Bank Reputation, Bank Commitment, and the Effects of Competition in Credit Markets

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This article discusses the effects of credit market competition on a bank's incentive to keep its commitment to lend to a borrower when the borrower's credit quality deteriorates. It is shown that, unlike in the borrower's commitment problem to keep borrowing from the same bank in "good" times, the increased competition may strengthen a bank's incentive to keep its commitment. Banks offer loans with commitment to the highest quality borrowers but, when faced with competition from bond markets, they also give these loans to lower quality borrowers. An increase in the number of banks has a non-monotonic effect; new banks reinforce a bank's incentive only if there are small number of banks.

The inability to contract across all contingencies may result in inefficiencies in bank lending. The borrower may not undertake efficient investments if future refinancing is difficult to obtain in the case of temporary distress. The lender may not provide funds when the borrower is in distress if the surplus cannot be shared in the long run.[1] This problem can be mitigated, however, if the lender and the borrower interact repeatedly. For example, a bank's concern to maintain a "good" reputation can induce the bank to keep its commitment to a costly action [see, e.g., Sharpe (1990), Boot, Greenbaum, and Thakor (1993), Aoki (1994), Chemmanur and Fulghieri (1994)]. Indeed, the use of bank reputation as an enforcement mechanism seems to be widespread.[2]

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[1] Although this is an old problem in economics, Mayer (1988) appears to be the first one to discuss it in the context of finance. See also Hellwig (1991).

[2] Duca and Vanhoose (1990) observe that 80% of commercial loans in the United States are made via loan commitments that the bank has little or no legal obligation to honor. Boot, Greenbaum, and Thakor (1993) give examples of bank off-the-balance-sheet activities in which bank reputation plays an important role. Aoki (1994) discusses the importance of bank reputation in inducing a main bank to rescue its distressed borrowers in Japan.

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Although the importance of reputation in banking is well studied, our understanding about the effects of credit market competition on a bank reputation mechanism is limited because much of the existing theory assumes the bank's return to be independent from the competition it faces. This leaves many important questions unanswered: Is a reputation mechanism sustainable with increased competition? Does it matter if the competition comes mainly from security markets instead of other banks? To what type of borrower does a bank offer to lend with commitment? How do the characteristics of these borrowers change with increased competition?

This article examines how credit market competition changes the effectiveness of bank reputation in enforcing a bank's commitment. It provides a theory in which the bank's incentive to keep its commitment is derived as a function of (1) its reputation, (2) the number of competing banks and their reputation, and (3) the competition from bond markets. The type of borrower that is offered bank commitments is also determined.

A bank can provide *arm's length lending* in which the bank makes no commitment to future refinancing if the borrower experiences financial distress. A bank with a good reputation can also provide *relationship lending* in which the bank promises refinancing, which may be costly to the bank in the short term. The difference between the future (discounted) expected return from arm's length lending and that of relationship lending determines the bank's incentive to incur any short-term cost to keep its commitment and maintain a good reputation.

An increase in credit market competition may decrease the bank's return from relationship lending. Whether this decrease weakens the bank's incentive to maintain a good reputation depends, however, on how the same increase in competition affects the bank's return from arm's length lending, which does not require a good reputation. In particular, if the increased competition decreases the bank's return from arm's length lending more than it decreases its return from relationship lending, the additional competition *strengthens* the bank's incentive to maintain a good reputation. Thus it can be misleading to conclude that any increase in credit market competition that decreases the bank's return from relationship lending is necessarily harmful for the effectiveness of a reputation mechanism. This article shows that whether the additional competition is beneficial or harmful depends both on the *source* of competition and the *level* of competition.

To understand why the source of an increase in credit market competition can be important, consider the case in which borrowers that could previously borrow only from banks gain access to bond markets. Bonds are a closer substitute for arm's length lending than relationship lending. Hence when a bank faces competition from bond markets, its profit from arm's length loans decreases more than its profit from relationship lending. This asymmetric effect increases the bank's incentive to keep its commitment in relationship lending (i.e., maintaining a good reputation), although its profits from it decrease.

The level of competition is also important because an increase in the number of banks may have a nonmonotonic effect on the feasibility of a reputation mechanism. If the banks have large market power, they already earn so much from arm's length loans that any additional return they can capture does not justify the cost of a commitment. On the other hand, reputational rents ultimately decrease with the number of banks that have a good reputation, which makes the reputation mechanism most effective with an intermediate number of banks.

This article also makes predictions about the type of borrower to which a bank offers relationship lending. The bank offers relationship lending to borrowers with the highest credit quality because only these borrowers have a sufficiently high net return from their projects to cover the commitment costs. The bank offers to give only arm's length loans to medium-quality borrowers, and it refuses to lend to the lowest level altogether. Whether a borrower is offered relationship lending or not also depends on the competition the bank faces. In particular, since the funds raised in the bond market are a closer substitute for arm's length loans, the competition from bond markets forces the bank to lower the threshold above which it offers relationship lending.

This article sheds light on several trends in banking. One is the *deregulation* of capital markets that is taking place in many countries, including Japan and the European Union. The impact of deregulation is reinforced by another trend, the closer *integration* of financial markets. An important concern is how the resulting increase in competition will affect relationship lending. Indeed, as argued by Allen and Gale (1998), the importance of relationship lending—or lack thereof—is an important difference among financial systems. This article shows that not only do the bank's incentives to invest in these lending relationships survive the increased competition, but they may even be strengthened, provided that borrowers continue to value these relationships.[3]

Disintermediation is a trend in which borrowers increasingly use security markets to raise funds instead of borrowing directly from banks. An interesting aspect of this trend is that banks continue to play a role even if they do not provide the funds, because the securities the borrowers issue are often "backed up" by loan commitments from banks. How the capital market competition affects the bank's incentive to monitor the borrower, and ultimately honor its commitment, is an open question. This article shows that capital market competition may actually enhance a bank's incentive to honor its commitment, although the competition decreases its profit from doing so.

[3] See Aoki and Dinç (2000) for a discussion of the Japanese case.

Finally, bank *mergers*, some of them of unprecedented magnitude, are an important trend worldwide. An important issue is whether a bank will continue to honor its commitments if the increase in its market power following a merger makes its borrowers reluctant to "punish" that bank by deserting it if it does not keep its promises. This article demonstrates that the borrowers' easier access to capital markets decreases the minimum number of banks necessary to sustain a reputation mechanism and hence mitigates the potential negative effects of mergers.

Petersen and Rajan (1995) study the borrower's commitment problem to share future surplus with the bank; inability to commit may prevent the borrower from obtaining funds for a project. The market power of a bank in the credit market mitigates this commitment problem by allowing the bank to capture in relationship lending some of the borrower's future surplus. Petersen and Rajan show that an increase in the credit market competition, which decreases the bank's market power and weakens the bank's incentive to offer funds at the beginning, has a negative effect on relationship lending. Alternatively, this article studies the bank's commitment problem to lend to a borrower in temporary distress after financing that borrower in "good" times. In the model, the bank can offer relationship lending or arm's length lending to a borrower based on the borrower's credit quality. Unlike the borrower's commitment problem in Petersen and Rajan, an increase in the credit market competition may help mitigate the bank's commitment problem in relationship lending. This article demonstrates that the effect of any increase in credit market competition is not uniform, but depends both on the source and the level of competition. It also provides empirically testable predictions about the type of borrowers that are offered relationship lending and how their characteristics change with an increase in credit market competition.

Boot and Thakor (1999) also study the viability of relationship lending under increasing competition. They show that initially the expected amount of relationship lending increases, but it decreases as competition escalates. In addition, they find that capital market competition causes the bank to increase its relationship lending relative to its arm's length lending. Although these results are similar, different empirical implications about the type of borrower that is offered relationship lending are obtained in this article.[4] This article predicts that (1) higher-quality borrowers are offered loans with commitment, but the threshold of creditworthiness above which a loan with commitment is offered decreases with competition, and (2) bond markets decrease the minimum number of banks necessary to sustain a reputation mechanism. Boot and

[4] Among the major differences that lead to different predictions are (1) entry restrictions in banking and the bank's credit screening ability are the sources of bank rents in this article (in addition to any reputational rents) while it is the access to cheaper core deposits in Boot and Thakor (1999); (2) the bank's return from relationship lending depends only on the number of other banks in Boot and Thakor, while it also depends on their reputation and the borrower's access to bond markets in this article. The second difference leads to more precise predictions about the effects of increasing competition in this article.

Thakor offer opposite predictions for the first and have no counterpart for the second, as the existence of relationship lending (but not its importance relative to arm's length lending) is independent of the borrowers' access to bond markets in their article. The predictions in this article appear to be consistent with the existing empirical literature, as discussed in the conclusion.

The rest of the article is organized as follows. Section 1 presents the model. Section 2 provides a preliminary analysis, which shows that the assumption of decreasing market power with increasing competition has, by itself, only ambiguous implications. Accordingly, the model is extended in Section 3 to derive a bank's market power as a function of the number of competing banks. The effects of an increase in the credit market competition are examined in Section 4, where both an increase in the number of banks as well as the borrowers' access to bond markets are considered. Section 5 discusses the robustness of the findings. The final section concludes.

