

Lending Booms and Lending Standards

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ABSTRACT

We examine how the informational structure of loan markets interacts with banks' strategic behavior in determining lending standards, lending volume, and the aggregate allocation of credit. We show that, as banks obtain private information about borrowers and information asymmetries across banks decrease, banks may loosen their lending standards, leading to an equilibrium with deteriorated bank portfolios, lower profits, and expanded aggregate credit. These lower standards are associated with greater aggregate surplus and greater risk of financial instability. We therefore provide an explanation for the sequence of financial liberalization, lending booms, and banking crises observed in many emerging markets.

BANKS PERFORM THE IMPORTANT ROLE OF LIMITING adverse selection problems in the economy by screening out applicant borrowers that do not meet satisfactory lending standards. Failure to adequately perform this function leads to riskier portfolios and weaker balance sheets, with potentially negative consequences for the stability of credit markets. The focus of this paper is on how the distribution of information about borrowers across banks interacts with banks' strategic behavior in determining lending standards, lending volume, and the aggregate allocation of credit.

Our analysis shows that changes in the information structure of the market can have a significant impact on the likelihood of a banking crisis. Specifically, a reduction in the information asymmetries across banks may lead to an easing of lending standards and, in turn, an increase in the volume of lending, a deterioration of bank portfolios, and lower and more volatile profits. Thus, such "lending boom" can render banks more prone to financial distress in the event the economy experiences a downturn. This finding establishes a new

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explanation for the relationship between lending booms and episodes of financial distress that recent empirical studies document.¹

To study this issue formally, we present a model of a credit market in which banks have private information about the creditworthiness of some borrowers ("known" borrowers) but not others ("unknown" borrowers). For this latter set, banks can choose to use collateral requirements to sort "good" from "bad" borrowers, or they can choose to lend with no such requirement. The informational asymmetries both across banks and between banks and borrowers generate adverse selection problems that constitute the main incentives for banks to screen loan applicants.

We show that, when the proportion of unknown borrowers in the market is sufficiently low, in equilibrium banks will choose to screen out bad borrowers by demanding a sufficiently high collateral requirement. However, when the proportion of unknown borrowers is high, banks will offer contracts with no collateral requirement, that is, they will grant credit to all borrowers indiscriminately. The intuition is the following. When extending credit, banks are approached either by entrepreneurs with new or untested projects, or by those whose projects have been previously evaluated and rejected by competitor banks. To the extent that banks cannot distinguish between these two groups, as the proportion of new projects in the market increases, the distribution of borrowers applying to each bank improves as well. In this scenario, banks find it profitable to reduce collateral requirements in an effort to undercut their competitors and increase their market share.

These findings have several implications. First, switching from tight lending standards (enforced by collateral requirements) to a looser regime in which all borrowers obtain credit leads to a credit expansion that exceeds the increased demand for credit that triggered the shift in banks' lending strategies. In other words, the increase in credit demand leads to a lending boom. Moreover, the pooling of borrowers that results is (second-best) efficient since it is optimal exactly when the costs associated with collateral liquidation exceed those associated with the financing of bad borrowers. That is, by avoiding the inefficient liquidation of collateral, booms maximize aggregate surplus. There is a downside, however, in that the reduction in screening results in a banking system with a deteriorated loan portfolio and thus lower profits. Further, the expansion in credit increases the sensitivity of bank profits to aggregate shocks, thereby making the banking system more vulnerable in the event of an economic downturn. To summarize, a lending boom that is induced by a reduction in information asymmetries can lead to a higher probability of a banking crisis. This result demonstrates the existence of a trade-off between overall output and banking system stability.

The analysis in this paper is relevant for regulatory and competition policy, as it suggests that policies that generate an inflow of borrowers may reduce the amount of screening that banks perform, increasing the probability of systemic

¹ See, for example, Kaminsky and Reinhart (1999), Gourinchas et al. (2001), Tornell and Westermann (2001), and Demirgüç-Kunt and Detragiache (2002).

financial distress. For instance, this paper suggests possibly negative aspects of the expansionary phases of the business cycle, periods during which more firms may be seeking credit. In this scenario, the proportion of unknown borrowers (or projects) in a market increases, due, for example, to the introduction of a new technology or to changes in the value of collateralizable assets. As we argue above, banks may respond to the increased proportion of unknown borrowers by reducing their lending standards and expanding credit, which increases aggregate surplus but also increases the probability of a banking crisis.

Our results also suggest that lending booms and the associated weakening of bank portfolios can be the result of financial sector reforms that modify the competitive landscape of credit markets. This is particularly relevant given recent evidence that, in many instances, banking crises and periods of financial distress have been preceded by financial reforms that lack a concomitant strengthening of regulatory and supervisory frameworks (see, e.g., Gourinchas, Valdes, and Landerretche (2001)). For example, we show that capital inflows, such as those that often accompany capital account liberalizations, reduce the cost of financing for banks, increasing the likelihood of both a credit boom and a banking crisis. Moreover, we show that the introduction of the threat of competition into a protected monopolistic market may induce the incumbent to switch from screening to borrower pooling. This latter result is important for the analysis of the effects of financial liberalizations that allow new entry into previously regulated credit markets.

While our initial analysis assumes that banks can make maximal use of their private information, our results continue to hold even if banks share borrower information such as the history of past defaults. The sharing of default history, or “black information,” is of particular interest because this information is often available through the credit bureaus. We show that, although this kind of information sharing always increases aggregate output, in many instances it reduces bank profitability and therefore may not emerge endogenously. Furthermore, policies that mandate that banks collect and disseminate black information increase lending volume and reduce bank profitability, and therefore may increase the probability of a banking crisis. For completeness, we also examine the relationship between bank market concentration and borrower screening. We show that adverse selection and, as a consequence, the benefit from screening borrowers, is greater in markets that have a larger number of banks.

By establishing a link between (i) the notion that the willingness of banks to screen borrowers depends on the distribution of applicant borrowers and (ii) the idea that under asymmetric information competition generates an adverse selection problem for banks, this paper provides two main contributions.² First, it relates changes in bank lending standards and screening behavior to changes in credit demand and the informational structure of the market. Second, it

² For models illustrating the former, see, for example, Bester (1985), Dasgupta and Maskin (1986), Besanko and Thakor (1987), and Hellwig (1987). For the latter, see, for example, Broecker (1990), Dell’Ariccia (2001), Marquez (2002), and von Thadden (2004).

provides a novel mechanism that links lending booms and banking crises to the quality of the projects financed by banks. Recent papers relate bank screening to an improvement in the prospects of businesses (Ruckes (2004)) and to attrition in the ranks of loan officers skilled at identifying bad loans (Berger and Udell (2004)). We show that changes in the information structure of the market itself may play a role in transmitting macroeconomic shocks to the banking system. Furthermore, we show (in Appendix B) that this effect does not depend on the exact mechanism banks use to acquire information; similar issues arise if banks implement, for instance, costly credit screens rather than collateral requirements to generate information about borrowers.

Recent work investigates the issue of credit cycles and variable credit standards. In Rajan (1994), bank managers with short-term concerns select the bank's credit policies. Rajan finds that when most borrowers are performing well, bank managers relax credit standards to hide losses on bad loans and protect their own reputation, whereas when a common negative shock hits a sector, reputational considerations diminish and bank managers tighten credit standards. Ruckes (2004) presents a model in which variations in the quality of borrowers over the cycle can affect the standards that banks apply in lending. Similarly, Weinberg (1995) shows that an increase in the expected payoff of all borrowers' projects can lead banks to grant loans to borrowers with a lower success probability. The novelty of our paper is that banks may switch their screening behavior purely for informational reasons, even if the overall creditworthiness of borrowers remains unchanged.³ Kiyotaki and Moore (1997) study how the interaction between asset prices and credit limits set by collateral amplifies the size and duration of shocks. In their model, the quality of loans that banks finance does not vary over the cycle. Here, in contrast, we identify an additional mechanism that magnifies credit swings through changes in the distribution of information, linking the average creditworthiness of banks' portfolios to the volume of credit that banks extend. Manove, Padilla, and Pagano (2001) show that the act of sorting borrowers through collateral requirements may reduce additional bank screening. In our model, the reduction in the use of collateral reflects the decrease in lending standards and leads to a credit boom.

A line of empirical research examines how banks' lending standards vary over the cycle and how they are related to the volume of lending and output.⁴ By focusing on the effects of changes in the demand for credit, our model identifies an important channel through which macroeconomic cycles affect the banking system. However, since we purposefully hold fixed the creditworthiness of borrowers in order to isolate the effect of information, our framework does not explicitly address how banks behave over the business cycle (see, however, the discussion in Section IV.A). In the concluding section, we discuss how the pre-

³ Our findings are also similar to those of Berlin and Butler (2002), who show that increasingly competitive markets can lead to less stringent collateral requirements. In our model, information asymmetries limit competition, so that reductions in these asymmetries lower the barriers to competition. See also Gorton and He (2003) and Gehrig and Stenbacka (2003), who identify alternative channels for swings in lenders' standards for granting credit.

⁴ See, for example, Asea and Blomberg (1998), Lown and Morgan (2003), and Berger and Udell (2004).

dictions of our model relate to the findings of recent empirical work on the cyclicalities of standards and on loan collateralization.

The paper proceeds as follows. Section I presents a model in which banks compete for both known and unknown borrowers. Section II solves the model and examines its welfare implications. We study the implications of the analysis for banking crises in Section III. Section IV discusses the role of bank market structure and contestability, and how our framework can be applied to the analysis of the business cycle. Section V extends the analysis to incorporate information sharing. In Section V, we examine in greater detail the testable implications of our model as well as the recent empirical evidence. Appendix A contains all proofs, and Appendix B presents an extension to the case where banks conduct costly credit screens.

I. Model

Consider an economy in which there is a continuum of entrepreneurs of mass $1 + \lambda$, each of which has a known end-of-period endowment W .⁵ Each entrepreneur is endowed with a project that requires a capital inflow of \$1 and that generates a payoff of $\tilde{y} = y > 0$ in the case of success and $\tilde{y} = 0$ in the case of failure. There are two types of entrepreneurs, namely, good and bad, with probabilities of success θ_g and θ_b , respectively, where $\theta_g > \theta_b$.⁶ Good entrepreneurs, which comprise a fraction α of the population, are creditworthy while bad ones, which comprise the complementary fraction $1 - \alpha$, are not. Formally, this means that $\theta_g y > \bar{d}$ and $\theta_b y < \bar{d}$, where $\bar{d}$ is the (risk-free) cost of funds for the banking system, such as the cost of insured deposits. We also assume that on average borrowers are creditworthy: $\bar{\theta} y > \bar{d}$, where $\bar{\theta} = \alpha\theta_g + (1 - \alpha)\theta_b$.

