turn, exacerbates the asset-substitution problem between the bank and the depositors, and motivates the bank to be more aggressive in risk taking. We call this risk-inducing role of accounting information the deposit-market effect.

In the trade-off between the two opposing effects of heightened information quality, the risk-inducing deposit-market effect more than offsets the disciplinary false-alarm-cost effect. As a result, increasing accounting information quality motivates banks to take more risk. Indeed, this result illustrates that, when examining the relation between information quality
and banks’ risk-taking decisions, it is important to consider the endogeneity of investment decisions. Improving the quality of accounting information improves the discriminating efficiency of the capital requirement policy, thereby reducing the chances of forcing solvent banks to liquidate assets. This restrains a bank’s risk-taking incentive because the associated efficiency improvement raises the charter values for banks, and higher charter values motivate banks to make more prudent decisions. However, the influence of accounting information quality is reversed once we consider the endogeneity of investment decisions. This is because banks respond to the improvement in discriminating efficiency by expanding investments, which raises the deposit rate. A higher deposit rate, in return, lowers the charter value and results in excessive risk-taking.

The disciplinary effect of an increase in the assets sales has a similar interpretation. If bank regulators raise the capital requirement ratio, resulting in a higher $\alpha$, this affects a bank’s risk-taking decision in two ways. First, it forces a bank to sell more assets upon a bad signal to satisfy the capital requirement, which in turn leads to a higher expected false-alarm cost. Taking investment decisions as exogenous, a higher expected false-alarm cost strengthens the bank’s asset-substitution incentive and encourages the bank to take risk more aggressively. However, the larger expected false-alarm cost leads to a lower marginal investment return. As a result, if we consider investment decisions to be endogenous, banks tend to invest less and compete less aggressively in the deposit market. Therefore, a higher $\alpha$ softens the competition in the deposit market, thereby reducing the deposit rate. A lower deposit rate mitigates the asset-substitution problem between the bank and the depositors, and induces the bank to take less risk. Overall, this latter disciplinary effect dominates the former risk-inducing effect and, as a result, a higher $\alpha$ restrains banks from aggressive
risk taking. That is, requiring banks to hold more capital not only builds an extra layer of protection for depositors, but also discourages banks from taking excessive risk.

Proposition 2 also shows that \( \frac{\partial^2 S^*}{\partial \phi \partial \alpha} > 0 \). That is, forcing capital-deficient banks to sell more assets can reinforce the risk-inducing effect of accounting information. The key driving force is that when banks are forced to sell a larger fraction of their assets to satisfy the regulatory capital requirement, the false-alarm cost associated with the assets sales is also more substantial. Therefore, an improvement in the accounting information quality leads to a greater reduction in the false-alarm cost and further intensifies the competition in the deposit market, which causes banks to take risk more aggressively.

4.2 Case of \( N \geq \hat{N} \)

When the number of banks is larger than \( \hat{N} \), banks’ investment and risk decisions are no longer affected by information quality or the assets sales portion. We state this result formally in the following proposition:

Proposition 3 When \( N \geq \hat{N} \), a bank’s investment and risk-taking decisions are independent of \( \phi \) and \( \alpha \).

From the expressions for the equilibrium banks’ decisions stated in Proposition 3, one can see that the risk taken by each bank is increasing in the number of banks in the market, \( N \), and tends asymptotically to 1, the maximum level of risk, as \( N \to \infty \). The investment of each bank, however, decreases with the number of banks, as they split the deposit market, and tends to zero as \( N \to \infty \), as each bank becomes infinitesimally small. Nevertheless, the aggregate investment increases with the number of banks and tends to a constant \( \frac{2}{\hat{b}} \) as
$N \to \infty$. The limit case as the number of banks approaches infinity is, in fact, the case of a perfectly competitive deposit market and deserves a formal statement, which we provide in the following corollary:

**Corollary 1** In the case of perfect competition, each bank makes the equilibrium risk taking and loan decisions $(S^*, D^*)$ that satisfy $S^* = 1$ and $D^*_A = \lim_{N \to \infty} N D^* = \frac{2}{b}$.