1. The Model

Entrepreneur: Consider a risk-neutral entrepreneur who has a two-subperiod project.[5] The project requires one unit of capital at date 0 and returns are obtained at date 2. At date 1, the project can be at one of three states: success, distress, or failure with probability p_S, p_D, and p_F, respectively. In success, the project returns a cash flow R_S and nontransferable control benefits C_S to the entrepreneur. These benefits can be prestige, perks, or rents to the entrepreneur from an accumulated knowledge about the project as well as the expected return from being able to undertake future projects upon the successful completion of the current one. In failure, both cash and nontransferable returns are zero. In distress, the returns are the same as in failure, unless the entrepreneur further invests one unit of capital at date 1. In that case, cash and nontransferable returns are R_D and C_D. This additional investment will be referred to as *rescue* investment. Any such investment in other states is wasted. The project has no liquidation value and there is no discounting between subperiods. The following parametric assumptions are made.

Assumption 1.

(i) $R_D < 1$
(ii) $R_D + C_D > 1$
(iii) $p_S R_S - p_D(1 - R_D) > 1$
(iv) $p_S R_S + p_D R_D < 2$

Assumption 1(i) implies that investing an additional unit in a distressed project has a negative net present value (NPV) if only cash returns are considered. Assumption 1(ii) states that a distressed project has positive NPV

[5] This game will be the stage game when its infinitely repeated version is studied. The term *subperiod* is used now since the term *period* in repeated games is traditionally reserved for the time during which the stage game takes place.

if the nontransferable returns to the entrepreneur are also included. Assumption 1(iii) implies that the project has a positive expected NPV in cash returns at date 0, including the (cash) losses from further investing at the distressed state. Assumption 1(iv) states that the borrower cannot borrow rescue funds at date 0 to use them in case of distress at date 1.

Lenders: The entrepreneur has no funds, but can borrow from a type of institutional lender, or, simply, a "bank." To model the market power of banks in the credit market, it is assumed that the banks have a riskless lending opportunity at date 0 that gives them a net return $M > 0$ at date 2. The model will be extended in Section 3 to determine endogenously a bank's market power and its lending strategy as a function of the number of competing banks. The bondholders will be introduced in Section 4.

Information and contracts: The uncertainty about the project state is revealed at date 1 and, while it can be publicly observed, it cannot be verified in courts. The cash returns are verifiable at date 2 without cost. This article focuses on debt contracts. One way to justify this focus is that equity contracts may be too risky for the lenders.

The time line of this two-subperiod game is summarized as follows:

Date 0: The bank determines the interest factor (one plus the interest rate). The entrepreneur borrows funds and undertakes the project.
Date 1: The project state is revealed and publicly observed. In the distressed state, the bank decides whether to offer a rescue credit. If provided with funds, the entrepreneur undertakes the rescue investment.
Date 2: The returns are obtained; payments are made.

2. Preliminary Analysis

2.1 One-shot lending

In a subgame perfect equilibrium, the bank must be provided with incentives to offer rescue financing in the distressed state. Since the project state is not verifiable, these incentives cannot be provided by court-enforced contractual clauses that oblige the bank to give a rescue loan in a distressed state but not in others. The bank therefore provides rescue financing only if the cash returns in a distressed state are sufficient to pay back the loan. By Assumption 1(i), they are not; hence the bank does not provide rescue financing in a distressed state in a subgame perfect equilibrium.

Proposition 1. *The following strategy profile is the subgame perfect equilibrium: At $t = 0$, the bank lends one unit with the interest factor (one plus the interest rate) b, where:*

$$b = \frac{1 + M}{p_S} \tag{1}$$

At $t = 1$, if the project is in distress, the bank does not rescue the entrepreneur.

It is important to consider whether an equity contract could induce the bank to provide rescue funds. If the equity contract allows the bank to capture some of the entrepreneur's control benefits, the bank might indeed have an incentive to rescue the entrepreneur. The control benefits may, however, include future returns to the entrepreneur, who may not be forced to distribute dividends [Hart and Moore (1989, 1994)].[6] Furthermore, the bank is unlikely to capture any managerial perks.

More complicated contracts, even if they are feasible,[7] are not likely to improve efficiency either, as long as the project state at date 1 and the entrepreneur's control benefits remain unverifiable in court. However, it is useful to examine why the contracts that give the entrepreneur the option to borrow one unit at date 1 are not feasible. The entrepreneur would use that option not only in distress, but also in failure. Thus any such option would also have to give the bank the discretion to refuse the loan in the failure state but to impose costs to the bank if it also refused to lend in the distressed state. Since the project state is not verifiable, such discretion and costs cannot be contracted upon; hence that discretion must be provided within a different institutional arrangement. The following subsection analyzes one of the most common of such institutions, namely, bank reputation.

2.2 Bank commitment in repeated lending

Banks are not one-time, anonymous participants in the credit market; they engage in repeated lending with many borrowers. This repeated, nonanonymous nature of bank lending might make a reputation mechanism feasible to enforce bank commitments.[8] Accordingly, an infinitely repeated game framework is used to analyze whether a bank's commitment to rescue an entrepreneur in distress can be enforced by bank reputation. In the repeated games terminology, the investment game of the previous section becomes the *stage game* of the repeated game. The length of the stage game is referred to as a *period*. A common discount factor $\delta < 1$ is assumed between the periods, with no discounting within a period. The entrepreneurs exit the economy

[6] The entrepreneurs can provide themselves with large salaries instead of distributing dividends or can do business with companies that are self-owned; these possibilities also rule out preferred shares as a way to mitigate the bank commitment problem.

[7] See Hart (1995) for why such contracts may not be feasible.

[8] Reflections of a bank's concern for its reputation are often seen in the popular press. Yoh Kurosawa, the deputy president of Industrial Bank of Japan, explains their incentive as the main bank to rescue a distressed borrower by stating that "[o]ur reputation is that we never let a client go bust," [*Economist* (October 17, 1987)]. Indeed, banks may go to great lengths to keep a good reputation. After real estate prices in Japan suddenly and drastically declined in 1991, the banks continued to support even the companies that had clearly gambled. The banks' motives were interpreted by one analyst with Nikko Research Center Ltd. as "[b]anks have been supporting deadlocked debtors to save face as main banks, but current public opinion is that banks are better off disposing of non-working assets for their health," [*Nikkei Weekly* (August 2, 1993)]. The difference between the main bank loans that include a rescue commitment and the bank loans without such commitment also seems to be clearly recognized. When Azabu Tatenomo Co., a real estate company that faced large debts after investing heavily during the 1980s, rejected the Mitsui Bank's conditions for a rescue, Mitsui Bank declared that "[they] will have to change from being the main bank to a legalistic relationship of creditor and debtor," [*Japan Economic Newswire* (March 11, 1993)].

after one period, while the banks live infinitely long. This assumption allows for a focus on the bank's commitment problem by abstracting from the possibility of the entrepreneur's commitment to borrow from the same bank in the future. It is also assumed that the history of the economy is common knowledge and that a bank, for simplicity, only lends to one entrepreneur in a given period.

Consider now a reputation mechanism with the following features: At $t = 0$ in a given period the bank commits to a rescue if the project is in distress at $t = 1$ (in the same period). If it does not rescue the entrepreneur in the distressed state, it loses its good reputation and no other entrepreneur will ever take a loan with a rescue commitment from that bank again. Since an entrepreneur can borrow from another bank, this threat is credible. By not rescuing, the bank saves the rescue costs but loses future return from lending with a rescue commitment. If the present value of such losses is greater than the rescue cost, this reputation mechanism can enforce a bank's commitment.

Some additional terminology and notation will facilitate the formal statement of a repeated game equilibrium. The term *relationship lending* is used interchangeably with loans with commitment, and *arm's length lending* with loans without commitment. Let M^G, with $M \leq M^G$, denote the market power of a bank with a good reputation when the bank lends with the promise of rescue. Although M^G depends on the number of competing banks with the same reputation, as shown in the next section, it is taken as given in this section in order to focus on the equilibrium features. To avoid triviality, it is assumed that the entrepreneur prefers to borrow with a bank commitment, that is,

Assumption 2. $p_D C_D \geq M^G - M$.

Proposition 2. *Consider the following strategy profile of the repeated game: At $t = 0$ in a given period the entrepreneur borrows from a bank that has never shirked from rescuing. At $t = 1$, if the project is in distress, the bank rescues the entrepreneur. If it fails to do so, future entrepreneurs do not borrow from that bank; if an entrepreneur borrows, the bank does not rescue the entrepreneur. If*

$$M^G - M > p_D(1 - R_D) \tag{2}$$

then there exists a $\bar{\delta}$, where

$$\bar{\delta} = \frac{1 - R_D}{M^G - M + (1 - p_D)(1 - R_D)} \tag{3}$$

such that for $\delta \geq \bar{\delta}$ this strategy profile is a subgame perfect equilibrium of the repeated game.

Proof. Let $W^G(\delta)$ and $W(\delta)$ be the present value of a bank's net return on the equilibrium path and on the punishment path while being punished, respectively. Then

$$W^G(\delta) = \frac{M^G - p_D(1 - R_D)}{1 - \delta} \quad \text{and} \quad W(\delta) = \frac{M}{1 - \delta}. \tag{4}$$

It is only necessary to verify that a one-shot deviation on the equilibrium path is not beneficial. The bank's incentive constraint to rescue an entrepreneur in distress is given by

$$R_D - 1 + \delta W^G(\delta) \geq \delta W(\delta). \tag{5}$$

Equation (2) is a necessary and sufficient condition for Equation (5) to be satisfied for some δ. Equation (3) then follows. The interest factor b^G is then given by

$$b^G = \frac{1 + M^G}{p_S}. \tag{6}$$

On the punishment path, the entrepreneur has no incentive to borrow from the deviant bank because a loan can be obtained with a commitment from another bank. Finally, the deviant bank has no incentive to rescue a distressed borrower, as no future entrepreneur will believe its commitment once it has shirked. **Q.E.D.**

The bank does not rescue every entrepreneur who is unable to meet debt obligations; the genuine failures are not provided with credit. This feature of the equilibrium is similar to the material adverse change clause that is observed in virtually all loan commitment contracts [Shockley and Thakor (1997)]. This clause gives the bank the right not to honor its commitment. If the public state is not perfectly and publicly observed, the use of this clause may have reputational costs to the bank. However, the banks and the entrepreneurs may still prefer loan commitment contracts to other feasible contracts [Boot, Greenbaum, and Thakor (1993)].