The market for loans consists of two groups of borrowers, a mass $\lambda \in [0, \infty)$ of unknown borrowers and a mass 1 of known borrowers. Known borrowers are those whose type is known to one of the banks, whereas unknown borrowers are those whose type is unknown to any bank; we assume, however, that all borrowers know their own types. Both of these groups have the same distribution over types. When first approached by an applicant borrower, banks are unable to distinguish an unknown borrower from one whose type is known to a competitor bank.⁷ We relax this assumption in Section V.

⁵ We assume throughout that $W \geq \frac{\theta_b(y\theta_g - \bar{d})}{(1 - \theta_b)\theta_g - \delta(1 - \theta_g)\theta_b}$, which is a sufficient condition for borrowers to be able to meet any collateral requirement by the banks in equilibrium. We discuss the effect of loosening this restriction in Section III.C.

⁶ Henceforward, we use the terms entrepreneur, project, and borrower interchangeably. Similarly, we use the terms lender, intermediary, and bank interchangeably.

⁷ This is a convenient way of introducing informational asymmetries among financial intermediaries. See Dell'Ariccia (2001) and Marquez (2002) for similar setups. An alternative interpretation is that all borrowers are evaluated in some way, but only a fraction $\frac{1}{1+\lambda}$ of these evaluations yield private information to a particular bank, with $\frac{\lambda}{1+\lambda}$ of them yielding inconclusive information, so that the type of these borrowers is unknown to any lender. Similarly, $\frac{1}{1+\lambda}$ can also represent the probability that the success rate of any given borrower's project is correlated across time, so that the ratio $\frac{\lambda}{1+\lambda}$ represents the fraction of the population whose type will be unknown to any bank. All results go through exactly as stated under these alternative setups.

There are N banks competing for borrowers. We consider the symmetric case in which each bank possesses private information about a non-overlapping mass $\frac{1}{N}$ of borrowers, where the borrowers that each bank knows are different, that is, each borrower's type is known by only one bank.

The game has three stages. In stage 1, banks compete for the pool of customers whose type is unknown to them.⁸ Banks can offer applicant borrowers a menu of loan contracts $\{(R^k, C^k), k = g, b\}$, where $R \geq 0$ represents the repayment a bank obtains when the project succeeds, and $C \geq 0$ is the collateral a bank can liquidate when a project fails. Collateral liquidation is costly, so the net value of the collateral to the bank is δC , with $\delta < 1$. This constraint can also be interpreted as saying that assets are more productive in use than under liquidation and allows us to exclude the unrealistic case wherein banks pool borrowers by offering a contract that requires positive collateral and pays zero interest rate.

In stage 2, each bank observes the realization of stage 1 and can offer competitive contracts to the borrowers whose types it knows. Borrowers then choose their preferred contract among those offered. This timing assumption captures the idea that borrowers are able to observe public offers made by all banks and can use them to bargain for better conditions from the bank that knows their type. Finally, in the third stage, banks have the opportunity to reject borrowers' loan applications.⁹ In the event that more than one bank offers the same contract to a group of borrowers, the following procedure breaks the tie: All the borrowers that would choose a contract offered by more than one bank are randomly allocated to one of these banks.¹⁰

Finally, entrepreneurs are risk neutral and seek to maximize their own profit. The expected value to an entrepreneur of accepting a loan contract (R, C) is

$$\theta_k(y - R) - (1 - \theta_k)C; \quad \text{for } k = g, b. \quad (1)$$

For simplicity, we assume that the reservation utility of the entrepreneurs is zero, as they have no access to nonbank financing. The individual rationality (IR) constraints can therefore be written as

$$\theta_k(y - R) - (1 - \theta_k)C \geq 0 \quad \text{for } k = g, b. \quad (2)$$

II. Equilibrium

We solve the game by backward induction. Stage 3 is trivial since banks will reject loan applications if and only if the expected quality of the set of borrowers

⁸ For each bank, this pool consists of all the unknown entrepreneurs on the market seeking financing (mass λ), and the entrepreneurs known to competitor banks (mass $\frac{N-1}{N}$).

⁹ The general structure of our model is as in Bester (1985), as extended by Hellwig (1987), with the important addition of asymmetric information among banks. The advantage of this approach is that it guarantees the existence of pure-strategy equilibria.

¹⁰ This tie-breaking rule guarantees the existence of an equilibrium for all parameter values. See Simon and Zame (1990) for a general analysis of the role of sharing rules in establishing the existence of an equilibrium.

that accept a given contract is too low to provide nonnegative profits. Therefore, borrowers cannot coordinate on a contract in a way that would yield losses for the bank offering that contract. We elaborate on this below, since the logic will be useful for distinguishing between the two types of equilibria we discuss.

In stage 2, banks observe the realization of stage 1 and choose to whom they should make competitive offers among the borrowers whose type they know. For each bank i , define (R^{-i}, C^{-i}) as the contract that good borrowers prefer among those offered in stage 1 by the competitors of bank i and that at least breaks even when accepted by good borrowers only. The following result characterizes the equilibrium of the subgame.

LEMMA 1: *i) Each bank i will offer its known good borrowers a contract $(R_g^i, 0)$, where R_g^i is such that good borrowers are indifferent between $(R_g^i, 0)$ and (R^{-i}, C^{-i}) ; ii) each bank i will deny credit to its known bad borrowers.*

Proof: With respect to part (i), since the bank knows the type of these borrowers, it has no reason to include a costly collateral requirement in the contract. The value R_g is the highest interest rate the bank can charge these known good borrowers without losing them to the competition. With respect to part (ii), the expected return on bad borrowers is always negative. Hence, under no conditions will a bank lend to known bad borrowers. Q.E.D.

We can now solve stage 1. Lemma 1 implies that when banks choose their stage 1 strategy, they have to take into account two facts. First, they will not be able to poach profitably from the pool of borrowers that are known to their rival banks. Second, the pool of potential borrowers unknown to a particular bank will consist of borrowers unknown to all banks as well as bad borrowers known to its competitors. Since our focus is on the case in which banks are symmetric, we limit our analysis to the case of symmetric equilibria. As Besanko and Thakor (1987) describe, a Nash equilibrium here is a profile of sets of contracts such that: (1) each bank earns nonnegative profits on each contract; and (2) there exists no other set of contracts that would earn positive profits in aggregate if offered in addition to the original set, with each individual contract in the set earning nonnegative profits. Additionally, we require that the equilibrium be “robust” in the sense of satisfying the stability criterion of Kohlberg and Mertens (1986),¹¹ and we restrict our attention to pure strategy equilibria.

A. Equilibrium with Borrower Screening

We first show that, for certain parameter values, the only stable equilibrium is one with screening, that is, only high quality borrowers obtain credit and all banks offer the same contract (we use the terms “separating” and “screening”

¹¹ In principle, other (weaker) refinements of the equilibrium can be used, which deliver the same results since the stable equilibrium we derive is unique.

equilibrium interchangeably). In this separating equilibrium, banks try to attract good borrowers and screen out bad borrowers by offering a menu of contracts that satisfies the incentive compatibility (*IC*) and individual rationality (*IR*) constraints. If a set of contracts (R^k, C^k) , $k = g, b$, are offered, the *IC* constraints can be expressed as

$$\begin{aligned}\theta_g(y - R^g) - (1 - \theta_g)C^g &\geq \theta_g(y - R^b) - (1 - \theta_g)C^b \\ \theta_b(y - R^b) - (1 - \theta_b)C^b &\geq \theta_b(y - R^g) - (1 - \theta_b)C^g.\end{aligned}$$

In the case we study here, the *IC* constraint for the bad type is the same as its *IR* constraint because no alternative contract is offered to bad borrowers given their projects generate negative expected value. Hence, to find the competitive separating contract we only need to satisfy the *IC* constraint for the bad borrowers, which we achieve by setting their *IR* constraint to be satisfied with equality. Since we have competitive banks, we also impose the condition that banks make zero profits on the contract. Formally, the competitive separating contract $(\hat{R}_s, \hat{C}_s)$ is the solution to the following set of equations

$$\begin{aligned}\theta_g R - \bar{d} + (1 - \theta_g)\delta C &= 0 \quad (\text{Zero profit for banks}) \\ \theta_b(y - R) - (1 - \theta_b)C &= 0. \quad (\text{IC for bad borrowers})\end{aligned}$$

Note that we need not be concerned about the good type's *IC* constraint, since only one contract will be offered: the zero-profit condition guarantees that no bank has an incentive to offer a different separating contract, and the *IC* constraint guarantees that no bad borrower has an incentive to accept this contract. Solving the two equations, we obtain $\hat{R}_s = \frac{(1 - \theta_b)\bar{d} - \delta(1 - \theta_g)\theta_b y}{(1 - \theta_b)\theta_g - \delta(1 - \theta_g)\theta_b}$ and $\hat{C}_s = \frac{\theta_b(y\theta_g - \bar{d})}{(1 - \theta_b)\theta_g - \delta(1 - \theta_g)\theta_b}$. This is a valid solution since the *IR* constraint for the good type is always satisfied by this contract.