Our results for the case with a sufficiently large number of banks (i.e., the case of $N \geq \hat{N}$, including the perfect competition case $N \to \infty$) extend the results of Allen and Gale (2000). Allen and Gale (2000) study a similar setting with $N$ banks competing in the same market, but in their model banks are not subject to a capital requirement examination and accounting information plays no role. As in this study, they also find that banks choose to take more risk as $N$ increases, and that banks choose the maximum level of risk in a perfectly competitive market. Our contribution is to state that harsher competition induces banks to become more aggressive in risk taking even in the presence of a capital requirement examination. Moreover, we show that neither capital requirement nor information quality has any effect on the banks’ decisions beyond a certain level of competitiveness.

To understand the intuition underlying this result, notice that the payoff for a bank that receives a bad signal and ends up in the $H$ state is $(X_i^H - r_D D_i) - c_S$. As the number of banks increases, the increasing competition erodes the profit margin $X_H - r_D D_i$, and in the case of perfect competition, the profit margin is reduced to zero. However, the false-alarm cost $c_S$ remains positive as $N$ approaches infinity. This is because the false-alarm cost depends on the difference between the proceeds from assets sales and the cash flows from the loan assets obtained in the $H$ state, neither of which is net of the interest payment; therefore it is not
affected by the profit margin and remains positive. When \( N \geq \hat{N} \), upon a bad signal, the profit margin \( X_H - r_D D_i \) cannot cover the false-alarm cost, resulting in the bank’s insolvency even if the bank eventually ends up in the \( H \) state. As a result, the bank only cares about its payoff in the case of receiving a good signal. The net cash flow obtained in the \( H \) state decreases with \( N \) as the loan profit margin decreases, and therefore the bank becomes more aggressive in risk taking in trying to regain some of that margin.

Our analysis for both cases, \( N < \hat{N} \) and \( N \geq \hat{N} \), illustrates the interaction between interbank competition and accounting information quality and their effects on banks’ risk-taking behavior. Bank regulators may believe that competition should be restricted by regulation to enhance bank stability. Separately, better accounting disclosure is often posited as an important market disciplining device for banks. However, our article shows that there is an interaction between the two mechanisms: improving information quality may actually increase risk taking in an environment with mild competition while it may have no effect on risk decisions in an environment with fierce competition. Therefore, our results imply that these two mechanisms cannot be evaluated in isolation and that regulators need to consider the interaction between them.

5 EXTENSION: ACCOUNTING CONSERVATISM

In this section, we consider an extension of our main setting that incorporates accounting conservatism. To study how accounting conservatism affects our results, we model conservatism by assuming that the conditional probabilities of observing a good or a bad signal for a certain state of the loan are as follows: \( \Pr(\eta_i = G|\theta_i = H) = \phi - \lambda \) and \( \Pr(\eta_i = B|\theta_i = L) = \phi + \lambda \),
where $\phi \in [1/2, 1]$ and $\lambda \in [0, 1 - \phi]$. The parameter $\phi$ measures the quality of the information as before, and the parameter $\lambda$ captures the level of conservatism. We follow previous studies such as Chen et al. (2007), Gigler et al. (2009), Gao (2013), and Nan and Wen (forthcoming), in modelling conservatism as shifting the conditional distribution of the accounting signal towards the bad signal, making the observation of a bad signal less informative. We present the results of our analysis in Proposition 4.

**Proposition 4** There exists a $N_c$ such that,

(i) when $N < N_c$, $\frac{\partial S^*}{\partial \phi} > 0$ and $\frac{\partial S^*}{\partial \lambda} < 0$;

(ii) when $N \geq N_c$, $S^*$ is independent of $\phi$ and $\lambda$;

We find that the effect of information quality on banks' risk decisions generally does not change qualitatively with the presence of accounting conservatism. In particular, we still find that when the number of banks is small ($N < N_c$), the equilibrium risk chosen by banks strictly increases in the information quality, and that risk decisions are not affected when the number of banks is large ($N \geq N_c$). Moreover, in the latter case, the level of conservatism does not affect risk decisions either. However, the level of conservatism does affect risk decisions when the number of banks is small ($N < N_c$). In particular, a more conservative accounting system (higher $\lambda$) decreases the risk taken by banks. That is, conservatism plays a disciplinary role. Given the results in our main setting, the effect of conservatism on the risk decisions is quite intuitive. As mentioned above, a more conservative information system generates a downward bias on the signal, making a bad signal less informative about the underlying state of the loans. Since for the capital requirement examination purpose the informativeness of the accounting signal is only relevant upon the realization of a bad
signal, conservatism effectively reduces the quality of information. Therefore, making the accounting information more conservative in our setting is effectively equivalent to lowering the quality of information, and thus induces banks to take less risk, as we know from the results in the main setting.