The assumption about the perfect public observability of the distressed state facilitates the analysis, but the equilibrium is robust to that assumption. Even if the distressed state cannot be distinguished from the failure state by outsiders, a bank rescue can still be observed because it is likely to include a significant restructuring in the firm with possible asset sales. If a bank denies the occurrence of the distressed state to avoid rescue costs, its rescues—and all the observable activities associated with it—will have a different frequency from the rescues by a bank that keeps its commitment. A finding by Fudenberg, Levine, and Maskin (1994) implies that this difference is sufficient for a similar repeated game equilibrium to exist.[9]

Proposition 2 gives the conditions for a reputation equilibrium. As is typical in repeated games, this is not the only equilibrium. The stage game equilibrium given in Proposition 1 is also an equilibrium when it is repeated every period. In this article I abstract away from how a reputational equilibrium is selected or how the banks build their reputation. The focus here is on the feasibility of building a reputation and on the effects of competition once banks have built their reputation.

Equations (2) and (3) hint at the nontrivial impact of bank competition on the reputation mechanism. Equation (3) indicates that whether a reputation mechanism is feasible or not does not depend on the bank's market power per se, but on the *difference* between the bank's market power when it has a good reputation and its power without such a reputation. In particular, even if an increase in competition decreases the bank's market power, it may be easier to sustain a reputation mechanism if this difference increases. This gives the following corollary.

Corollary 1. *$\bar{\delta}$ decreases—and the reputation mechanism becomes easier to sustain—as $M^G - M$ increases. In particular, $\bar{\delta}$ decreases if an increase in competition decreases both and M^G and M but increases $M^G - M$.*

It may seem that Equation (2) can be easily satisfied if the entrepreneurs voluntarily leave more of the project return to the bank whenever the bank's market power is not enough to induce it to keep its commitment. The entrepreneur can, after all, increase the bank's return by purchasing additional services from the bank and/or by concentrating all their borrowing needs on one bank to give information rents. Although these practices are indeed observed in reality, they will have only a limited effect for at least two reasons. First, the asymmetric information problems between a borrower and a lender limit the effectiveness of such practices; borrowers with the highest probability of requiring a rescue will be the most willing to offer such concessions to a bank. Second, what the entrepreneur can voluntarily leave to the bank is limited by the total cash return from the project. This is likely to be a problem when a bank's market power in lending without a commitment is already large.

Thus the mere assumption that a bank's market power decreases with an increase in competition has ambiguous implications. For a theory with more

[9] Technically speaking, suppose the project state is observable only by the bank but not by the public. There are two *pure actions* the bank can take: rescue and not rescue. The probability distributions induced by these actions on the publicly observable outcome (date 2 returns) are linearly independent of each other. Hence the action profile that prescribes rescue when the entrepreneur is in distress but not otherwise has *individual full rank* [Definition 5.1 in Fudenberg, Levine, and Maskin (1994, p. 1014)]. Consequently, Condition 2 (p. 1021) is trivially satisfied and the Nash-threat folk theorem 6.1 (p. 1022) follows. Unfortunately this theorem only gives the existence of an equilibrium; it does not give the equilibrium strategy profile.

powerful implications, a bank's market power and its lending strategy must instead be determined endogenously as a function of the competition the bank faces.

3. Equilibrium with Bank Competition

To determine a bank's market power and its lending strategy endogenously as a function of the number of its competitors, the model is extended to incorporate one of the main characteristics of banks as institutional lenders: information processing capabilities that mitigate the asymmetric information problem in creditor-debtor transactions.[10] This article focuses on the credit screening activities of banks before they offer a loan. The analysis below follows Dinç (1997), showing that the credit screening abilities of banks are enough to give them market power in the credit market when there are entry restrictions in banking.

Consider a second type of entrepreneur who always fails. These entrepreneurs are referred to as "bad" and those described earlier as "good." An entrepreneur is of the good type with probability λ. The entrepreneur's type is her private information at date 0. Each bank screens the entrepreneur by obtaining a costless signal at date 0. These signals are correlated with the entrepreneur's type but are subject to errors that are independent across banks. In particular, it is assumed that bank i obtains the signal x_i that is real valued and has full support over $[\underline{x}, \bar{x}]$ for any given type θ of the entrepreneur. Given the nontransferable nature of the information obtained in the credit screening, it is assumed that each bank's signal is its private information. The signals are identically and, conditional on the entrepreneur's type θ, independently distributed across banks with conditional density function $f(x|\theta)$. The standard assumption that $f(x|\theta)$ satisfies the monotone likelihood ratio property (MLRP) is adopted, that is,

Assumption 3 (MLRP). *$f(x|\theta = G)/f(x|\theta = B)$ increases in x.*

Therefore if a bank obtains the signal x, its probability estimate $\mu(x)$ that the entrepreneur is of the good type is given by

$$\Pr(\theta = G|x) = \frac{\lambda f(x|\theta = G)}{\lambda f(x|\theta = G) + (1-\lambda) f(x|\theta = B)} \equiv \mu(x). \qquad (7)$$

Notice that $\mu(x)$ is increasing in x by Assumption 3. It is assumed that lending and rescuing an entrepreneur is a positive-NPV project for the bank

[10] For theoretical arguments see, for example, Leland and Pyle (1977), Campbell and Kracaw (1980), Diamond (1984, 1991), and Fama (1985). For empirical evidence, see, for example, James (1987), Lummer and McConnell (1989), Hoshi, Kashyap, and Scharfstein (1990), James and Wier (1990), Petersen and Rajan (1994), Berger and Udell (1995).

if its signal indicates sufficiently good credit quality, that is,

Assumption 4. $\mu(\bar{x})(p_S R_S - p_D(1 - R_D)) - 1 > 0.$

At date 0, the entrepreneur asks each bank the interest rate it demands for a unit loan. Each bank quotes its interest rate without observing the quotations of other banks; the entrepreneur selects the bank that offers the lowest rate. The bank has the option to refuse to lend. The analysis that follows focuses on the symmetric equilibrium that banks with the same reputation have the same strategies.[11]

3.1 One-shot lending

The equilibrium in the one-shot lending game has the same features as stated earlier, except the determination of the interest rate. A bank with a low estimate $\mu(x)$—or with a low signal x—refuses to lend; hence there is a threshold of x below which the bank does not lend. However, the calculation of this threshold and of the interest rate the bank quotes when it lends is not immediate due to the "winner's curse." Technically this bank competition model is a sealed-bid, first-price, common-value auction; thus the insights developed in other contexts are valid [see Milgrom and Weber (1982)].

To gain intuition about the winner's curse and a bank's strategy in determining the interest rate quoted at equilibrium, suppose that the rate the bank quotes decreases with $\mu(x)$—hence with its signal x (this is indeed the case in equilibrium). Consequently a bank lends only if it quotes the lowest interest rate. In a symmetric equilibrium, this implies that the bank's loan offer is taken if it has the highest estimate $\mu(x)$, or equivalently, the highest signal x, among all the banks. Therefore the bank that gets to lend is the most optimistic bank about the entrepreneur's prospects as its signal provides an upper bound on the signals of all other banks. Consequently, a bank chooses its quote to maximize its expected profit based on not only its own signal, but also the fact that winning the competition gives an upper bound on the other banks' signals.

Proposition 3 (Arms's length lending). *The following strategy profile is the (symmetric) subgame perfect equilibrium of the (stage) game: At $t = 0$, the interest factor demanded by a bank is given by the decreasing function $b_N(x)$ for $x \geq x_N$—derived in the appendix—with no loan offered for $x < x_N$, where x_N decreases with λ.*[12] *The entrepreneur borrows from the bank that*

[11] This article shares the same bank competition model with Rajan (1992) with the important exception of the information structure. In Rajan, one bank (the insider) knows everything—and more—the other banks (outsiders) know about the borrower. In this model, all the banks are symmetric at the time of competition in the sense that (i) none of them has access to what the other banks know about the borrower; and (ii) all the banks have the same credit screening technology. The information structure of this model is closer to Broecker (1990) and Thakor (1996).

[12] "N" mnemonic for no commitment.

demands the smallest interest factor. If the loan is not obtained, the project is not undertaken. At $t = 1$, if the project is in distress, no bank rescues the entrepreneur. The expected profit of each bank at date 0 is positive; it decreases with the number of banks and converges to zero as the number of banks goes to infinity. There is no subgame perfect equilibrium in which the bank rescues the entrepreneur in distress.

Proof. See the appendix.