For a strategy profile in which all banks offer the contract $(\hat{R}_s, \hat{C}_s)$ to be an equilibrium, we also require that no bank can make positive profits by offering some other contract $(\tilde{R}, 0)$ in which all borrowers are pooled. To verify this condition is met, first consider that, since bad borrowers' projects generate a negative expected value, any pooling contract must attract unknown good borrowers to be profitable. This is accomplished by setting the repayment on the loan, $\tilde{R}$, sufficiently low that $\theta_g(y - \tilde{R}) > \theta_g(y - \hat{R}_s) - (1 - \theta_g)\hat{C}_s \Leftrightarrow$

$$\tilde{R} < \hat{R}_s + \left(\frac{1 - \theta_g}{\theta_g} \right) \hat{C}_s. \quad (3)$$

In addition, the payment specified in the contract must be such that the bank at least breaks even when financing all the unknown borrowers plus the bad borrowers rejected by competitor banks, that is, $\lambda(\bar{\theta}\tilde{R} - \bar{d}) + (1 - \alpha)(\frac{N-1}{N})(\theta_b\tilde{R} - \bar{d}) \geq 0 \Leftrightarrow$

$$\tilde{R} \geq \bar{d} \frac{\left(\frac{N-1}{N}\right)(1-\alpha) + \lambda}{\left(\frac{N-1}{N}\right)(1-\alpha)\theta_b + \lambda\bar{\theta}}. \quad (4)$$

Hence, we can obtain the necessary and sufficient condition for the strategy profile in which all banks offer the single (separating) contract $(\hat{R}_s, \hat{C}_s)$ to be a Nash equilibrium by combining conditions (3) and (4), which yields

$$\bar{d} \frac{(N-1)(1-\alpha) + \lambda N}{(N-1)(1-\alpha)\theta_b + \lambda\bar{\theta}N} \geq \hat{R}_s + \left(\frac{1-\theta_g}{\theta_g}\right) \hat{C}_s. \quad (5)$$

Note that condition (5) establishes a link between the proportion of unknown borrowers in the economy and the existence of a pure-strategy equilibrium in which borrowers are screened. For λ sufficiently close to zero, condition (5) is always satisfied and offering the separating contract is an equilibrium: In the limit there are no unknown borrowers in the market, so by offering a pooling contract, each bank would attract only the bad borrowers that are rejected by its competitors—as this would always generate losses, no such equilibrium is possible and banks must instead screen borrowers. However, as the distribution of applicant borrowers faced by a deviating bank improves with λ , the viability of this equilibrium depends on the proportion of unknown borrowers. If, as the adverse selection problems associated with informational asymmetries among banks vanish, which occurs as $\lambda \rightarrow \infty$, it is profitable to deviate from the separating equilibrium, then the equilibrium set will depend on λ . Otherwise, the strategy profile with the separating contract will always be an equilibrium, as it would never be profitable to offer a pooling contract. By letting $\lambda \rightarrow \infty$ in condition (5), we can state the condition for the equilibrium set to depend on λ as

$$\frac{\bar{d}}{\bar{\theta}} < \hat{R}_s + \left(\frac{1-\theta_g}{\theta_g}\right) \hat{C}_s. \quad (6)$$

If this condition is satisfied, a pooling equilibrium will exist for a sufficiently high value of λ . High values of $\bar{\theta}$ make pooling contracts relatively attractive for banks, while high liquidation values of collateral (δ) make separating contracts relatively cheap. It follows that the minimum $\bar{\theta}$ for which condition (6) is satisfied is increasing in δ . This suggests that our analysis applies not only to mature markets with high average borrower quality, but also to riskier markets with relatively high liquidation costs, such as emerging economies with poor enforcement of property rights. We can now state the following result.

PROPOSITION 1: *If condition (6) holds, then there exists $0 < \hat{\lambda} < \infty$ such that: i) for $\lambda \leq \hat{\lambda}$, the strategy profile in which all banks offer the contract $(\hat{R}_s, \hat{C}_s)$ is the unique stable pure-strategy equilibrium; ii) for $\lambda > \hat{\lambda}$, no stable pure-strategy separating equilibrium exists.*

Proof: See Appendix A.

For λ higher than $\hat{\lambda}$, each bank suffers relatively less from the adverse selection of financing other banks' poor credit risks and the distribution of unknown applicant borrowers faced by each individual bank becomes too creditworthy for a separating equilibrium to exist. The intuition is the following. For good entrepreneurs, the perfect sorting of the separating equilibrium carries the advantage of a lower interest rate, but also the cost of a higher collateral requirement. The need to post collateral generates an inefficiency since liquidation is costly. This inefficiency is essentially the cost of sorting and, if the average creditworthiness of applicant borrowers is good enough (as is the case for $\lambda > \hat{\lambda}$), it will exceed the benefits of sorting. In that case, the proposed separating contract is strictly dominated by some pooling contract $(R_p, 0)$, and no separating equilibrium exists.¹² We discuss this case in the next section. Proposition 1 also establishes that the equilibrium is stable (in the sense of Kohlberg and Mertens (1986)). Furthermore, the equilibrium is also robust to most other refinements as it represents the unique stable equilibrium. Finally, it is worth emphasizing that changes in λ do not affect the average quality of the total pool of borrowers, but rather that of those applying in equilibrium to each bank. Overall, borrower quality remains constant and all the effects are driven purely by reductions in information asymmetries.

B. The Pooling Equilibrium

The same conditions that preclude the existence of a pure-strategy separating equilibrium guarantee the existence of an equilibrium that pools all borrowers and offers everyone credit on the same terms. Consider the break-even pooling contract $(\hat{R}_p, 0)$, with

$$\hat{R}_p = \bar{d} \frac{\left(\frac{N-1}{N}\right)(1-\alpha) + \lambda}{\left(\frac{N-1}{N}\right)(1-\alpha)\theta_b + \lambda\bar{\theta}}. \quad (7)$$

PROPOSITION 2: *If condition (6) holds, then, for $\lambda > \hat{\lambda}$, the strategy profile in which all banks offer the contract $(\hat{R}_p, 0)$ is the unique stable pure-strategy equilibrium.*

Proof: See Appendix A.

As before, whenever condition (5) does not hold, there exists a pooling contract that good borrowers prefer to the zero-profit screening contract such that any bank offering it would make positive profits if no other bank also offers that contract. Hence, there is no separating equilibrium. However, there is a

¹² This is as in Rothschild and Stiglitz (1976), Wilson (1977), and Hellwig (1987).

stable pooling equilibrium, as no contract with $C > 0$ can represent a profitable deviation from the pooling equilibrium contract $(\hat{R}_p, 0)$, since all applications to the deviating contract would need to be rejected in the third stage because they would fail to draw a better-than-average pool of borrowers given all applications to $(\hat{R}_p, 0)$ would be rejected.¹³

We base the analysis from here forward on the two equilibria characterized in Propositions 1 and 2. Using the fact that in equilibrium bank profits are just the profits from their pool of known borrowers since banks make zero profits on unknown borrowers, we can now compare these two scenarios.

PROPOSITION 3: *Relative to the separating equilibrium, in the pooling equilibrium:*

- i) *Banks' profits are lower;*
- ii) *The average quality of banks' portfolios is lower;*
- iii) *Aggregate credit is larger, even on a per-applicant borrower basis (after dividing by $1 + \lambda$).*

Proof: See Appendix A.

The first result in Proposition 3 establishes a link between market information structure and bank profitability. Points (ii) and (iii) compare the properties of the two equilibria in terms of bank portfolio quality and aggregate credit. When screening takes place, only good borrowers obtain financing. Thus, it is clear that the average quality of bank portfolios will be higher under screening than in a pooling equilibrium, in which case credit is extended to all but a small fraction ($\frac{1}{N}$) of bad borrowers.

The same considerations also imply that aggregate credit is larger under pooling than screening, even controlling for differences in market size. For instance, all results so far continue to hold if λ instead represents the fraction of unknown borrowers of a fixed market size of 1, with $1 - \lambda$ being the mass of known borrowers. Note as well that the strategic behavior of banks has a multiplier effect on the demand for credit. When demand is low ($\lambda < \hat{\lambda}$), only good borrowers obtain financing, so that aggregate credit increases linearly with demand. However, if demand increases enough ($\lambda > \hat{\lambda}$), the switch in equilibrium strategies from screening to pooling generates a credit boom with both good and bad borrowers obtaining financing.

The intuition for this result is the following. Each bank's market power is linked to its information, since profits stem solely from the adverse selection each bank generates for its competitors. Essentially, banks are able to extract rents from borrowers whose type they know because it is difficult for these

¹³ For these parameter values, this model may admit other equilibria supported by beliefs off the equilibrium path that are not robust to most refinements. Indeed, only the proposed zero-profit pooling equilibrium survives the stability criterion of Kohlberg and Mertens (1986). We note that Wilson (1977) proposes an alternative equilibrium concept whereby the zero-profit pooling contract is also the only solution.

borrowers to credibly signal their quality to other lenders. When the proportion of unknown borrowers in the market increases, adverse selection becomes less severe and, hence, banks' market power over their known borrowers decreases. The finding that banks reduce their lending standards so that all borrowers obtain credit therefore results from the improvement in the distribution of borrowers applying to any given bank. The result is similar to the finding in de Meza and Webb (1987) that good borrowers may draw in bad ones, with the important difference that in our model the overall distribution of borrowers in the economy remains constant.

While we derive the results in this section for a fixed deposit rate, they continue to hold if the deposit rate is increasing in the banking system's demand for funds as long as the supply of deposits is sufficiently elastic. As long as the deposit rate does not increase too quickly or discretely when aggregate lending increases (as might be the case if the supply of deposits were fixed), there will be a value of λ such that the pooling contract will dominate the separating one even after taking into account the higher deposit rate associated with the increase in aggregate lending.

The negative relationship between aggregate credit and bank portfolio quality established in Proposition 3 sheds some light on why banking crises are often preceded by lending booms, as is well documented empirically. When the proportion of unknown borrowers increases, the strategic interaction of banks may cause both a lending boom and a deterioration of bank portfolios, both of which are accompanied by a reduction in bank profitability. Under these conditions, an aggregate shock to the banking system will be more deleterious than in a situation in which only good borrowers are financed and banks' profits are higher. We discuss this issue further in Section III.

C. Welfare Analysis

In a separating equilibrium, economy-wide net output (or surplus) is the sum of the expected returns from good projects minus both the cost of funds and the cost associated with the liquidation of the collateral for those projects that, although good, do not produce a positive return. This can be written as

$$W_s = \alpha(\theta_g y - \bar{d}) + \lambda\alpha(\theta_g y - (1 - \delta)(1 - \theta_g)\hat{C}_s - \bar{d}). \quad (8)$$

In a pooling equilibrium, collateral requirements are zero, in which case expected total surplus is just the sum of the net expected returns of all borrowers who are financed. This can be written as

$$W_p = \alpha(\theta_g y - \bar{d}) + \left(\frac{N-1}{N}\right)(1 - \alpha)(\theta_b y - \bar{d}) + \lambda(\bar{\theta} - \bar{d}). \quad (9)$$

Note that in both cases there is no welfare loss associated with financing known good borrowers; for these borrowers, asymmetric information represents a pure transfer from borrowers to lenders in the form of higher interest rates, but no inefficient liquidation of collateral.

We now examine whether the prevailing equilibrium maximizes total surplus or, whether instead, a social planner would want to intervene to restrict banks' strategies and impose a particular (and potentially different) outcome. In other words, if both equilibria were possible, we ask whether one is superior in terms of maximizing aggregate net output.

PROPOSITION 4: *If condition (6) is satisfied, then there will exist a λ^w such that: i) $W_p > W_s \Leftrightarrow \lambda > \lambda^w$; ii) $\lambda^w < \hat{\lambda}$.*

Proof: See Appendix A.