6 ROBUSTNESS AND CAVEATS

The results illustrated so far in this article are obtained under some simplifying assumptions. Perhaps the two main simplifying assumptions made in the model are: (i) the non-perfect observability of the banks decisions by the market, and (ii) the exogenous and constant assets sales portion $\alpha$. To assess the robustness of our results to the relaxation of the former assumption, we examine an alternative specification to the main setup which assumes that the market can perfectly observe both the investment and risk decisions of each bank. This specification of the model leads to a high-degree polynomial in $S_i$ that can only be analyzed numerically. However, we see a similar pattern of increasing equilibrium risk decisions with increasing information quality. This allows us to conclude with some confidence that the unobservability assumptions in isolation do not seem to drive our results.

We also analyze the effect of an endogenous $\alpha$ on our results by assuming that, after the accounting signals are released, each bank that obtains a bad signal sells a portion of its assets such that the capital ratio satisfies the capital requirement. This model specification is also difficult to examine analytically. However, numerical simulations facilitate the analysis and show that equilibrium risk decisions are still increasing in information quality for any capital requirement above a certain threshold. Below this threshold, however, risk decisions
can decrease with information quality, especially when the number of firms is small.

We also examine the simultaneous relaxation of both simplifying assumptions. That is, we introduce the perfect observability of banks’ decisions and the endogeneity of $\alpha$ in the same setting. Since, in our opinion, arguing that risk decisions are perfectly observable is quite unrealistic, we first examine a setting with an endogenous $\alpha$, a perfectly observable $D_i$, and a non-perfectly observable $S_i$. Numerical simulations show that the qualitative nature of the results is similar to those obtained with an endogenous $\alpha$ and unobservable decisions. That is, we still find a positive relation between banks’ risk decisions and information quality for a capital requirement larger than a threshold and the opposite result below this threshold. For completeness, we also examine the most extreme case: an endogenous $\alpha$ and perfectly observable investment and risk decisions. In this case, one can still obtain a positive relation between risk and information quality for high capital requirements. Overall, the numerical analyses lead us to believe that the positive relation between risk and information quality described in Proposition 1 is quite robust.

There are aspects of the real world that we do not reflect in our model but that might potentially affect the results if considered. One such factor is that banks have the possibility of satisfying the capital requirement by raising capital through the issuance of new equity. Another such factor, examined by Boyd and Nicolò (2005), is allowing the risk level to be privately selected by borrowers, but indirectly induced by banks through the offer of menus of contracts. We analyzed both factors separately and were able to show that the revised models yield qualitatively similar results to the ones in Proposition 1.

Finally, although distressed banks sell risky assets with the purpose of increasing their capital ratio, ironically, it is often observed that, after obtaining the cash proceeds, they
immediately pay bonuses to top executives and/or dividends to their shareholders. Regulators have taken actions to restrict this kind of “cash out” and investors can potentially claw back part of these executive bonuses through litigation. Nevertheless, it may be instructive to study the case in which at least a portion of the sales proceeds is appropriated by the decision makers in the bank. We analyzed such a setting and found that our results in the main setting still remain when the information quality $\phi$ is low and/or the proportion of appropriated cash proceeds is small. However, when $\phi$ is sufficiently high and the proportion of appropriated cash proceeds is high, the introduction of this “cash out” makes the bank’s risk-taking level decrease in the information quality. Intuitively, when the information quality is high, the assets price upon a bad signal is lower than when accounting information is noisy, which in turn diminishes the size of the benefit from “cash out.” This, in turn, motivates the bank to take less risk. As the cash-out benefit joins the false-alarm-cost effect in disciplining banks’ risk taking, the trade-off with the deposit-market effect becomes more balanced, and that yields a non-monotonic relation between the information quality and the risk taken by the bank.\footnote{Detailed analyses of our robustness checks are available upon request.}

7 CONCLUSIONS

We study the interaction between interbank competition and accounting information quality and their effects on banks’ risk-taking behavior. We identify a false-alarm cost of assets sales for banks. This cost, together with the imperfect competition among the banks, play important roles in the relation between accounting information quality and the banks’ risk.
taking. We find that an improvement in the quality of accounting information may induce banks to take more risk when the competition is less intense. Bank regulators may believe that competition should be restricted by regulation to enhance bank stability. Separately, better accounting disclosure is often posited as an important market disciplining device for banks. Our article shows that there is an interaction between the two mechanisms, where improving information quality actually increases risk taking with mild competition while it has no effect under fierce competition. The results imply that these mechanisms cannot be evaluated in isolation.