An important feature of this model is that it derives both a bank's market power and its lending strategy with respect to the number of banks. Although the economic intuition behind the positive profits of the banks is the same as those of the bidders in mineral rights auctions [Milgrom and Weber (1982)], it is worth discussing how the banks with the same screening technology and no inside information make positive profits. Each bank bases its strategy on its signal about the entrepreneur; consequently the probability of winning the competition for a given bank, and thus the bank's return, depends on other banks' signals as well. However, each bank's signal is its private information. The private nature of these signals gives the bank a rent to private information. As the bank always has the option of not offering a loan when it expects losses, this information rent leads to positive expected profits when the entry into banking is restricted.[13,14]

3.2 Bank commitment in repeated lending

The equilibrium strategy profile presented in Proposition 2 is maintained when the bank commits to rescuing in the distressed state, but the lending strategy of the banks is modified. To allow a bank to offer loans both with a rescue commitment and without, it is assumed that whether a loan carries a rescue commitment or not is publicly observed.[15]

The lending strategy of banks that commit to rescue is similar to their strategy when they do not commit except for one important difference. A bank's

[13] For a more technical intuition about why banks earn positive profits, suppose that they do not. If the bidding function b_N leaves the bank with zero expected profits before obtaining signal x, then the bank must also make zero profits for any signal x (otherwise, for the range of x where the bank makes a negative profit, the bank could do better by not bidding). Suppose for some $x > x_N$ the bank bids slightly higher than $b_N(x)$. The probability that it wins the bidding then decreases, but it would make a positive profit when it wins. Therefore the bank could do better by deviating from b_N, which contradicts the fact that b_N is an equilibrium bidding function.

[14] The different information structure in this article gives a very different result from the one in Rajan (1992), who adopts the same competition model. In Rajan, the insider bank not only has better information about the entrepreneur than other banks, but it also knows what the others know about the entrepreneur. Since the information of each outside bank is not its private information, each makes zero profit and their number has no effect for the inside bank's rent.

[15] An important lending practice in which a bank's reputation enforces its rescue commitment is the main bank lending in Japan. Although this commitment is implicit, it is publicly known which bank acts as a main bank for a given company [see Aoki, Patrick, and Sheard (1994)]. The observability of the bank commitment is, of course, not an issue for loan commitment contracts in the United States.

lending strategy now has a three-tiered structure with respect to its signal instead of two. At the top range, it offers a loan with commitment, while its loan offer does not carry a commitment at the middle range. The bank refuses to lend at the lower range. For intuition, suppose that the entrepreneur always prefers to be rescued even if all the cash return has to be left to the bank in the success state. If the bank lends to a good type with a rescue commitment for a given interest factor b, its expected net return at date 0 is

$$p_S b - p_D(1 - R_D) - 1, \tag{8}$$

which is less than what it would be without a rescue commitment. The interest factor the bank can demand is naturally bounded from above by the available cash return, so the threshold below which the bank does not lend with a commitment is higher than the threshold for a loan without a commitment. This three-tiered lending strategy is consistent with the empirical evidence on loan commitment contracts in the United States [see Avery and Berger (1991), Qi and Shockley (1995)].

However, the lending strategies of banks on the punishment path (i.e., the deviant bank cannot lend with a commitment while all the others can) are very complicated to derive explicitly for generic parameters because the symmetry among the banks is lost.[16] To simplify the derivation, the private benefits an entrepreneur obtains from refinancing in the distressed state are assumed to be sufficiently high. Thus even if a bank offers relationship lending in exchange for all the cash return in the success state, its offer cannot be undercut by a bank that offers only an arm's length loan.

Assumption 5. $p_D C_D \geq p_S R_S - 1.$

Proposition 4 (Relationship lending). *Consider the following modifications in the strategy profile given in Proposition 2 (b_C and x_C are derived in the appendix).*[17]

Equilibrium path: At $t = 0$ in a given period, the bank lending strategies are given by

$b_C(x)$ *and the bank commits to rescue,*	*for* $x \geq x_C$
$b_N(x)$ *and the bank does not commit to rescue,*	*for* $x_N \leq x < x_C$
no loan,	*for* $x < x_N$

where b_N and x_N are as given in Proposition 3.
The entrepreneur considers an offer with a rescue commitment only if the bank has never shirked from rescuing. At $t = 1$, if the project is in distress

[16] The derivation of equilibrium strategies in a sealed-bid, first-price, common-value auction with n bidders who have *asymmetric* payoff functions is an open question in auction theory. Thus reputation building by banks is not modeled explicitly here, as reputation building inherently involves asymmetries among banks.

[17] "*C*" mnemonic for commitment.

and the loan carries a rescue commitment, the bank that lends at $t = 0$ rescues the entrepreneur.

Punishment path: The deviant bank offers only loans without a commitment while all the other banks adopt a similar three-tiered lending strategy as on the equilibrium path. (The exact lending strategies are given in the appendix.)

There exists $\bar{n} \geq 2$ such that for $n \geq \bar{n}$ a subgame perfect (repeated game) equilibrium with features given earlier exists for $\delta \geq \bar{\delta}(n)$. For all $n < \bar{n}$ no subgame perfect equilibrium with these features exists for any $\delta < 1$.

Proof. See the appendix.

In three-tiered lending strategies, banks offer a rescue commitment—and incur rescue costs in distress—only if a borrower is a good credit risk. Accordingly the bank's profit shows a qualitative difference between x_C and x_N. Although the reason for the existence of a middle range $[x_N, x_C)$ in bank strategies is the rescue cost, x_C is not the threshold below which the bank makes expected loses if it lends with a commitment. Instead, x_C is the level at which the bank is indifferent between lending with a commitment for all of the cash return in the success state and lending without a commitment at the (lower) equilibrium bid. Since the bank makes positive expected profits from lending without a commitment when $x > x_N$, it also makes positive profits if it lends with a commitment at $x = x_C$. However, the bank is indifferent at $x = x_N$ to lending at all, for the bank's profit is zero at $x = x_N$.

A deviant bank can still make positive profits on the punishment path due to information rents discussed earlier. However, its expected profit is less than the profit of a bank with a good reputation on the equilibrium path. This difference, which induces the bank to keep a good reputation for high δ, can be interpreted as rents to reputation.

An important aspect of the equilibrium is that it exists only if there is a sufficient number of competing banks. In fact, the reputation mechanism cannot be sustained with a monopolist bank and it may take more than a duopoly to sustain it. For example, if the monopolist bank judges an entrepreneur creditworthy, it sets the interest rate such that it receives all the cash return in the success state. Since it already receives all it can, it has no incentive to commit to a rescue and incur costs; therefore lending without a commitment is more profitable.

Corollary 2. *The monopolist bank has no incentive to commit to a rescue.*

By the same reasoning, the condition $\bar{n} \geq 2$ may hold as a strict inequality.[18] The profit from arm's length lending decreases to zero as the number of banks increases; after a threshold, relationship lending becomes more profitable if the entrepreneur is sufficiently creditworthy.

[18] By making the left-hand side of Assumption 4 arbitrarily small, $\bar{n}$ can be made arbitrarily large.

4. The Effects of Competition

4.1 Entry of new banks

An important issue is whether new banks can provide relationship lending. Depending on δ, there exist multiple equilibria that differ as to whether new banks can provide relationship lending; the repeated game theory is silent in equilibrium selection. Since reputation building by banks is not modeled explicitly,[19] the entry of banks is studied under two different assumptions.

4.1.1 Entry of new banks that can commit to rescue. It is helpful to start with a study of the limit behavior when the number of banks that can provide relationship lending goes to infinity. At the limit, the minimum discount factor that sustains a reputation mechanism converges to 1. Intuitively, as the number of banks with a good reputation increases, the rent to a good reputation converges to zero; hence it becomes more difficult to sustain the reputation mechanism.

Proposition 5. $\lim_{n\to\infty} \bar{\delta}(n) = 1$.

Proof. See the appendix.

This finding is consistent with the view that commitment is difficult to sustain by a reputation mechanism with fierce competition. Notice, however, that this is a limit result. It does not imply that the reputation mechanism becomes monotonically more difficult as the number of banks increases. In fact, Propositions 4 and 5 together establish the lack of any such monotonicity. They imply that additional competition may be beneficial to sustain a reputation mechanism when the number of banks is small; hence an intermediate number of banks is optimal.

Corollary 3. *It is easiest to sustain a reputation mechanism with an intermediate number of banks, that is,* $\bar{\delta}(n)$ *is minimized at* n^* *where* $1 < n^* < \infty$.

4.1.2 Entry of new banks that cannot commit to rescue. At the other extreme, the entry of banks that cannot commit affects directly the competition for arm's length loans. This is sufficient, however, for the banks that can provide relationship lending to change their equilibrium behavior. As the market for arm's length loans becomes more competitive with new banks, the return from such loans decreases. Thus relationship lending becomes more profitable for the banks that give these loans relative to arm's length lending.

[19] The model can be modified where rescues require certain banking skills, for example, intense monitoring, but the banks have heterogeneous skills and their skills are their private information. The capable banks would build a reputation by gradually revealing their type. The analysis of bank competition in that context is very complicated, however, because the symmetry among banks is lost (see note 16). A natural conjecture would be that whenever the competition enhances the reputation mechanism in the model, it would also facilitate reputation building of capable banks.

These banks decrease the minimum credit quality they demand to extend relationship lending and the share of relationship lending increases in their loan portfolios. Even though new entrants only provide arm's length lending, relationship lending becomes easier to obtain from banks with a good reputation.

The entry of banks that cannot commit also extends the range of parameters where the reputation mechanism can be sustainable. Recall that if a bank with a good reputation does not keep its commitment, it tarnishes its reputation and it can then provide only arm's length loans. The entry of new banks decreases the return from such loans, and, hence, it decreases the return from not keeping a commitment. This enhances a bank's incentive to keep its commitment and the reputation mechanism becomes easier to sustain with the entry of banks that cannot provide relationship lending. Thus an increase in competition increases the effectiveness of a reputation mechanism.

Proposition 6. *The entry of banks that cannot commit makes the reputation mechanism easier to sustain and lowers the minimum credit quality demanded for relationship lending, that is, $\bar{\delta}(n)$, $\bar{n}$, and x_C decrease with the number of banks that cannot commit.*

Proof. See the appendix.