The first part of this proposition states that output will be higher with pooling than with screening if and only if the proportion of unknown borrowers in the market is above a certain threshold. The intuition for this result is straightforward. On the one hand, the welfare loss associated with pooling consists of two parts, one due to the financing of some of the competing banks' known bad borrowers, and the other due to the financing of unknown bad borrowers. While the latter grows linearly with λ , the former is constant, with its weight tending to zero as λ approaches infinity. On the other hand, the welfare loss associated with screening consists entirely of the collateral liquidation cost, which grows linearly with λ . As a result of condition (6), pooling of borrowers will Pareto dominate whenever the adverse selection caused by the informational asymmetries among banks is low. Hence, there must be some positive λ such that the loss associated with collateral liquidation costs exceeds that associated with financing bad borrowers.

Proposition 4 also establishes that if information asymmetries are low and a pooling equilibrium exists, this equilibrium is also optimal from the perspective of maximizing aggregate output. The fact that $\lambda^w < \hat{\lambda}$ is not surprising once one considers that at $\lambda = \hat{\lambda}$ banks as well as good borrowers are indifferent between the pooling and the separating equilibria, whereas bad borrowers are obviously better off under the pooling equilibrium.

All the results so far apply to the case in which all borrowers have sufficient wealth W that they are able to post collateral if necessary and therefore no one is "underserved" in equilibrium (i.e., there is no true credit rationing). However, it is straightforward to show that similar, and in fact stronger, results obtain if instead some borrowers are unable to meet the collateral requirement of the bank and therefore are unable to obtain financing even if they have positive net present value (NPV) investments. To see this, consider a simple extension to the model and assume that some fraction γ of the borrowers has zero wealth ($W = 0$) and can therefore post no collateral. When banks screen via collateral requirements, borrowers with no wealth will be rationed out of the market. However, if λ is sufficiently high that banks instead pool all borrowers, the elimination of the collateral requirement allows good but poor borrowers that would otherwise be rationed to obtain credit. This reinforces our finding that aggregate output is maximized under the pooling equilibrium, even if the average quality of the banks' portfolios decreases.

The analysis in this section, as well as the other results in this paper, carry through to a model in which banks screen borrowers through a costly credit-worthiness test. In Appendix B we provide such a model and show that, in a setting in which banks do not duplicate each other's screening, all our main results hold.¹⁴ However, borrower wealth plays no role in that model, and hence the effect we identify in the paragraph above is absent.

III. Macroeconomic Shocks and Banking Crises

The results in the previous section demonstrate that strategic interaction among banks creates a link among (1) market information structure, (2) the aggregate amount of credit in the economy, (3) bank portfolio quality, and (4) bank profitability. In this section we show that, once a measure of aggregate uncertainty is incorporated into the model, the market's information structure has additional implications for the stability of the banking system. In the next section we discuss how business cycles and financial liberalizations, by changing either the information structure or the cost structure of the market, may affect the likelihood of observing a banking crisis.

A natural source of aggregate uncertainty arises from the banking system's function of maturity transformation, whereby banks convert short-term deposits into longer-term loans. Since the availability, as well as the cost, of banks' liabilities may fluctuate while their assets are tied up in commitments with longer-term maturity, there is an inherent risk associated with this maturity transformation function. We model this risk by assuming that, at the time they make their lending decisions, banks do not know with certainty their cost of funds, which is a random variable $\tilde{d}$ with mean $\bar{d}$ and distribution $F(\tilde{d})$. The realized value of $\tilde{d}$ becomes known only at the end of stage 3, after loans have been granted. In terms of the extensive form of this game, this is equivalent to assuming that banks commit themselves to provide a loan before the deposit market has cleared, and thus the realized interest rate on deposits is unknown. Alternatively, one can assume that the deposit rate is a short-term rate that can change before loans are repaid, and that banks need to rollover their liabilities.

For simplicity, we assume that banks have unlimited liability, but that they fail whenever their profits drop below zero. The behavior of banks is therefore fully characterized by the distribution of the average of the cost of funds. Hence, all the results we obtain in the previous sections hold in expectation. However, since there is aggregate uncertainty in the economy, the realized outcome may differ from the expected one. We define a banking crisis as a situation in which the aggregate banking system realizes negative profits, and thus has negative capital.¹⁵ This leads us to the main result of this section.

¹⁴ An analysis of the additional costs related to duplicated monitoring in banking can be found in von Thadden (1994). In particular, duplicated monitoring can introduce a social cost that is borne primarily by good borrowers.

¹⁵ Alternatively, we could define a banking crisis as a situation in which one or more banks realize ex post losses. The main results would be the same.

PROPOSITION 5: *The probability of a banking crisis is nondecreasing in λ , the number of unknown borrowers in the market, and is strictly increasing for $\lambda \geq \hat{\lambda}$.*

Proof: See Appendix A.

This result stems from two separate effects. The first is directly linked to the credit boom. When λ increases enough, banks stop screening and extend credit to all applicant borrowers. This expansion in lending increases the exposure of banks to shocks to their cost of funds. Since banks earn positive profits only from known borrowers, the sensitivity of total profits to changes in the cost of funds is larger the greater is the volume of credit. This effect can most readily be seen at the cutoff value of $\hat{\lambda}$, at which point bank profits are the same in the pooling and the separating equilibrium, but credit is discretely larger in the former. Hence, this proposition establishes that small changes in the information structure of the market can cause a discrete increase in the probability of a crisis if they lead banks to reduce their standards and switch from screening borrowers to pooling everyone together.

The second effect is analogous to that behind Proposition 3. When the proportion of unknown borrowers in the economy increases, banks lose some informational capital and the market power that comes with it. Credit markets become more competitive, which lowers banks' profits on known borrowers and reduces their ability to withstand negative shocks. Then, even within the region in which no bank performs any screening, an increase in the number of unknown borrowers leads to an unambiguous increase in the probability that banks are insolvent. It is worth noting that while this second effect may arise in other models in which bank profits are a buffer against aggregate uncertainty, the first effect is novel and specific to our framework based on an information-generated lending boom.

It bears emphasizing that the result in Proposition 5 holds even though there is no change in the aggregate quality as λ increases. The result stems purely from the fact that banks are better able to withstand macroeconomic downturns when they are more profitable, granting loans to fewer, but relatively better, borrowers, than when they earn lower profits, financing all borrowers indiscriminately. We therefore have an increased probability of a crisis that is based on purely strategic reasons, even with rational and competitive banks. In other words, both the credit expansion and the greater possibility of a banking crisis emerge as pure information-based phenomena. It is worth noting, however, that a banking crisis in our framework simply represents a collapse of a sufficiently large number of individual banks, and does not address the possibility of contagion among banks, an issue that has dominated the recent debate on this topic. In particular, bank failures in our model stem from increased fragility at the bank level rather than from some underlying systemic instability.

This result highlights a trade-off between the output generated as a result of bank lending and banking system stability. While pooling borrowers generates higher aggregate output, it is also associated with a higher probability of a

banking crisis.¹⁶ Moreover, if banking crises involve an aggregate welfare loss beyond that suffered by the banking system, this analysis suggests that there may be scope for policy intervention. In particular, a social planner averse to volatility is confronted with a trade-off between enhancing either the output or the stability of the banking system when information asymmetries are low. In that context, policies such as risk-based capital requirements that link banks' costs to the riskiness of their portfolios may help extend the region in which screening is feasible and thus reduce the probability of a crisis.¹⁷ Minimum collateral requirements on bank lending would have a similar effect, but may introduce a distortion if regulators are less informed than banks about market conditions.

While the results in Proposition 5 obtain for the case in which the cost of deposits, $\tilde{d}$, is independent of bank behavior, one can show that similar results obtain if the deposit rate is endogenized so as to compensate depositors for the possibility of default by the bank. In other words, our qualitative results are unchanged if the deposit rate must be set to compensate depositors for the risk of bank failure, or of a banking crisis. In this instance, the deposit rate in equilibrium would be (weakly) increasing in λ , since a larger λ corresponds to an increased probability of bank failure. Thus, an increase in λ further squeezes banks and increases the likelihood of a crisis.

Note that $\hat{\lambda}$, the upper bound for screening to be feasible, is a decreasing function of the cost of liquidation, $1 - \delta$, so that markets with lower liquidation costs should find it easier to support borrower screening. Similarly, reforms aimed at improving bankruptcy laws and clarifying property rights should also increase the incidence of borrower screening by reducing liquidation costs. Furthermore, by reducing the cross-subsidization that occurs under a pooling equilibrium, the overall cost of borrowing can be reduced. Nevertheless, it is likely that some cost of liquidation will always remain as long as collateral is more valuable to the entrepreneur than to the financier.

We can derive two main contributions from the analysis of this section. First, our model proposes a rational bank lending mechanism that explains bank fragility as a function of purely informational factors. The literature on financial accelerators (e.g., Kiyotaki and Moore (1997)) identifies small changes in fundamentals as the initial catalyst for the crisis, which then becomes amplified through the financial system.¹⁸ We identify a new channel that magnifies the impact that changes in macroeconomic conditions have on the probability of banking crises. Second, we provide a simple mechanism that links booms and

¹⁶ This paper is, therefore, also related to the literature on the effects of competition on the stability of the banking system (see, for example, Matutes and Vives (1996), and Allen and Gale (2004)).

¹⁷ In addition, it is easy to show that in a model in which banks have some market power over unknown borrowers, policies aimed at limiting banks' lending capacity would have a similar effect.

¹⁸ An example of such a change is the value of durable assets used as collateral. When this value increases, credit constraints are loosened and leverage increases. Because of the higher leverage, the system becomes vulnerable to small shocks, and thus a small drop in the price of collateral may turn the boom into a crisis.

crises to the quality of the projects that obtain bank financing, for a given aggregate distribution of borrowers. In contrast, recent papers link lending standards to business cycles through changes in aggregate borrower quality (Ruckes (2004)) or attrition in the ranks of loan officers skilled at detecting bad loans (Berger and Udell (2004)). These different effects may coexist with ours to the extent that the factors responsible for an increase in the proportion of new borrowers also affect their aggregate quality.

IV. Determinants of Equilibrium

We now turn to examining factors that, by either changing the proportion of unknown borrowers or changing its threshold value, determine whether borrowers are screened or are pooled together. Changes in the proportion of unknown borrowers can be caused by the business cycle, the introduction of new technology, or by changes in the value of collateralizable assets. From a cross-sectional perspective, differences in the fraction of unknown borrowers may be driven by differences in the maturity of the industry and the banking sector, or by the extent to which past information on project success correlates across time. Similarly, changes in the threshold value may be related to monetary policy, financial sector reforms, and changes in bank market structure. In what follows, we study these issues in greater detail.