References


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Appendix I: Derivations of Bayesian Probabilities

The conditional probability of the $H$ state given a $G$ signal is $P_{H|G} = \frac{\phi(1-S_i)}{\phi(1-S_i)+(1-\phi)S_i}$.

The conditional probability of the $H$ state given a $B$ signal is $P_{H|B} = \frac{(1-\phi)(1-S_i)}{(1-\phi)(1-S_i)+\phi S_i}$.

The probability of a $G$ signal is $P_G = \phi(1-S_i)+(1-\phi)S_i$.

The probability of a $B$ signal is $P_B = 1-P_G$.

Appendix II: Proofs

Proof of Proposition 1

Proof. Let’s assume first that the bank is solvent when it receives a $B$ signal and ends up in the $H$ state. That is, there exists a threshold $\hat{N}$ such that for $N < \hat{N}$ we must have in equilibrium

$$(1-\alpha)(1+S_i)D_i + \alpha Asset^B_i - D_i b D_A > 0.$$  \hfill (15)

In this case, from equation (9) in the main text, we can state

$$b D_A - 2[\phi + (1-\phi)(1-\alpha)]S_i + \alpha[\phi(\delta + 1) - 1] \left( \frac{(1-\phi)(1-S_i)}{(1-\phi)(1-S_i)+\phi S_i} \right) (1+S_i) = 0.$$  \hfill (16)

Solving for $S_i$ in the above equation, we obtain two solutions. One of them is obviously not a feasible solution because it is either negative or larger than 1 and, therefore, is discarded. For brevity, we call the feasible solution $S_i(D_A)$. Notice that $S_i(D_A)$ is only contingent on the basic parameters and the aggregate investment $D_A$. This implies that for a given aggregate investment there is a unique interior risk decision. From equation (10) in the main text, we can state $(1+S_i(D_A))(1-\alpha(1-\phi)) - b(D_A+D_i) = 0$. 

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From the previous derivation we know that $S_i$ is only contingent on $D_A$, thus we can aggregate this equation across all banks and obtain $N(1+S_i)(1-\alpha(1-\phi)) - b(N+1)D_A = 0$. Solving for $D_A$ we obtain $D_A = \frac{N(1+S_i)(1-\alpha(1-\phi))}{b(N+1)}$. Substituting this expression into the expression for $S_i(D_A)$ gives us a quadratic equation, which has a unique solution between zero and one, and is given by:

$$S^* = \frac{-k_2 - \sqrt{k_2^2 - 4k_1 k_3}}{2k_1}.$$  \hspace{1cm} (16)

Therefore, given our assumptions on $(\alpha, \phi, N)$, there exists a unique interior equilibrium $(S^*, D^*)$. All we need to show is that the second-order conditions are also satisfied and that the corner solutions for $S_i$ are never optimal. To show this, we start with showing that the second-order conditions are satisfied locally at the interior optimal choices:

$$\frac{\partial^2 E[\pi_i]}{\partial S_i^2} = -[1 - \alpha(1-\phi)]D_i < 0,$$

$$\frac{\partial^2 E[\pi_i]}{\partial D_i} \frac{\partial^2 E[\pi_i]}{\partial S_i^2} - \frac{\partial^2 E[\pi_i]}{\partial D_i \partial S_i} \frac{\partial^2 E[\pi_i]}{\partial S_i^2 \partial D_i} = -4b[1 - \alpha(1-\phi)]D_i(1 - S_i) - \{b(D_A + D_i) - [1 - \alpha(1-\phi)]S_i\}^2 > 0.$$