4.2 Competition from security markets

Banks face increasing competition from bond and commercial paper markets, since the funds raised in these markets are close—but not perfect—substitutes for bank loans. The effect of this competition is likely to be different on different types of loans. In fact, one of the conditions for a reputation mechanism to be effective is the identifiability of the lender that makes a commitment. The anonymous and diffuse nature of security markets does not allow the reputation mechanism to be an enforcement mechanism for a security holder's commitment [Chemmanur and Fulghieri (1994)]. Funds raised through these markets are a closer substitute for arm's length loans than for relationship loans. This difference makes the competition from security markets similar to the competition from the entry of banks that cannot commit; it decreases the return to a deviant bank more than it does to a bank that keeps its commitment.

The model is modified to incorporate bond issues by entrepreneurs. At date 0, the entrepreneur decides on the fraction to be raised by bond issues. This may be different for different types of loans. Banks make offers for loans. To minimize the signaling issues and focus on bank reputation, it is assumed that bondholders observe only whether the loan is obtained and the type of loan—arm's length or relationship—but not the default premium on loans. Bondholders do not have any credit screening capabilities, unlike banks, so they make zero expected profits. Although the debt priority structure is not essential for the results, it is assumed for concreteness that the bonds have seniority over bank loans.[20]

Proposition 7 (Relationship lending with bond markets). *There is a relationship lending equilibrium at which the entrepreneurs raise a fraction of their needs by issuing bonds; the bank provides the rest through a loan with a commitment to rescue. The borrower's access to bond markets makes the relationship lending easier to sustain and lowers the minimum credit quality demanded for loans with commitment, that is,* $\bar{\delta}(n)$, $\bar{n}$, *and* x_C *decrease with the borrower's access to bond markets.*

Proof. See the appendix.

This finding indicates that the idea that bond markets are not compatible with banking relationships is not necessarily correct as far as the bank's incentives to commit to a rescue are concerned. First, it shows that raising funds through the bond market and maintaining a lending relationship are not mutually exclusive for a borrower. The borrower raises some funds by issuing bonds while also obtaining relationship lending. Second, the borrower's access to a bond market does not limit the bank's ability to commit to a costly rescue, but, in fact, it enhances its incentives to do so. This is true, although the bank's return from relationship lending decreases with competition from the bond market. Relationship lending becomes easier to sustain and the necessary number of banks for an effective reputation mechanism declines. Finally, competition from bond markets forces banks to offer relationship lending to borrowers with lower credit quality.

5. Robustness

5.1 Bank competition

While this article adopts a specific bank competition model to analyze bank strategies and returns, the finding that banks make positive profits under restricted entry depends not on the specific game form, but on the private information a bank obtains by credit screening. This suggests that the finding about the effects of competition on bank reputation is valid for different bank competition models, including when the entrepreneur approaches banks sequentially, as long as a bank's screening results are not observed—or inferred—by other banks before they make their own loan offers [see Dinç (1997) for a more detailed discussion].

[20] The model can also be modified in such a way that the entrepreneur uses the bank commitment to back up its obligations to bondholders.

5.2 Costly screening

Although this article assumes zero screening costs for banks, the results are robust as long as screening costs are not too large. If a bank incurs a (fixed) screening cost, the size of the cost determines whether the bank makes ex ante positive profits. If the screening cost is less than the expected profit, every bank screens and participates in the bidding; the qualitative results remain unchanged. If the cost is high with respect to the loan size and the number of competing banks, each bank plays a mixed strategy in screening and participating in the bidding. The mixing probability is determined such that each bank makes zero expected profits. Which case is relevant is, of course, an empirical question. However, one immediate implication of large screening costs is that an increase in the number of banks does not change the (average) number of banks that bid for the loan. It only decreases the probability with which a bank screens and participates in the bidding process; the equilibrium (average) interest rate remains constant. Thus the empirical evidence about the effects of an increase in the number of banks on bank lending is not consistent with screening costs that are high enough to erase bank profit.[21]

5.3 Bank risk taking

Agency problems between bank managers and shareholders are not a part of the model. Although this omission is necessary to keep the model tractable, it has to be kept in mind in determining the overall effects of the changes in credit market competition. For example, while an increase in competition may enhance the bank's incentive to keep its reputation, it may also induce bank managers to take risks to keep their perks [Gorton and Rosen (1995)]. Indeed, Dinç (1999) finds that Japanese banks increased their real estate lending in the 1980s after the capital market deregulation, and that the keiretsu ties between banks and some of their shareholders provided protection to bank managers from the discipline of other shareholders. Such risk taking may affect relationship banking in Japan more substantially than any change in the bank's incentive to keep its commitment due to increased competition.

5.4 Long-lived entrepreneurs

In order to focus on the problem of bank commitment, it was assumed that each entrepreneur exits the economy after one period. If there are long-lived entrepreneurs, then this affects R_D, the bank's return at the end of a rescue. Such an extension to the model does not change the qualitative results, but it does raise further issues. One issue is the inside information the bank would have in the following rounds of lending. In that case, R_D can include the information rent to the bank after a rescue. Rajan (1992) shows that the bank's rent from this *inside* information is independent of the number of

[21] See, for example, Hannan (1991), Petersen and Rajan (1995), as well as the references cited in Dinç (1997).

competing banks. Thus the results reported here on the effects of competition on bank reputation would be the same. Another issue is that repeated lending allows the entrepreneur to commit to borrowing from the same bank and/or not to raise more than a certain fraction by issuing bonds. This has the same effect as increasing R_D; it facilitates the bank's commitment. It does not change the finding about the effects of competition.

With long-lived entrepreneurs, the positive effects of competition may be offset by the negative effects identified by Petersen and Rajan (1995). Banks are likely to face this tension as credit markets are deregulated because, while their ability to capture rents from a borrower in future lending will decrease, they will have to focus on the type of lending that distinguishes them from the security markets.[22]

6. Conclusion

This article studies the bank's commitment problem to lend to a borrower in distress after financing the borrower in good times. It shows that a reputation mechanism may mitigate this problem in a repeated bank lending setting. The effectiveness of this reputation mechanism depends on the credit market competition. Unlike the borrower's commitment problem, an increase in credit market competition may enhance the bank's incentive to lend to a borrower in distress and maintain a good reputation. Whether an increase in competition is beneficial or not depends on both the source and the level of competition. For example, bonds are a closer substitute for arm's length bank lending (loans without commitment) than for relationship lending (loans with commitment). Hence the borrower's access to bond markets decreases the bank's return from arm's length lending more than that of relationship lending. This enhances the bank's incentive to keep its commitment and maintain a good reputation.

The effect of an increase in the number of banks depends on the number of banks already in the market. An increase in banks may decrease reputational rents too much to sustain a reputation mechanism if there is already a large number of banks. On the other hand, if banks have large market power, they can capture so much of the borrower's surplus that they do not have incentive to offer costly commitments. In that case, an increase in the number of banks is beneficial for the reputation mechanism.

The theory presented has further empirical implications. These include

Entrepreneurs with higher credit quality are more likely to be offered bank commitments.

[22] The comments of Reese Harasawa, a corporate planner at Mitsubishi Bank, made at a time when Japanese companies drastically increased the amount they raised from security markets after deregulation, seem to reflect these opposing effects in main bank lending: "Banks are still lenders of last resorts. [However,] banks used to endure bad times in the hope of better deals later. That idea is changing now." [*Financial Times* (September 23, 1988)].

The interest rate charged decreases with credit quality.

The average credit quality of the entrepreneurs who are offered relationship lending decreases if the banks face competition from bond markets.

Faced with competition from bond markets, the share of relationship lending in a bank's loan portfolio increases.

The minimum number of banks necessary to sustain a reputation mechanism decreases with the borrowers' access to bond markets.

The entry into a banking market by banks that cannot offer relationship lending has implications similar to those of the competition from bond markets.

Some of these empirical implications already have support in the empirical literature. Avery and Berger (1991) observe that the performance of the loans extended through loan commitments is better than that of noncommitment loans, implying that borrowers with higher credit quality are offered loan commitments. Qi and Shockley (1995) show that better quality firms tend to finance with loan commitments. Shockley and Thakor (1997) find that interest rates and fees paid on loan commitment contracts decrease with the borrower's credit quality.

The available empirical evidence about the effect of bond markets on bank lending incentives is also consistent with the theoretical predictions provided in this article. Horiuchi (1994) and Dinç (1999) observe that large Japanese banks substantially increased the share of loans made to small and medium-size companies after the capital market deregulation in the early 1980s. Anderson and Makhija (1999) find that the proportion of bond debt of Japanese companies in the late 1980s was inversely related to their growth opportunities, which is consistent with the prediction that bond markets strengthen a bank's incentive to keep its commitment not to hold up its borrowers in relationship banking. Gande, Puri, and Saunders (1999) find that smaller companies benefited more from the increasing competition in bond underwriting, which is similar to this article's prediction that increased competition induces banks to offer services to lower-rated borrowers than they previously did.

The theory presented has additional implications for empirical work on the effects of credit market competition on bank lending. One of the main points is that the effects of credit market competition are different for different types of bank lending. Consequently any empirical study on credit market competition has to be precise about the type of bank lending studied. Such studies also have to be explicit about the source of the increase in competition, especially whether this increase is due to better access to security markets or to the entry of new banks. Finally, the impact of a change in competition may not be monotonic but may show qualitative differences at different levels.