A. Business Cycle and Industry Effects

One possible source of changes in the aggregate demand for credit (λ) is the business cycle. During an upswing in the business cycle, market conditions are favorable for the expansion of existing businesses, yielding an increase in the demand for credit. A sufficiently large swing in the business cycle yields a switch in the equilibrium strategy and a reduction in lending standards, resulting in a lending boom that is more than commensurate to the increase in the demand for credit.¹⁹ The entry of new firms over the business cycle may have a similar effect if we assume, as mentioned previously, that banks conduct minimal credit screens of all customers, but such screens generate useful information only with probability $\frac{1}{1+\lambda}$. In such a setting, as new firms enter (λ increases), information asymmetries across banks decrease, thus fueling a lending boom.²⁰ Thus, in this

¹⁹ It is worth noting that upswings in the business cycle are often accompanied by improved prospects for all firms. In our model, this would correspond to an overall improvement in the distribution of borrowers, an issue from which we abstract in order to focus purely on the role of information. See Ruckes (2004) for a study of lending standards as borrower quality changes.

²⁰ If these new firms could be perfectly identified as being unknown to all banks, then their entry would have no effect on the equilibrium incentives to screen. The market may be segmented in this case, with firms identified as being unknown to all banks being pooled separately from all other firms.

model even small business cycle swings can have large effects on the allocation of credit and on aggregate output (see Proposition 3).

Although our model focuses on adverse selection, it is straightforward to add a moral hazard dimension to the problem, as in Kiyotaki and Moore (1997). In this scenario, banks would always demand a minimum amount of collateral to solve moral hazard problems, but collateral requirements would still be higher in the screening equilibrium than in the pooling one. Moreover, the business cycle would have an additional effect through the asset price channel: An increase in the price of assets used as collateral would act like an increase in λ , and grant access to credit to entrepreneurs previously too wealth constrained to post the minimum collateral necessary to apply for a loan.

The results of this model can also be used to study cross-sectional differences in lending to different market sectors or different industries. It has been alleged that during the high-tech boom of the late 1990's, investors (as well as lenders) were channelling funds to firms about which they had very little information, and that this kind of behavior led to the eventual collapse of these markets. Using λ to represent an inverse measure of the extent to which past information about a firm is indicative of future success (i.e., the extent to which the success of a firm's projects correlate across time), our model predicts precisely this kind of behavior when there is very little extant information about firms. While in this case information asymmetries between banks and borrowers may remain large, those across banks are likely to be small since little of the information gathered from prior experience will be reusable. We should therefore observe fairly competitive markets with loose credit standards, increasing the probability of an eventual collapse.

B. Financial Sector Reforms and Monetary Policy

Financial reforms, such as capital account liberalizations, are another event that may trigger a change in lending standards by affecting banks' average cost of funds. We formalize this idea in the following proposition.

PROPOSITION 6: *The threshold $\hat{\lambda}$ below which borrower screening is feasible is increasing in the expected cost of funds of the banking system $\bar{d}$.*

Proof: See Appendix A.

The intuition for this result is that, when the expected cost of funding for the banking system increases, the promised repayment in the pooling equilibrium needs to increase enough to cover the losses associated with the loans to all borrowers, including those with a low probability of repayment. This results in a greater than one for one pass-through of the increase in the cost of funds. For the case in which borrowers are screened, the pass-through is smaller since only good borrowers obtain financing. Moreover, the collateral that banks obtain helps them absorb some of the losses associated with failed projects. This difference in interest rate pass-throughs implies that when banks' cost of funds

increases, borrower pooling becomes relatively more expensive and less attractive, in which case banks are more likely to retain high standards and screen loan applicants.

This result has two immediate interpretations. First, capital inflows that reduce the interest rate paid by banks to depositors and investors, such as those in the aftermath of a capital account liberalization, may cause a strategic reduction in lending standards and in turn a lending boom. In that context, our model is consistent with the recent literature on the “twin crises”—balance of payments and banking—that identifies international movements in capital, which often arise as a result of a financial liberalization, as a potential source of banking instability and financial vulnerability (see, e.g., Kaminsky and Reinhart (1999)).²¹ Our result matches the empirical finding that lending booms are often preceded by financial reforms that substantially reduce banks’ cost of financing through liberalization of capital flows and reductions of reserve requirements.

Second, this result suggests that changes in monetary policy that affect interest rates, and thus banks’ borrowing costs, may trigger changes in banks’ screening strategies. In our model, a monetary tightening will cause a flight to quality that is similar to that identified in agency cost models. Here, however, this effect is the result of an increase in the costs associated with adverse selection rather than more severe agency problems.

C. Entry and Contestability

In this section, we examine the reaction of a monopolist incumbent to the introduction of a competitive threat. This issue is of importance given the recent literature suggesting that financial sector liberalization may lower the profitability and charter value of domestic banks, thereby increasing systemic vulnerability (see Claessens et al. (2001)). For this purpose, consider the case of a market that consists of a single bank protected from entry by regulation. It is straightforward to show that this monopolist will always screen out the bad borrowers by offering a separating contract.

LEMMA 2: *There exists an $\bar{\varepsilon} > 0$ such that for all $0 < \varepsilon < \bar{\varepsilon}$, the separating contract $(\hat{R}_\varepsilon, \hat{C}_\varepsilon)$, with $\hat{R}_\varepsilon = y - \varepsilon$ and $\hat{C}_\varepsilon = \varepsilon \frac{1-\theta_g}{\theta_g}$, is more profitable than the pooling contract $(y, 0)$.*

Now consider a reform that allows new or foreign lenders with no private information about this market to compete with the incumbent. The presence of this competitive threat induces the incumbent to switch to a pooling strategy to

²¹ There may, of course, be additional factors that influence the probability of a crisis. A recent paper by Goldstein (2005), for instance, suggests that strategic complementarities between depositors and currency speculators can cause a crisis in one sector to spiral into the other sector. Allen and Gale (2000) examine similar issues.

exploit its informational advantage. We summarize this result in the following proposition.

PROPOSITION 7: *Suppose an incumbent with an informational monopoly over the known borrowers faces a competitive fringe of potential entrants that possess no private information. In the unique stable pure-strategy equilibrium, the potential entrants offer the separating contract $(\hat{R}_s, \hat{C}_s)$, the incumbent offers the pooling contract $(\hat{R}_m, 0)$, where $\hat{R}_m = \hat{R}_s + (\frac{1-\theta_g}{\theta_g})\hat{C}_s$, and all borrowers obtain credit from the incumbent.*

Proof: See Appendix A.

The result demonstrates that in equilibrium the incumbent maintains its monopolistic position, but with a market power that is now limited by the threat of entry. This result therefore extends Dell’Ariccia, Friedman, and Marquez’s (1999) finding on how an incumbent’s informational advantage can create a limit to competition to a setting in which banks can use alternative screening mechanisms, such as enforcing collateral requirements.

More importantly, Lemma 2 and Proposition 7 show that financial reforms that introduce competition into previously protected monopolistic markets may trigger a change in the lending standards applied by the incumbent. To respond to the threat of entry, the monopolist bank switches from screening to pooling so as to make the most of its informational advantage. This causes an increase in the volume of lending, a deterioration of the bank’s loan portfolio, and a reduction in the incumbent bank’s profits. The results in this section therefore isolate an additional effect that arises purely from the informational structure of the market.

D. Market Structure

Recent literature emphasizes how changes in financial markets over the last decade have had broad implications for the banking industry, with consequent changes to the behavior and profitability of banks.²² These changes have often led to alterations in the structure of the industry through, for instance, increased incentives for entry or for consolidation. In this section, we analyze how credit market structure interacts with the informational characteristics of the market in determining banks’ strategies.

PROPOSITION 8: *For $N > 2$, the threshold proportion of unknown borrowers above which a pooling equilibrium exists is increasing in the number of symmetric banks: $\hat{\lambda}(N) < \hat{\lambda}(N + 1)$.*

²² Empirically, Berger and Mester (2003) and Petersen and Rajan (2002), among others, study this issue. See Boot and Thakor (2000) for a theoretical analysis of the effects of competition on banks’ lending practices.

Proof: See Appendix A.

Changing the number of symmetric banks in the market has two competing effects. On the one hand, as the number of competing banks increases, the proportion of borrowers known to each bank shrinks, leading to a more severe adverse selection problem for each bank. This increases the incentive to screen applicant borrowers and reinforces the separating equilibrium. On the other hand, with a larger number of competing banks there is a stronger temptation to deviate from a separating equilibrium since the extra market share a deviating bank can grasp increases. Consequently, there is an increased incentive to reduce lending standards by not screening borrowers. Since in equilibrium banks make zero profits on unknown borrowers, the first effect prevails, and the threshold value $\hat{\lambda}$ increases with N . In other words, markets characterized by lower bank concentration permit a screening equilibrium for a larger proportion of unknown borrowers.

It is also straightforward to see, from inspection of equation (4), that whenever borrowers are pooled, the equilibrium lending rate will be increasing in the number of banks. This somewhat counterintuitive result is the combined product of Bertrand competition and the adverse selection caused by the informational asymmetry among banks. When there are a large number of banks, each bank has less information, and banks must raise the interest rate they charge to break even. This finding is consistent with recent theoretical results in Broecker (1990) and Marquez (2002) on competition in lending markets, and derives some empirical support from the finding that charge-off rates for bank commercial loans increase with the number of competing banks, as documented by Shaffer (1998). However, this evidence should not be seen as a direct test of our theory, since Proposition 8 also demonstrates that an increase in the number of banks can actually improve their portfolios if the increase leads them to switch to a screening equilibrium. That said, it is worth noting that the empirical results concerning loan chargeoffs and the number of banks do not extend to real-estate and consumer loans, for which, as Shaffer argues, collateral may play an important role.

V. The Role of Information Sharing

The existence of information asymmetries among banks is one key assumption of the framework we present in this paper. However, recent literature emphasizes that information sharing is a common element in credit markets.²³ In this section, we study some implications of allowing banks to share information about borrowers.

Under full information sharing, whereby banks provide each other all relevant information concerning their known customers, banks would always offer the pooling contract to unknown borrowers and the break-even contract $(\frac{\bar{d}}{\theta_g}, 0)$

²³ For example, see Pagano and Jappelli (1993) and Padilla and Pagano (1997).

to good known borrowers, but would deny credit to bad known borrowers. Hence, full information sharing among banks would never arise endogenously in this model, since it would lead to an equilibrium with zero profits as banks compete more aggressively when information is symmetric.