The first equation above is obviously satisfied. The second equation, using equation (10), can be reduced to the condition $S^* > \frac{N-3}{N+5}$. This condition is always satisfied for all $N \geq 2$, $0 \leq \alpha \leq 1/2$, and $1/2 \leq \phi \leq 1$. Therefore, we can state that the interior solution is a local maximum. Since there is only one interior solution we just need to prove that $S_i = 0$ and $S_i = 1$ are not optimal. For $S_i = 1$, we have that $E[\pi_i] = 0$, and, therefore, it cannot be optimal. For $S_i = 0$, it can be proven that $\frac{\partial E[\pi_i]}{\partial S_i} \Big|_{S_i=0} > 0$. Thus, $S_i = 0$ cannot be optimal solution either. Therefore, we have proven that the interior solution for $S_i$ given by expression (16) is the absolute maximum for $N < \hat{N}$. 

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Substituting \((S^*, D^*)\) into constraint (15), it can be reduced to two conditions: 

\[
S^* < \frac{(1-\phi)^2}{1-2\phi(1-\phi)}, \quad \text{or} \quad \frac{N - \frac{1}{\alpha} \frac{1-\phi}{1-2\phi(1-\phi)} S^*}{(1-\phi)^2} < 0.
\]

The first condition can be further reduced to 

\[N < \hat{N}_1,\]

where 

\[S^*(\hat{N}_1) = \frac{(1-\phi)^2}{1-2\phi(1-\phi)},\]

since \(S^*\) is strictly increasing in \(N\). In addition, it can be verified that when \(N > \hat{N}_1\), the LHS of the second condition is strictly increasing in \(S^*\) and hence increasing in \(N\). Therefore, there exists another threshold \(\hat{N}_2\), such that 

\[
\hat{N}_2 - \frac{1}{\alpha} \frac{1-\phi}{1-2\phi(1-\phi)} S^*(\hat{N}_2) = 0.
\]

Moreover, when \(N < \hat{N}_2\), 

\[
N - \frac{1}{\alpha} \frac{1-\phi}{1-2\phi(1-\phi)} S^* < 0.
\]

Define \(\hat{N} = \min(\hat{N}_1, \hat{N}_2)\). Combining these analyses, we have when \(N < \hat{N}\), constraint (15) is satisfied. However, when \(N \geq \hat{N}\), constraint (15) is violated, which makes the bank insolvent when the bank receives a bad signal but ends up in the \(H\) state. Solving the first-order conditions in this case gives 

\[S^* = \frac{N}{N+2} \quad \text{and} \quad D^* = \frac{2}{b(N+2)}.\]

We can prove that the second-order conditions for the case of \(N \geq \hat{N}\) are also satisfied in an analogous way. ■

**Proof of Proposition 2**

**Proof.** When \(N < \hat{N}\), the bank is solvent when the bank receives a \(B\) signal but ends up in the \(H\) state. In the case, \(\frac{\partial S^*}{\partial \phi}\) can be derived as follows:

\[
\frac{\partial S^*}{\partial \phi} = -\frac{\frac{\partial k_1}{\partial \phi} S^* + \frac{\partial k_2}{\partial \phi} S^* + \frac{\partial k_3}{\partial \phi}}{2k_1 S^* + k_2}.
\]

First, the denominator \(2k_1 S^* + k_2\) can be simplified as \(\sqrt{k_2^2 - 4k_1 k_3}\), which is positive given that the equilibrium exists. Hence, the sign of \(\frac{\partial S^*}{\partial \phi}\) is solely determined by the numerator. With a few algebra steps, we can verify 

\[
\frac{\partial k_1}{\partial \phi} S^* + \frac{\partial k_2}{\partial \phi} S^* + \frac{\partial k_3}{\partial \phi} < 0,
\]

and as a result, 

\[
\frac{\partial S^*}{\partial \phi} > 0.
\]
Similarly, $\frac{\partial S^*}{\partial \alpha}$ can be derived as follows:

$$\frac{\partial S^*}{\partial \alpha} = -\frac{\partial k_1}{\partial \alpha} S^{*2} + \frac{\partial k_2}{\partial \alpha} S^* + \frac{\partial k_3}{\partial \alpha}.$$ 