Appendix

Proof of Proposition 3. The symmetric equilibrium of the competition game is analyzed with a more general payoff function for banks than implied in Proposition 3, for this competition game will be the main building block for the analysis to come. Let $X = (X_1, \ldots, X_n)$ denote a vector, the components of which are real-valued signals of the banks, and Y_1 be the maximum signal among $X_{-1} = (X_2, \ldots, X_n)$. Let f_{Y_1} and F_{Y_1} denote the density and the distribution functions of Y_1 and

$$v(x, y) = E[V(\theta)|X_1 = x, Y_1 = y], \tag{A1}$$

respectively, where $V(\theta)$ is the identity function that takes the value 1 if $\theta = G$, and 0 otherwise. Notice that $v(x, y)$ depends on the number of banks n through y. Milgrom and Weber (1982) show that, if the density $f(x_i|\theta)$ has MLRP for all i, then variables $\theta, X_1, \ldots, X_n$ are affiliated,[23] and that $v(x, y)$ increases in both x and y.

Lemma A1. Let the bank's payoff function π be given by

$$\pi(b) = V(\theta)(p_S bL - \kappa) - L, \tag{A2}$$

where L is the loan size, $\kappa \geq 0$ is any possible cost incurred in lending to a good type, and b is the interest factor (interest rate plus one). Let T denote the maximum cash return the bank can obtain. The equilibrium bidding strategies in bank competition are then given by

$$b^*(x) = \int_{x_L}^{x} \frac{v(\alpha, \alpha)\kappa + L}{v(\alpha, \alpha)p_S L} dM(\alpha|x) \quad \text{for} \quad x \geq x_0 \tag{A3}$$

where $M(\alpha|x) = \exp\left\{ -\int_\alpha^x \frac{v(s,s)f_{Y_1}(s|s)}{H(s,s)}\, ds\right\}$ with $H(x, s) = \int_{\underline{x}}^{s} v(x, \alpha) f_{Y_1}(\alpha|x)\, d\alpha$,

$$x_L = \sup_x \left\{ \int_x^{x_0} \frac{v(\alpha, \alpha)\kappa + L}{v(\alpha, \alpha)p_S L} dM(\alpha|x) \geq T \right\} \quad \text{and}$$
$$x_0 = \inf_x \{\Pi(T; x) \geq 0\}.$$

The bank does not offer a loan for $x < x_0$. The bank's expected profit is positive and decreasing in n.

Proof. The symmetric equilibrium $(b^*, \ldots, b^*)$ is studied, and, without loss of generality, the bidding strategy of bidder 1 is examined. The analysis follows Milgrom and Weber (1982). The necessary conditions are derived for a symmetric equilibrium by assuming that b^* is a decreasing function of x. A bidding function that satisfies these necessary conditions is then found and verified that it is indeed an equilibrium strategy if all the other banks bid according to that strategy.

[23] Recall that two random variables X and Y are affiliated if $f(x, y)f(x', y') \geq f(x', y)f(x, y')$ for any $x' < x$ and $y' < y$.

If all other banks bid according to b^*, bank 1's return at Equation (A.2) given its signal becomes

$$\begin{aligned}\Pi(b; b^*_{-1}, x) &= E\big[(V(\theta)(p_S bL - \kappa) - L)1_{\{b^*(Y_1)>b\}}|X_1 = x\big]\\ &= E\big[E\big[(V(\theta)(p_S bL - \kappa) - L)1_{\{b^*(Y_1)>b\}}|X_1, Y_1\big]|X_1 = x\big]\\ &= E\big[(v(X_1, Y_1)(p_S bL - \kappa) - L)1_{\{b^*(Y_1)>b\}}|X_1 = x\big]\\ &= \int_{\underline{x}}^{b^{*-1}(b)} (v(x, \alpha)(p_S bL - \kappa) - L) f_{Y_1}(\alpha|x)d\alpha. \end{aligned} \tag{A4}$$

Two of the *necessary* conditions for the equilibrium are

$$b^*(x) \le T, \text{ for all } x \tag{A5}$$

$$\Pi(b^*; b^*_{-1}, x) \ge 0, \text{ for all } x. \tag{A6}$$

Equations (5) and (6) imply that the bank does not offer a loan for $x < x_0$, where

$$x_0 = \inf_x\{\Pi(T; b^*_{-1}, x) \ge 0\}. \tag{A7}$$

Differentiating Equation (A4) with respect to b and using the inverse function theorem,

$$\begin{aligned}\Pi_b(b; b^*_{-1}, x) = {}& \frac{1}{b^{*\prime}(b^{*-1}(b))}\big(\big(v(x, b^{*-1}(b))(p_S bL - \kappa) - L\big) f_{Y_1}(b^{*-1}(b)|x)\big)\\ &+ \int_{\underline{x}}^{b^{*-1}(b)} v(x, \alpha) p_S L f_{Y_1}(\alpha|x)d\alpha. \end{aligned} \tag{A8}$$

Setting $\Pi_b(b; b^*_{-1}, x) = 0$ and arranging terms gives the linear differential equation:

$$b^{*\prime}(x) = \frac{-\big(\big(v(x, x)(p_S b^*(x)L - \kappa) - L\big) f_{Y_1}(x|x)\big)}{\int_{\underline{x}}^{x} v(x, \alpha) p_S L f_{Y_1}(\alpha|x)d\alpha}, \text{ for } x \ge x_0. \tag{A9}$$

This first-order linear differential equation is a necessary condition. Equations (A5) and (A6) give the boundary condition for Equation (A9):

$$b^*(x_0) = \frac{T}{L}. \tag{A10}$$

The solution [Equation (A3)] to the differential equation [Equation (A9)] with the boundary condition [Equation (A10)] gives the bidding strategies in the symmetric equilibrium. Finally, notice that $M(\alpha|x)$, regarded as a probability distribution on $(\underline{x}, x)$ is stochastically increasing in x, that is, $M(\alpha|x)$ decreases in x. Hence $b^*(x)$ is (strictly) decreasing in x.

Verification of $b^*(x)$*:* The change of variable

$$dM(\alpha|x) = M(\alpha|x)\frac{v(\alpha, \alpha) f_{Y_1}(\alpha|\alpha)}{H(\alpha, \alpha)}\, d\alpha$$

gives

$$\begin{aligned}b^{*\prime}(x) = {}& \frac{(v(x, x)\kappa + L)}{p_S L}\frac{f_{Y_1}(x|x)}{H(x, x)}\\ &+ \int_{x_L}^{x} \frac{v(\alpha, \alpha)\kappa + L}{p_S L} M(\alpha|x)\left(-\frac{v(x, x) f_{Y_1}(x|x)}{H(x, x)}\right)\frac{f_{Y_1}(\alpha|\alpha)}{H(\alpha, \alpha)}\, d\alpha. \end{aligned}$$

Equation (A9) then follows from Equation (A3).

Sufficiency: To show that b^* is a best response when all the other players play b^*, it is sufficient to consider only the bids in the range of b^*. For $b^*(z)$ to be an optimal bid when $X_1 = z$, it is sufficient for $\Pi_b(b^*(x); z)$ to be nonnegative for $x > z$ and nonpositive for $x < z$. From Equation (A8),

$$\begin{aligned}\Pi_b(b^*(x); z) &= \frac{1}{b^{*\prime}(x)}\big((v(z,x)(p_S bL - \kappa) - L) f_{Y_1}(x|z)\big)\\ &\quad + \int_{\underline{x}}^{x} v(z,\alpha) p_S L f_{Y_1}(\alpha|z)\, d\alpha\\ &= \frac{1}{b^{*\prime}(x)} \frac{(v(z,x)(p_S bL - \kappa) - L)}{v(z,x) p_S L}\\ &\quad + \frac{\int_{\underline{x}}^{x} v(z,\alpha) f_{Y_1}(\alpha|z)\, d\alpha}{v(z,x) f_{Y_1}(x|z)}. \end{aligned} \tag{A11}$$

The right-hand side of Equation (A11) is, of course, zero for $z = x$. The following working lemma will be used to show $\{\Pi_b(b^*(x); z) - \Pi_b(b^*(x); x)\} = \mathrm{sgn}\{x - z\}$.

Lemma A2. $(\int_{\underline{x}}^{x} v(z,\alpha) f_{Y_1}(\alpha|z) d\alpha)/v(z,x) f_{Y_1}(x|z)$ is decreasing in z.

Proof. The affiliation property implies that

$$v(z,\alpha) f_{Y_1}(\alpha|z) v(z',x) f_{Y_1}(x|z') \le v(z',\alpha) f_{Y_1}(\alpha|z') v(z,x) f_{Y_1}(x|z)$$

or

$$\frac{v(z,\alpha) f_{Y_1}(\alpha|z)}{v(z,x) f_{Y_1}(x|z)} \le \frac{v(z',\alpha) f_{Y_1}(\alpha|z')}{v(z',x) f_{Y_1}(x|z')}. \tag{A12}$$

Integrating both sides of Equation (A12) with respect to α gives the desired result. **Q.E.D.**

Note that

$$\mathrm{sgn}\left\{\frac{v(z,x)(p_S b^*(x) L - \kappa) - L}{v(z,x) p_S L} - \frac{v(x,x)(p_S b^*(x) L - \kappa) - L}{v(x,x) p_S L}\right\} = \mathrm{sgn}\{z - x\}. \tag{A13}$$

As $b^{*\prime}(x) < 0$, it follows from Equation (A13) and Lemma A2 that

$$\mathrm{sgn}\big\{\Pi_b(b^*(x); z) - \Pi_b(b^*(x); x)\big\} = \mathrm{sgn}\{x - z\}. \tag{A14}$$

Positive profits: For $x > x_0$,

$$\begin{aligned}\Pi(b^*(x); x) &> \Pi(b^*(x_0); x)\\ &> \Pi(b^*(x_0); x_0)\\ &= 0,\end{aligned}$$

where the first inequality follows from the equilibrium property while the second follows from Equation (A4) and the fact that $v(x, y)$ increases with x.[24] Hence the bank's expected profit before it obtains its signal is given by $E_\theta[E_X[\Pi(b^*(x); x)|\theta]] > 0$.