However, in a recent paper Bouckaert and Degryse (2004) show that the strategic disclosure of some, but not all, information may enhance profits in settings in which information asymmetries among banks exist. In their model, the sharing of “black information,” which constitutes the sharing of information about borrower defaults, has two effects. First, it increases bank competition (entry) by reducing adverse selection, since, for each bank, the type distribution of unknown borrowers with no record of defaulting improves. Second, it increases bank market power over those borrowers that, although good in type, are unlucky and default. The net impact on bank profits depends on which of these two effects prevails. Since the most commonly available information through credit bureaus is that on borrower default history, in what follows we extend the main results in this paper to the case of black information sharing.

Consider the following simple extension of the model. Suppose that, prior to stage 1, there is a stage 0, where each of the N banks lends to a (nonoverlapping) mass $\frac{1}{N}$ of borrowers and, as a consequence, learns their type. Borrowers invest in a project that is independent and identical to that described for stages 1 to 3, which succeeds with probability θ_i , $i \in \{g, b\}$. The lending bank also observes the outcome of this initial project. Suppose further that all banks are committed to share information about borrower default. In other words, it becomes common knowledge whether a project of a particular borrower is successful ($\tilde{y} = y$) or results in failure ($\tilde{y} = 0$), in which case the loan is not repaid. We now characterize the resulting equilibrium for stages 1 to 3. As before, assume that condition (6) is satisfied.

PROPOSITION 9: *Under “black information” sharing, there exists some $\hat{\lambda}^* < \infty$ such that: i) for $\lambda \leq \hat{\lambda}^*$, the unique stable equilibrium involves screening; ii) for $\lambda > \hat{\lambda}^*$, the unique stable equilibrium involves the pooling of borrowers; iii) banks always offer unknown borrowers with a record of defaulting a screening contract (R_s, C_s) ; and iv) $\hat{\lambda}^* < \hat{\lambda}$.*

Proof: See Appendix A.

This proposition extends the main result of this paper to the case in which banks share borrower default information. The intuition is as follows. The sharing of black information divides the pool of unknown borrowers faced by each bank into two segments characterized by different borrower distributions. In the segment of “black-listed” entrepreneurs for any given bank, there are no new or unknown borrowers. This means that no pooling contract can earn nonnegative profits on this segment of the market, since some other banks that know these borrowers’ exact type will match any viable offer made to good borrowers, but will let bad borrowers go. The other segment consists of all the

unknown borrowers and previously evaluated bad borrowers who did not default in the past. Hence, the equilibrium for this segment is similar to that for the game without information sharing. The only difference is that the type distribution of unknown borrowers for this segment is better, which implies that the proportion of unknown borrowers required to support a pooling equilibrium is lower relative to the case without information sharing: $\hat{\lambda}^* < \hat{\lambda}$.

We can also examine the conditions under which banks would choose whether or not to share black information. To endogenize this choice, assume that, at the beginning of stage 1, banks choose whether they want to share their own information in exchange for that of their competitors.²⁴ This leads to the next result.

PROPOSITION 10: *i) Banks' profits with black information sharing will exceed profits without information sharing if and only if the proportion of unknown borrowers in the market exceeds a certain threshold, $\lambda \geq \lambda^*$. ii) This threshold is greater than that required to support pooling in the absence of information sharing: $\lambda^* > \hat{\lambda}$.*

Proof: See Appendix A.

From Proposition 9, we know that information sharing lowers the threshold required for pooling to be optimal. Therefore, there is a range of values of λ for which, in the absence of information sharing, only an equilibrium in which borrowers are screened exists, but in the presence of information sharing, banks no longer find it feasible to screen and instead pool all borrowers. For this region, banks' profits are reduced. It follows that it will be profitable for banks to share information only when, in the absence of information sharing, the equilibrium would pool all borrowers.

The results in Propositions 9 and 10 imply that, when information sharing among banks emerges endogenously, it also increases the aggregate surplus. However, there are values of λ for which, although information sharing does not emerge endogenously, it would still increase the aggregate surplus either by expanding the region in which a pooling equilibrium exists (for $\lambda \in (\hat{\lambda}^*, \hat{\lambda})$), or by reducing the number of bad borrowers financed in equilibrium whenever the pooling of borrowers is viable (for $\lambda \in (\hat{\lambda}, \lambda^*)$). A policy-maker concerned with maximizing aggregate surplus would therefore find it optimal to collect and disseminate black information, perhaps by means of a public credit rating agency.

We note, however, that a policy of forcing the dissemination of black information may not be unambiguously beneficial if one is concerned about banking system stability in addition to pure output. When information sharing among banks emerges endogenously, it increases bank profitability and reduces the volume of credit that is allocated to bad projects, thereby reducing

²⁴ This is equivalent to determining the conditions under which banks would lobby for regulation that forces all banks to participate in an information sharing agreement.

the probability of a banking crisis. However, when such policies do not emerge endogenously among banks, forcing banks to disseminate black information may also reduce banks' profits, and therefore carries the risk of an increased probability of a crisis. Using the notation of the model, one can show that there is a $\Delta > 0$ such that for $\lambda \in (\lambda^* - \Delta, \lambda^*)$, such a policy would not only increase the aggregate surplus, but would also reduce the probability of a crisis. This is true since, for values of λ just below λ^* , banks' profits are only marginally affected by information sharing, whereas the improvement in credit allocation is of first order. However, for λ near $\hat{\lambda}$, forced information sharing has the opposite effect, since it moves the equilibrium away from one in which banks screen their borrowers to one in which all borrowers are pooled. Associated with this is a reduction in banks' profits and an increase in the volume of credit to bad borrowers, and in turn an increase in the probability of a crisis.

VI. Discussion and Conclusions

This paper presents a framework wherein the strategic behavior of banks interacts with the market information structure in determining bank lending standards. Adverse selection problems that stem from informational asymmetries among lenders induce banks to screen applicant customers to avoid financing those borrowers that are rejected by their competitors. However, when the proportion of unknown projects in the economy increases, as may happen after a deregulation or during the expansionary phase of a business cycle, such adverse selection problems become less severe, reducing banks' lending standards. This in turn results in lower bank profitability, higher aggregate credit, and higher vulnerability to macroeconomic shocks. These results continue to hold when banks share information about borrower defaults.

The model provides several testable implications that are well in line with existing empirical literature. First, the model predicts a negative relationship between new loan demand and lending standards. This is established indirectly in Asea and Blomberg (1998), who find that in the United States, lending standards tend to vary systematically over the cycle, with the probability of collateralization increasing during contractions and decreasing during expansions. Lown and Morgan (2003) also find that the lending standards that banks apply vary over the cycle. In particular, they find that higher levels of past loans are associated with a tightening of current standards, which, to the extent that more prior lending reflects more private information, is consistent with the predictions of our model. More recently, Berger and Udell (2004) find evidence for the cyclical nature of standards that is consistent with our results concerning changes in the distribution of information. While their focus is on a testing strategy and explanation at the bank-level, they recognize the importance of a system-wide rationale for the easing of lending standards, such as our information-based story.

A second empirical prediction of the model is that loan collateralization should decrease with the existence of a bank-borrower relationship that generates private information for the bank, while interest rates should increase.

These findings parallel those in Degryse and Van Cayseele (2000), who examine detailed contract information on nearly 18,000 bank loans to small Belgian firms (see also Degryse and Ongena (2004)). Also consistent with the model's prediction is the evidence in Harhoff and Korting (1998) on credit markets in Germany; the authors use relationship duration as a measure of the importance of the relationship and find that it has a negative effect on collateral requirements, and a positive, although not significant, effect on loan prices.

Finally, our model predicts that episodes of financial distress are more likely in the aftermath of periods of strong credit expansion. This chain of events, of which Argentina in 1980, Chile in 1982, Sweden, Norway, and Finland in 1992, Mexico in 1994, and Thailand, Indonesia, and Korea in 1997 are the most significant examples, has been well documented by a growing literature on banking crises. For example, Demirgüç-Kunt and Detragiache (2002) find evidence that lending booms precede banking crises. Gourinchas et al. (2001) examine a large number of episodes characterized as lending booms and find that the probability of observing a banking crisis significantly increases after such episodes. Moreover, the conditional incidence of having a banking crisis depends critically on the size of the boom. Notably, in our model, when banks screen borrowers, it is only for increases in lending large enough to induce a change in lending strategies that the probability of a banking crisis increases.

We show that the information structure of loan markets plays a crucial role in determining banks' lending standards and consequently has important implications for systemic stability and the volume of credit provided to the economy. A natural extension is to examine in more detail the factors and mechanisms that determine this information structure; in other words, to endogenize λ . We leave that task for future research.

Appendix A: Proofs

Proof of Proposition 1: The contract $(\hat{R}_s, \hat{C}_s)$ is the solution to the system

$$\theta_g R - \bar{d} + (1 - \theta_g)\delta C = 0, \quad (\text{Zero Profit}) \quad (\text{A1})$$

$$\theta_b(y - R) - (1 - \theta_b)C = 0. \quad (\text{IC}) \quad (\text{A2})$$

With this contract, the good borrowers' IR constraint is slack, that is,

$$\theta_g(y - \hat{R}_s) - (1 - \theta_g)\hat{C}_s > 0. \quad (\text{IR}) \quad (\text{A3})$$

which implies that $y > \hat{R}_s + (\frac{1-\theta_g}{\theta_g})\hat{C}_s$. Since by assumption we have $\theta_b y < \bar{d}$, it follows that $\frac{\bar{d}}{\theta_b} > \hat{R}_s + (\frac{1-\theta_g}{\theta_g})\hat{C}_s$. Then, from condition (5), this in turn implies that at $\lambda = 0$ we always have a separating equilibrium as no bank can profitably

deviate from the zero-profit separating contract. Now, it is easy to see that the left-hand side (LHS) of the inequality in (5),

$$\bar{d} \frac{(N-1)(1-\alpha) + \lambda N}{(N-1)(1-\alpha)\theta_b + \lambda \bar{\theta} N}, \quad (\text{A4})$$

is continuous and decreasing in λ , and tends to $\frac{\bar{d}}{\bar{\theta}}$ as $\lambda \rightarrow \infty$. Hence, if condition (6) holds, there must exist a $\hat{\lambda} > 0$ such that a separating equilibrium exists if and only if $\lambda \leq \hat{\lambda}$. Moreover, the zero-profit condition guarantees that no bank can profitably deviate by offering a different separating contract. Finally, if condition (5) is violated, which occurs by assumption as $\lambda \rightarrow \infty$, then no pure-strategy separating equilibrium exists because of the standard Rothschild–Stiglitz argument. This demonstrates that the equilibrium described above is the unique stable separating equilibrium, and exists if and only if $\lambda \leq \hat{\lambda}$.