As shown before, the numerator is positive given that the equilibrium exists. Hence, the sign of $\frac{\partial S^*}{\partial \alpha}$ is solely determined by the numerator. With more algebra steps, we can verify

$$\frac{\partial^2 S^*}{\partial \phi \partial \alpha} = \frac{m_1 S^{*3} + m_2 S^{*2} + m_3 S^* + m_4}{(2 k_1 S^* + k_2)^2},$$

where $m_1 = 2(\frac{\partial k_1}{\partial \alpha} \frac{\partial k_1}{\partial \phi} - k_1 \frac{\partial^2 k_1}{\partial \alpha \partial \phi}), m_2 = 2[\frac{\partial k_3}{\partial \alpha} \frac{\partial k_1}{\partial \phi} - k_1(\frac{\partial^2 k_2}{\partial \alpha \partial \phi} + \frac{\partial k_0}{\partial \alpha} \frac{\partial S^*}{\partial \phi})] + \frac{\partial k_3}{\partial \alpha} \frac{\partial k_2}{\partial \phi} - k_2 \frac{\partial^2 k_1}{\partial \alpha \partial \phi},$

$m_3 = 2[\frac{\partial k_3}{\partial \alpha} \frac{\partial k_1}{\partial \phi} - (k_1 \frac{\partial^2 k_1}{\partial \alpha \partial \phi} + k_2 \frac{\partial k_1}{\partial \alpha} \frac{\partial S^*}{\partial \phi})] + \frac{\partial k_3}{\partial \alpha} \frac{\partial k_2}{\partial \phi} - k_2 \frac{\partial^2 k_1}{\partial \alpha \partial \phi},$ and $m_4 = \frac{\partial k_3}{\partial \alpha} (\frac{\partial k_2}{\partial \phi} + 2k_1 \frac{\partial S^*}{\partial \phi}) - k_2 (\frac{\partial^2 k_3}{\partial \alpha \partial \phi} + \frac{\partial k_3}{\partial \alpha} \frac{\partial S^*}{\partial \phi}).$ With more algebra steps, we can verify $m_1 S^{*3} + m_2 S^{*2} + m_3 S^* + m_4 > 0,$

and as a result, $\frac{\partial^2 S^*}{\partial \phi \partial \alpha} > 0.$

**Proof of Proposition 3**

**Proof.** The proof is directly derived from Proposition 1 for the case $N \geq \hat{N}.$

**Proof of Corollary 1**

**Proof.** Perfect competition is a special case for $N \geq \hat{N}$. When $N$ goes to infinity, $S^* = 1$ and $D^* = 0$. The total deposit amount becomes $D^A = \frac{2}{b}$. Hence, $S^*$ is independent of either
α or φ. In this case, the second-order conditions become

\[ \frac{\partial^2 E[\pi_i]}{\partial S_i^2} = \lim_{N \to \infty} - \frac{4\phi}{b(N + 2)} = 0, \]

\[ \frac{\partial^2 E[\pi_i]}{\partial D_i^2} \frac{\partial^2 E[\pi_i]}{\partial S_i^2} - \frac{\partial^2 E[\pi_i]}{\partial D_i \partial S_i} \frac{\partial^2 E[\pi_i]}{\partial S_j \partial D_j} = \lim_{N \to \infty} \frac{12\phi^2}{(N + 2)^2} = 0. \]

Hence, the second-order conditions are satisfied for any N arbitrarily large and by continuity, they are also satisfied when N goes to infinity in the case of perfect competition.

**Proof of Proposition 4**

**Proof.** Following similar steps as in Proposition 1, we can show there exists a threshold \( N_c \), such that when \( N < N_c \), the bank is solvent when the bank receives a bad signal but ends up in the \( H \) state. When \( N \geq N_c \), the bank is always insolvent upon a bad signal.

In this case, solving the first-order conditions gives \( S^* = \frac{N}{N+2} \) and \( D^* = \frac{2}{\phi(N+2)} \), which is independent of accounting information quality \( \phi \) and conservatism \( \lambda \). When \( N < N_c \), solving first-order conditions gives \( S^* = \frac{-l_2 - \sqrt{l_2^2 - 4l_1 l_3}}{2l_1} \), where \( l_1, l_2, l_3 \) are functions of \( (\lambda, \phi, N, \alpha) \). By computing the derivatives, it is straightforward to verify that \( \frac{\partial S^*}{\partial \phi} > 0 \) and \( \frac{\partial S^*}{\partial \lambda} < 0 \).