[24] The strict inequality for *all* $x > x_0$ follows from the full support assumption for bank signals. Without that assumptions, the inequalities hold strictly only for some $x > x_0$. However, the qualitative results are unaffected.

Profits decreasing with n: Note that

$$v(x,\alpha)f_{Y_1}(\alpha|x) = \frac{f_{X_1Y_1}(x,\alpha|\theta=G)\Pr(\theta=G)}{f_{X_1Y_1}(x,\alpha)}\frac{f_{X_1Y_1}(x,\alpha)}{f(x)}$$
$$= \frac{f_{X_1Y_1}(x,\alpha|\theta=G)\Pr(\theta=G)}{f(x)}.$$

Therefore Equation (A4) becomes

$$\Pi(b^*(x);x) = \frac{F_{X_1Y_1}(x,x|\theta=G)\Pr(\theta=G)}{f(x)}p_S b_F - F_{Y_1}(x|x). \tag{A15}$$

Note that

$$F_{X_1Y_1}(x,x|\theta=G) = [F(x|\theta=G)]^n,$$
$$F_{Y_1}(x|x) = \frac{[F(x|\theta=G)]^{n-1}\Pr(\theta=G)+[F(x|\theta=B)]^{n-1}\Pr(\theta=B)}{f(x)}.$$

By MLRP $F(x|\theta=B) > F(x|\theta=G)$. Thus

$$\frac{\partial}{\partial n}\Pi(b^*(x);x) < \Pi(b^*(x);x)\ln[F(x|\theta=G)]$$
$$< 0. \tag{A16}$$

This concludes the proof of Lemma A1. **Q.E.D.**

With $L=1$, $\kappa=0$, and $T=R_S$ in Lemma A1, the bidding function b_N and the threshold level x_N in one-shot lending follow. The rest of the equilibrium is as given in Proposition 1. **Q.E.D.**

Proof of Proposition 4. As in Proposition 3, only the bidding strategies will be stated and verified; the rest follows from Proposition 2. Let $\Pi_N(\cdot)$ and $\Pi_C(\cdot)$ be the bank's profit function, as given in Equation (A4) with $\kappa=0$ and $\kappa=p_D(1-R_D)$, respectively. Suppose

$$\Pi_C(R;x) \geq \Pi_N(b_N(x);x) \quad \text{for some } x < \bar{x}. \tag{A17}$$

Let

$$x_C \equiv \inf_x\{\Pi_C(R;x) \geq \Pi_N(b_N(x);x)\}. \tag{A18}$$

Let $b_N(x)$ be as in Proposition 3 and $b_C(x)$ be the bidding function given in Lemma A1 with $\kappa=p_D(1-R_D)$, $T=R_S$, and $x_0=x_C$.

Punishment path: If a bank does not keep its rescue commitment, future entrepreneurs do not borrow a loan with a rescue commitment from that bank. Lending strategies of the deviant bank are

$b_N(x_C)$ and the bank does not commit to rescue,	for $x \geq x_C$
$b_N(x)$ and the bank does not commit to rescue,	for $x_N \leq x < x_C$
no loan,	for $x < x_N$.

Lending strategies of other banks are

$b_{CP}(x)$ and the bank commits to rescue,	for $x \geq x_{CP}$
$b_N(x)$ and the bank does not commit to rescue,	for $x_N \leq x < x_{CP}$
no loan,	for $x < x_N$.

Let $\Pi^{(n)}(\cdot)$ and $b^{(n)}(\cdot)$ be the bank's profit function and the equilibrium bidding function when the number of banks is n. Let

$$x_{CP} \equiv \inf_x \Big\{ \Pi_C^{(n-1)}(R;x) \geq \Pi_N^{(n)}\big(b_N^{(n)}(x);x\big)\Big\}. \tag{A19}$$

$b_{CP}(x)$ is then the bidding strategy $b^{(n-1)}(x)$ with $\kappa = p_D(1-R_D)$ and $x_0 = x_{CP}$ in Lemma A1.

$\bar{\delta}(n)$: Let w_C and w_P be the expected profit per period of a bank with a good reputation on the equilibrium path and of a deviant bank on the punishment path, respectively that is,

$$\begin{aligned} w_C = E_\theta\Big[&\int_{x_N}^{x_C} \Pi_N(b_N(x);x) f(x|\theta)dx \\ &+ \int_{x_C}^{\bar{x}} \Pi_C(b_C(x);x) f(x|\theta)dx\Big] \end{aligned} \tag{A20}$$

and

$$\begin{aligned} w_P = E_\theta\Big[&\int_{x_N}^{x_{CP}} \Pi_N(b_N(x);x) f(x|\theta)dx \\ &+ \int_{x_{CP}}^{\bar{x}} \Pi_N(b_N(x_{CP});x) f(x|\theta)dx\Big]. \end{aligned} \tag{A21}$$

Notice that w_C and w_P are a function of n. The bank's incentive constraint to rescue is

$$R_D - 1 + \frac{\delta}{1-\delta} w_C \geq \frac{\delta}{1-\delta} w_P \tag{A22}$$

or

$$\delta \geq \frac{1-R_D}{w_C - w_P + 1 - R_D} \equiv \bar{\delta}(n) \tag{A23}$$

$\bar{n}$: Note that

$$\lim_{n\to\infty} \nu(x,\alpha) = 0 \text{ for all } x < \bar{x},\ \ \alpha \leq x. \tag{A24}$$

Hence, for sufficiently high n, it follows from Assumptions 4 and 5 that a bank has an incentive to offer a loan with a commitment—and keep its commitment—if its signal about the entrepreneur is good enough, that is, there exists $\bar{n}$, such that for all $n \geq \bar{n}$,

$$\mu(x)\big(p_S R_S - p_D(1-R_D)\big) - 1 \geq \Pi_N(b_N(x);x) \text{ for some } x < \bar{x}. \tag{A25}$$

To see that Equation (A25) is sufficient for the existence of the equilibrium described, suppose all the banks except one are "forced" to lend without a commitment. Then an equilibrium exists with one bank offering both types of loans—depending on its signal—while $n-1$ banks offering only loans without commitment (Proposition 6 gives an equilibrium in which n banks offer both types of loans and m banks can offer only loans without commitment). The expected return to the bank that can lend with a commitment is higher than the return of the other banks and those banks are better off if they are also "allowed" to lend with a commitment. Hence an equilibrium can be constructed with two banks offering commitment loans, while $n-2$ banks are still forced to lend without a commitment, and the rest follows by induction.

Note that a monopolist bank always demands all the cash return from the project; hence rescuing a distressed borrower only adds a rescue cost without increasing its return. Therefore $\bar{n} \geq 2$. Finally, by making the right-hand side of Assumption 4 sufficiently low, $\bar{n}$ can be made arbitrarily large. **Q.E.D.**

Proof of Proposition 5. Equation (A24) implies that

$$\lim_{n\to\infty} \Pi_C(b_C(x); x) = \lim_{n\to\infty} \Pi_N(b_N(x); x) = 0 \text{ for } x < \bar{x}.$$

Hence, from Equations (A20), (A21), and (A23),

$$\lim_{n\to\infty} \bar{\delta}(n) = 1.$$

Proof of Proposition 6. As before, the symmetric equilibrium of the bank competition where the same type of banks using the same strategies is considered. The bidding strategies in this equilibrium are similar to those on the punishment path of bank lending with a rescue commitment, as described in Proposition 4. The banks that can lend with a commitment will be referred to as *established* and the other banks as *new*. Let the number of established banks be n and that of the new banks be m. The bidding strategies of established banks are

$$\begin{array}{ll} b_C^{(n)}(x) \text{ and the bank commits to rescue,} & \text{for } x \geq x_{CF} \\ b_N^{(n+m)}(x) \text{ and the bank does not commit to rescue,} & \text{for } x_{NF} \leq x < x_{CF} \\ \text{no loan,} & \text{for } x < x_{NF} \end{array}$$

where

$$x_{CF} \equiv \inf_x \left\{ \Pi_C^{(n)}(R; x) \geq \Pi_N^{(n+m)}\left(b_N^{(n+m)}(x); x\right) \right\} \tag{A26}$$

and x_{NF} is same as what x_N would be with $n + m$ banks.[25]

The lending strategy of a new bank with an estimate $x \geq x_{CF}$ is different from that of the deviant bank in Proposition 4 because it has to compete with other new banks. Let X, Y, Z be a (new) bank's own estimate, the highest estimate among all other new banks and the highest estimate among all established banks, respectively. Similar to Equation (A1), let

$$\nu_F(x, y, z) = E\left[V(\theta) | X = x, Y = y, Z = z\right]. \tag{A27}$$

Thus the expected profit of a new bank playing the equilibrium bidding strategies b_F when $x \geq x_{CF}$ is given by, from Equation (A4),

$$\Pi_F(b_F; x) = \int_{\underline{x}}^{x} (\nu_F(x, \alpha, x_{CF}) p_S b_F - 1) g_Y(\alpha | x, x_{CF}) d\alpha, \tag{A28}$$

where

$$g_Y(\alpha | x, x_{CF}) = f_Y(\alpha | X = x, Z \leq x_{CF}). \tag{A29}$$

b_F can be obtained from Lemma A1 by substituting $g_Y(\alpha | x, x_{CF})$ for $f_{Y_1}(\alpha | x)$ and determining x_L such that $b_F(x_{CF}) = b_N^{(n+m)}(x_{CF})$. Therefore a new bank's bidding strategies on the equilibrium path are

$$\begin{array}{ll} b_F(x) \text{ and bank does not commit to rescue,} & \text{for } x \geq x_{CF} \\ b_N^{(n+m)}(x) \text{ and bank does not commit to rescue,} & \text{for } x_{NF} \leq x < x_{CF} \\ \text{no loan,} & \text{for } x < x_{NF}. \end{array}$$

[25] Notice that $x_{CF} < x_{NF}$ for large m, in which case the established banks compete by offering only loans with a rescue commitment.