To show that no pooling equilibrium exists, note that condition (4) implies that the rate $\hat{R}$ offered on any candidate pooling contract needs to be sufficiently high so as to satisfy $\lambda(\bar{\theta}\hat{R} - \bar{d}) + (1-\alpha)(\frac{N-1}{N})(\theta_b\hat{R} - \bar{d}) \geq 0$ in order not to lose money. However, for $\lambda < \hat{\lambda}$, condition (5) establishes that a bank could deviate by offering the contract $(\hat{R}_s + \epsilon, \hat{C}_s)$, with $\hat{R}_s$ and $\hat{C}_s$ as defined above and $\epsilon > 0$, attracting only the good borrowers for ϵ sufficiently small, and making a profit. Therefore, no equilibrium that pools borrowers exists for $\lambda < \hat{\lambda}$, thus completing the proof. Q.E.D.

Proof of Proposition 2: The proof of the first part of the proposition is identical to that of Proposition 1. Consider what happens when all banks offer the contract $(\hat{R}_p, 0)$, with

$$\hat{R}_p = \bar{d} \frac{\left(\frac{N-1}{N}\right)(1-\alpha) + \lambda}{\left(\frac{N-1}{N}\right)(1-\alpha)\theta_b + \lambda \bar{\theta}}. \quad (\text{A5})$$

In stage 3, the rationing rule implies that one bank finances all unknown borrowers. This bank makes zero profits on this contract, as do all the other banks whose contracts were not accepted. The bad borrowers known to the winning bank are the only ones that do not obtain financing. It is obvious that no contract $(R, 0)$ with $R < \hat{R}_p$ can make nonnegative profits. Similarly, no contract $(R, 0)$ with $R > \hat{R}_p$ can make positive profits, as such a contract would not attract any borrowers. It remains to be shown that no contract with $C > 0$ can be profitable.

First, consider that, since for $\lambda > \hat{\lambda}$ condition (5) is violated, good borrowers prefer $(\hat{R}_p, 0)$ to the zero-profit separating contract $(\hat{R}_s, \hat{C}_s)$. Hence, any viable contract $(\tilde{R}, \tilde{C})$ with $\tilde{C} > 0$ that is preferred to $(\hat{R}_p, 0)$ by good borrowers would have to violate the bad borrowers' IC constraint in the absence of $(\hat{R}_p, 0)$. Now, following the argument in Hellwig (1987), we can show that $(\tilde{R}, \tilde{C})$ is not a profitable deviation because under the equilibrium strategies all applications

to $(\tilde{R}, \tilde{C})$ will have to be rejected at stage 3. In order to accept borrowers' applications, the deviating bank would have to receive applications from an above-average sample of the population. If that were the case, all other banks would reject all applications to $(\hat{R}_p, 0)$, as that contract just breaks even with the average population. However, taking this fact into account, all borrowers must apply to $(\tilde{R}, \tilde{C})$, contrary to the assumption that a "better-than-average" group of borrowers applied to that contract. Hence, all applications to $(\tilde{R}, \tilde{C})$ would have to be rejected, and consequently $(\tilde{R}, \tilde{C})$ cannot represent a profitable deviation. Therefore, $(\hat{R}_p, 0)$ constitutes an equilibrium. Moreover, an application of the stability criterion (Kohlberg and Mertens (1986)) establishes that this is the uniquely stable equilibrium. Q.E.D.

Proof of Proposition 3: i) First, note that, because of competition, all banks make zero profits on unknown borrowers under either the pooling or the separating equilibrium. Bank profits therefore stem solely from known borrowers. Denote the rate charged to each good known borrower as $R_g^j, j = s, p$ (separating or pooling). Following Lemma 1, each bank's profits on known borrowers can be written as

$$\Pi_k(R_g) = \frac{\alpha}{N}(\theta_g R_g - \bar{d}), \quad k = 1, \dots, N, \quad (\text{A6})$$

where $R_g = R_g^s = \hat{R}_s + (\frac{1-\theta_g}{\theta_g})\hat{C}_s$ in the separating equilibrium, and $R_g = R_g^p = \hat{R}_p$ in the pooling equilibrium. From Proposition 2, we know that $\hat{R}_s + (\frac{1-\theta_g}{\theta_g})\hat{C}_s > \hat{R}_p$ for $\lambda > \hat{\lambda}$. Hence, $\Pi_k(R_g^p) < \Pi_k(R_g^s)$.

ii) and iii) These results are trivial, since all unknown borrowers obtain financing. Q.E.D.

Proof of Proposition 4: To prove the first part, start by noting that at $\lambda = 0$ we have $W_p < W_s$. We now show that $W_p - W_s$ is continuously increasing in λ and $\lim_{\lambda \rightarrow \infty} (W_p - W_s) = +\infty$, so that there must exist a $\lambda^w > 0$ such that $W_p < W_s \Leftrightarrow \lambda < \lambda^w$. To see this, consider

$$\lim_{\lambda \rightarrow \infty} (W_p - W_s) = \lim_{\lambda \rightarrow \infty} \lambda \left((\alpha\theta_g y + (1-\alpha)\theta_b y - \bar{d}) - \frac{\alpha(\theta_g - \theta_b)\hat{C}_s}{\theta_b} \right), \quad (\text{A7})$$

and

$$\frac{\partial(W_p - W_s)}{\partial \lambda} = (\alpha\theta_g y + (1-\alpha)\theta_b y - \bar{d}) - \frac{\alpha(\theta_g - \theta_b)\hat{C}_s}{\theta_b}. \quad (\text{A8})$$

Condition (6) can be written as

$$\frac{\alpha(\theta_g - \theta_b)}{\theta_b} \hat{C}_s < \frac{\alpha\theta_g(\bar{\theta}y - \bar{d})}{\bar{\theta}}, \quad (\text{A9})$$

which, since $\frac{\alpha\theta_g}{\bar{\theta}} < 1$, implies that $\lim_{\lambda \rightarrow \infty} (W_p - W_s) = +\infty$ and $\frac{\partial(W_p - W_s)}{\partial \lambda} > 0$.

For the second part, consider, from the definitions of W_s and W_p , that $W_s < W_p \Leftrightarrow$

$$\lambda\alpha(\theta_g y - (1 - \delta)(1 - \theta_g)\hat{C}_s - \bar{d}) < \left(\frac{N-1}{N}\right)(1 - \alpha)(\theta_b y - \bar{d}) + \lambda(\bar{\theta} y - \bar{d}). \quad (\text{A10})$$

We can now rewrite $\lambda\alpha(\theta_g y - (1 - \delta)(1 - \theta_g)\hat{C}_s - \bar{d}) = \frac{\alpha\lambda(\theta_g - \theta_b)\hat{C}_s}{\theta_b}$. Hence, $W_s \leq W_p \Leftrightarrow$

$$\frac{\alpha\lambda(\theta_g - \theta_b)\hat{C}_s}{\theta_b} \leq \left(\frac{N-1}{N}\right)(1 - \alpha)(\theta_b y - \bar{d}) + \lambda(\bar{\theta} y - \bar{d}). \quad (\text{A11})$$

After substituting, we have $\hat{R}_s + (\frac{1-\theta_g}{\theta_g})\hat{C}_s = y - \frac{(\theta_g - \theta_b)}{\theta_g \theta_b}\hat{C}_s$. Therefore, condition (5), with the inequality reversed so that a pooling equilibrium exists, can be expressed as

$$\frac{\left(\frac{N-1}{N}\right)(1 - \alpha)(\theta_b y - \bar{d}) + \lambda(\bar{\theta} y - \bar{d})}{\left(\frac{N-1}{N}\right)(1 - \alpha)\theta_b + \lambda\bar{\theta}} \geq \frac{(\theta_g - \theta_b)}{\theta_g \theta_b}\hat{C}_s. \quad (\text{A12})$$

Note that we can now also rewrite condition (A11) as

$$\frac{\left(\frac{N-1}{N}\right)(1 - \alpha)(\theta_b y - \bar{d}) + \lambda(\bar{\theta} y - \bar{d})}{\alpha\lambda\theta_g} \geq \frac{(\theta_g - \theta_b)}{\theta_g \theta_b}\hat{C}_s, \quad (\text{A13})$$

which, since $(\frac{N-1}{N})(1 - \alpha)\theta_b + \lambda\bar{\theta} > \alpha\lambda\theta_g$, implies that if condition (A12) is satisfied, (A11) will also be satisfied, or in other words, $\lambda^w < \hat{\lambda}$. Q.E.D.

Proof of Proposition 5: We first show that the probability of a banking crisis is greater under the pooling equilibrium than under the separating equilibrium. We then show that, for $\lambda > \hat{\lambda}$ (the region of the pooling equilibrium), the probability of a crisis is strictly increasing in λ . To begin, define d_j^* , $j = s, p$, as the realized value of d at which the entire banking system breaks even under the separating or pooling equilibrium, respectively. Then, the probability of a banking crisis is $1 - F(d_j^*)$.

We can write the ex post total profits of the banking system as

$$\Pi^s(d) = \alpha(\theta_g R_g^s - d) + \lambda\alpha(\theta_g \hat{R}_s + \delta(1 - \theta_g)\hat{C}_s - d), \quad (\text{A14})$$

for the separating equilibrium, and as

$$\Pi^p(d) = \alpha(\theta_g \hat{R}_p - d) + \lambda\alpha(\bar{\theta} \hat{R}_p - d) + \frac{N-1}{N}(1 - \alpha)(\theta_b \hat{R}_p - d), \quad (\text{A15})$$

for the pooling equilibrium. From Proposition 3, we know that bank profits on known borrowers are higher in the separating equilibrium than in the pooling equilibrium. Thus, as the zero-profit condition on unknown borrowers holds for both equilibria at $d = \bar{d}$, we have $\Pi^s(\bar{d}) > \Pi^p(\bar{d})$. Total profits are linearly decreasing in d , so it is easy to verify that $|\frac{\partial \Pi^s(d)}{\partial d}| < |\frac{\partial \Pi^p(d)}{\partial d}|$. Therefore, because of linearity, we can write

$$d_s^* = \bar{d} + \frac{\Pi^s(\bar{d})}{\left| \frac{\partial \Pi^s(d)}{\partial d} \right|}, \quad (\text{A16})$$

and

$$d_p^* = \bar{d} + \frac{\Pi^p(\bar{d})}{\left| \frac{\partial \Pi^p(d)}{\partial d} \right|}, \quad (\text{A17})$$

so that $d_s^* > d_p^*$, which implies $1 - F(d_s^*) < 1 - F(d_p^*)$.