The bidding strategies on the punishment path are the same as those with $n-1$ established banks and $m+1$ new banks, with the deviant established bank playing the same strategies with the new banks. Let x_{CFP} be the threshold on the punishment path, that is,

$$x_{CFP} \equiv \inf_x \left\{ \Pi_C^{(n-1)}(R; x) \geq \Pi_N^{(n+m)}\left(b_N^{(n+m)}(x); x\right) \right\}. \tag{A30}$$

$\bar{\delta}$ *decreases with m:* Let $w_E(n, m)$ and $w_N(n, m)$ be the expected profit per period of an established bank and a new bank, respectively, when n established banks and m new banks compete. The bank's incentive constraint is analogous to Equation (A23), so $\bar{\delta}$ decreases with m, if

$$w_E(n, m) - w_E(n, m+1) < w_N(n-1, m+1) \\ - w_N(n-1, m+2). \tag{A31}$$

Note that

$$w_E(n, m) - w_E(n, m+1) < w_N(n, m+1) - w_N(n, m+2). \tag{A32}$$

The proof is then complete if it can be shown that the right-hand side of Equation (A31) is greater than the right-hand side of Equation (A32) or $(\partial^2 \Pi_F(b_F; x))/\partial m \partial n > 0$ for all x.

From Equation (A15),

$$\Pi_F(b_F; x) = \frac{F_Y(x, x, x_{CF}|\theta = G)\Pr(\theta = G)}{f(x, x_{CF})} p_S b_F \\ - G_Y(x|x, x_{CF}). \tag{A33}$$

Lemma A3.

$$\frac{\partial^2}{\partial m \partial n}\left(\frac{F_Y(x, x, x_{CF}|\theta = G)\Pr(\theta = G)}{f(x, x_{CF})} \right) \\ = \frac{ACD}{(A+C)^2}\left(\ln F(x_{CF}|\theta = G) - \ln F(x_{CF}|\theta = B) \right) \tag{A34}$$

and

$$\frac{\partial^2 G_Y(x|x, x_{CF})}{\partial m \partial n} = \frac{AC(D-E)}{(A+C)^2}\left(\ln F(x_{CF}|\theta = G) \right. \\ \left. - \ln F(x_{CF}|\theta = B) \right), \tag{A35}$$

where

$$A \equiv f(x|\theta = G)[F(x_{CF}|\theta = G)]^{n-1}\Pr(\theta = G) \tag{A36}$$

$$C \equiv f(x|\theta = B)[F(x_{CF}|\theta = B)]^{n-1}\Pr(\theta = B) \tag{A37}$$

$$D \equiv [F(x|\theta = G)]^{m-1}\ln F(x|\theta = G) \tag{A38}$$

$$E \equiv [F(x|\theta = B)]^{m-1}\ln F(x|\theta = B) \tag{A39}$$

Proof. Note that

$$F_Y(x, x, x_{CF}|\theta = G) = f(x|\theta = G)[F(x|\theta = G)]^{m-1} \times [F(x_{CF}|\theta = G)]^{n-1} \tag{A40}$$

$$f(x, x_{CF}) = f(x|\theta = G)[F(x_{CF}|\theta = G)]^{n-1}\Pr(\theta = G) + f(x|\theta = B)[F(x_{CF}|\theta = B)]^{n-1}\Pr(\theta = B) \tag{A41}$$

$$G_Y(x|x, x_{CF}) = \frac{F_Y(x, x, x_{CF}|\theta = G)\Pr(\theta = G)}{f(x, x_{CF})} + \frac{F_Y(x, x, x_{CF}|\theta = B)\Pr(\theta = B)}{f(x, x_{CF})}. \tag{A42}$$

Hence

$$\frac{\partial}{\partial m}\left(\frac{F_Y(x, x, x_{CF}|\theta = G)\Pr(\theta = G)}{f(x, x_{CF})}\right) = \frac{AD}{A + C};$$

$$\begin{aligned}\frac{\partial^2}{\partial m \partial n}\left(\frac{F_Y(x, x, x_{CF}|\theta = G)\Pr(\theta = G)}{f(x, x_{CF})}\right) &= \frac{D}{(A+C)^2}\big(A(A + C)\ln F(x_{CF}|\theta = G) \\ &\quad -A\big(A\ln F(x_{CF}|\theta = G) - C\ln F(x_{CF}|\theta = B)\big)\big),\end{aligned} \tag{A43}$$

and Equation (A34) follows. Similarly,

$$\frac{\partial^2 G_Y(x|x, x_{CF})}{\partial m \partial n} = \frac{ACD}{(A+C)^2}\big(\ln F(x_{CF}|\theta = G) - \ln F(x_{CF}|\theta = B)\big) + \frac{ACE}{(A+C)^2}\big(\ln F(x_{CF}|\theta = B) - \ln F(x_{CF}|\theta = G)\big)$$

and Equation (A35) follows. **Q.E.D.**

By Lemma A3,

$$\frac{\partial^2 \Pi_F(b_F; x)}{\partial m \partial n} = \frac{AC}{(A+C)^2}\big(D(p_S b_F(x) - 1) + E\big) \times \big(\ln F(x_{CF}|\theta = G) - \ln F(x_{CF}|\theta = B)\big). \tag{A44}$$

Notice that $D < 0$ and $E < 0$. From Equation (A6), $p_S b_F(x) - 1 > 0$. Finally, MLRP implies that $F(x_{CF}|\theta = G) < \ln F(x_{CF}|\theta = B)$; hence $\ln F(x_{CF}|\theta = G) - \ln F(x_{CF}|\theta = B) < 0$. This establishes that $\bar{\delta}$ decreases with m.

Finally, $\Pi_N^{(n+m)}(b_N^{(n+m)}(x); x)$ decreases with m; therefore $\bar{n}$ and x_{CF} decreases with m. **Q.E.D.**

Proof of Proposition 7**.** Although it is not essential for the results, the game has a signaling component at date 0, when the entrepreneur sets the amount to be raised from the bond market. Notice, however, that a bad entrepreneur always mimics the good one. Let β denote the amount the entrepreneur raises by issuing bonds. The loan size L will be explicit in the notation in this section, for example, $b(x, L)$ and $\Pi(b; x, L)$, respectively. Let Z_1 denote the highest estimate among banks.

Entrepreneur's strategy: Raise $\beta = \beta_N$ if a loan without commitment is offered and $\beta = \beta_C$ for a loan with commitment. Collect offers from banks for a loan of size $1 - \beta_N$ without commitment and $1 - \beta_C$ with commitment.

Beliefs of banks (before credit screening) and bondholders: If $\beta = \beta_N$ for a loan without commitment and $\beta = \beta_C$ for a loan with commitment, set $\Pr(\theta = G) = \lambda$. Otherwise $\Pr(\theta = G) = 0$.

Bondholders update their beliefs after observing the loan type as follows: The probability that the entrepreneur is good is

$$\Pr(\theta = G | x_{NB} \leq Z_1 < x_{CB}) \quad \text{if the loan comes } \textit{without} \text{ a rescue commitment,}$$
$$\Pr(\theta = G | x_{CB} \leq Z_1 \leq \bar{x}) \quad \text{if it comes } \textit{with} \text{ a rescue commitment.}$$

Bondholders' strategy: They do not lend if no bank offers to lend. When they lend, the repayment D they demand depends on both the type and the amount of the bank loan the entrepreneur obtains. If the lending bank does not commit to rescue, the repayment D_N satisfies

$$\Pr(\theta = G | x_{NB} \leq Z_1 < x_{CB}) p_S D_N(\beta_N) - \beta_N = 0. \tag{A45}$$

If the lending bank commits to rescue, the repayment D_C satisfies

$$\Pr(\theta = G | x_{CB} \leq Z_1 \leq \bar{x}) \big(p_S D_C(\beta_C) + p_D \min\{R_D, D_C(\beta_C)\} \big) - \beta_C = 0, \tag{A46}$$

with

$$x_{NB} = \inf_x \left\{ \Pi_N(R - D_N(\beta_N); x, 1 - \beta_N) \geq 0 \right\} \quad \text{and} \tag{A47}$$

$$x_{CB} = \inf_x \left\{ \Pi_{CB}(R - D_C(\beta_C); x, 1 - \beta_C) > \Pi_N(b_N(x; 1 - \beta_N); x, 1 - \beta_N) \right\}, \tag{A48}$$

where Π_{CB} is the profit function Π in Lemma A1 with $\kappa = p_D(1 - \max\{0, R_D - D_C(\beta_C)\})$. In equilibrium, Equations (A45)–(A48) are satisfied simultaneously.

Access to bond markets decreases $\underline{\bar{\delta}}$*:* Suppose $\beta_C = 0$ and $\beta_N = 1$. This case is equivalent to the entry of infinitely many new banks ($m = \infty$) in Proposition 6. Hence, by continuity, there exists an equilibrium with $0 < \beta_C, \beta_N < 1$, which decreases $\bar{\delta}$. **Q.E.D.**

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