Next, observe that the change in total profits with respect to an increase in λ under the pooling equilibrium is

$$\frac{\partial \Pi^p}{\partial \lambda} = \frac{\partial \hat{R}_p}{\partial \lambda} \left(\alpha \theta_g + \lambda \alpha \bar{\theta} + \frac{N-1}{N} (1-\alpha) \theta_b \right) - d. \quad (\text{A18})$$

Since

$$\frac{\partial \hat{R}_p}{\partial \lambda} = \bar{d} \frac{(\bar{\theta} - \theta_b)(\alpha - 1)(N-1)N}{((N-1)(1-\alpha)\theta_b + \lambda \bar{\theta} N)^2} < 0, \quad (\text{A19})$$

this implies that $\frac{\partial \Pi^p}{\partial \lambda} < 0$ for $\lambda > \hat{\lambda}$, as desired.

Note finally that the marginal effect of λ on Π^p is magnified by the realized cost of funds, d . In other words, $\frac{\partial^2 \Pi^p}{\partial \lambda \partial d} < 0$, implying that variability in the cost of funds is of greater consequence for larger values of λ , leading to a greater probability of a crisis. Q.E.D.

Proof of Proposition 6: The condition that defines $\hat{\lambda}$ is

$$\left(\hat{R}_s + \left(\frac{1-\theta_g}{\theta_g} \right) \hat{C}_s \right) - \hat{R}_p = 0. \quad (\text{A20})$$

Applying the Implicit Function Theorem, we obtain

$$\frac{\partial \hat{\lambda}}{\partial \bar{d}} = - \frac{\frac{\partial \left(\left(\hat{R}_s + \left(\frac{1-\theta_g}{\theta_g} \right) \hat{C}_s \right) - \hat{R}_p \right)}{\partial d}}{\frac{\partial \left(\left(\hat{R}_s + \left(\frac{1-\theta_g}{\theta_g} \right) \hat{C}_s \right) - \hat{R}_p \right)}{\partial \lambda}}. \quad (\text{A21})$$

We know that the denominator is positive, since $\hat{R}_p$ is decreasing in λ while $(\hat{R}_s + (\frac{1-\theta_g}{\theta_g})\hat{C}_s)$ is constant. For the numerator, from the definitions of $\hat{R}_s$ and $\hat{C}_s$, we have

$$\frac{\partial \left(\hat{R}_s + \left(\frac{1-\theta_g}{\theta_g} \right) \hat{C}_s \right)}{\partial \bar{d}} = \frac{\theta_g - \theta_b}{((1-\theta_b)\theta_g - \delta(1-\theta_g)\theta_b)\theta_g} > 0, \quad (\text{A22})$$

and for the pooling rate $\hat{R}_p$ we have

$$\frac{\partial \hat{R}_p}{\partial d} = \frac{\left(\frac{N-1}{N} \right) (1-\alpha) + \lambda}{\left(\frac{N-1}{N} \right) (1-\alpha)\theta_b + \lambda\bar{\theta}}. \quad (\text{A23})$$

The numerator of (A21) can therefore be written as

$$\begin{aligned} \frac{\partial \left(\left(\hat{R}_s + \left(\frac{1-\theta_g}{\theta_g} \right) \hat{C}_s \right) - \hat{R}_p \right)}{\partial \bar{d}} &= \frac{\theta_g - \theta_b}{((1-\theta_b)\theta_g - \delta(1-\theta_g)\theta_b)\theta_g} \\ &\quad - \frac{\left(\frac{N-1}{N} \right) (1-\alpha) + \lambda}{\left(\frac{N-1}{N} \right) (1-\alpha)\theta_b + \lambda\bar{\theta}}. \end{aligned} \quad (\text{A24})$$

To sign this expression, consider

$$\begin{aligned} \frac{\partial \left(\left(\hat{R}_s + \left(\frac{1-\theta_g}{\theta_g} \right) \hat{C}_s \right) - \hat{R}_p \right)}{\partial \bar{d}} \bar{d} &= \left(\hat{R}_s + \left(\frac{1-\theta_g}{\theta_g} \right) \hat{C}_s \right) \\ &\quad - \hat{R}_p - \frac{(1-\delta)(1-\theta_g)\theta_b y}{(1-\theta_b)\theta_g - \delta(1-\theta_g)\theta_b}. \end{aligned} \quad (\text{A25})$$

Then, since by definition $(\hat{R}_s + (\frac{1-\theta_g}{\theta_g})\hat{C}_s) - \hat{R}_p = 0$ at $\hat{\lambda}$ and the last term in the expression is positive, we have $\frac{\partial((\hat{R}_s + (\frac{1-\theta_g}{\theta_g})\hat{C}_s) - \hat{R}_p)}{\partial d} \bar{d} < 0$, implying that $\frac{\partial((\hat{R}_s + (\frac{1-\theta_g}{\theta_g})\hat{C}_s) - \hat{R}_p)}{\partial \bar{d}} < 0$ as well. This, in turn, implies that $\frac{\partial \hat{\lambda}}{\partial \bar{d}} > 0$, as desired. Q.E.D.

Proof of Proposition 7: Since the distribution of borrowers faced by the incumbent is better than that faced by the potential entrants (who face a mass $(1-\alpha)$ of bad borrowers rejected by the incumbent), the former will always be able to undercut any pooling contract offered by the latter, which would end up financing only rejected borrowers. Competition will then necessarily lead these

lenders to offer the zero-profit separating contract $(\hat{R}_s, \hat{C}_s)$. It follows that, by definition, there do not exist any separating contracts with which the incumbent can make positive profits on the pool of unknown borrowers. On the contrary, condition (6) guarantees that there exists a pooling contract with interest rate $R \in (\frac{\bar{d}}{\theta}, \hat{R}_s + (\frac{1-\theta_g}{\theta_g})\hat{C}_s)$ that is preferred by the good type to $(\hat{R}_s, \hat{C}_s)$ and that generates positive profits. Moreover, because of stage 3, this pooling contract cannot be undercut by any profitable separating contract. Q.E.D.

Proof of Proposition 8: The right-hand side (RHS) of condition (5) does not depend on N , whereas the LHS clearly does. Define $\hat{\lambda}_N$ as the proportion of untested borrowers such that (5) holds with equality when N banks are active in the market. Then, it easy to show that $\hat{\lambda}_N < \hat{\lambda}_{N+1}$: By definition, we have

$$\frac{(N-1)(1-\alpha) + \hat{\lambda}_N N}{(N-1)(1-\alpha)\theta_b + \hat{\lambda}_N \bar{\theta} N} = \frac{N(1-\alpha) + \hat{\lambda}_{N+1}(N+1)}{N(1-\alpha)\theta_b + \hat{\lambda}_{N+1}\bar{\theta}(N+1)}, \quad (\text{A26})$$

which, after some rewriting, becomes

$$\hat{\lambda}_N = \hat{\lambda}_{N+1} \frac{N^2 - 1}{N^2}, \quad (\text{A27})$$

thereby establishing that $\hat{\lambda}$ is increasing in N . Q.E.D.

Proof of Proposition 9: First, in equilibrium, since the market for unknown borrowers is now segmented, borrowers who defaulted are offered the separating contract $(\hat{R}_s, \hat{C}_s)$. Moreover, this is the only contract that can be part of a stable equilibrium, as for this market segment no pooling contract can make nonnegative profits since there are no unknown borrowers.

Second, under information sharing, the break-even pooling rate is

$$\hat{R}_p^* = \bar{d} \frac{(N-1)(1-\alpha)\theta_b + \lambda N}{(N-1)(1-\alpha)\theta_b^2 + \lambda \bar{\theta} N}. \quad (\text{A28})$$

Banks are now able to identify bad borrowers who defaulted in the past, which means that only a proportion θ_b of bad borrowers known to competitor banks enter the pool of unknown borrowers. This implies $\hat{R}_p^* < \hat{R}_p$, which in turn implies $\hat{\lambda}^* < \hat{\lambda}$. The rest of the proof is the same as in Proposition 2. Q.E.D.

Proof of Proposition 10: Start with the case in which $\lambda < \hat{\lambda}^* < \hat{\lambda}$, so that the model admits a unique stable separating equilibrium either with or without information sharing. Then, bank profits on good known borrowers who have not defaulted in the past are the same in both cases. Bank profits on “black-listed” good borrowers are also the same as in the model without information sharing. Indeed, we know that $R_g^s = \hat{R}_s + (\frac{1-\theta_g}{\theta_g})\hat{C}_s$ is the rate charged to these borrowers in equilibrium.

Second, consider the case in which $\hat{\lambda}^* < \hat{\lambda} < \lambda$, so that both scenarios admit a pooling equilibrium. In this case, profits on good known borrowers who have

not defaulted in the past are lower under information sharing than without. Indeed, we know from Proposition 9 that $\hat{R}_p^* < \hat{R}_p$ so that $R_g^{p*} < R_g^p$, where R_g^{p*} refers to the matching contract that is offered to known good borrowers in the pooling equilibrium of that proposition. However, bank profits on black-listed good borrowers are higher, as under information sharing these borrowers are charged a rate $R_g^s > \hat{R}_p = R_g^p$. For each bank, the difference in profits will be

$$\Pi^{sharing} - \Pi = \frac{\alpha\theta_g}{N}(\Pi(\hat{R}_p^*) - \Pi(\hat{R}_p)) + \frac{\alpha(1-\theta_g)}{N}(\Pi(R_g^s) - \Pi(\hat{R}_p)). \quad (A29)$$

Finally, for $\hat{\lambda}^* < \lambda < \hat{\lambda}$, the model with information sharing admits a pooling equilibrium, while without information sharing it has a separating equilibrium. In this case, the difference in profits can be written as

$$\begin{aligned} \Pi^{sharing} - \Pi &= \frac{\alpha\theta_g}{N}(\Pi(\hat{R}_p^*) - \Pi(R_g^s)) + \frac{\alpha(1-\theta_g)}{N}(\Pi(R_g^s) - \Pi(R_g^s)) \\ &= \frac{\alpha\theta_g}{N}(\Pi(\hat{R}_p^*) - \Pi(R_g^s)) < 0. \end{aligned} \quad (A30)$$

A necessary condition to have $\Pi^{sharing} > \Pi$ is therefore that $\hat{\lambda}^* < \hat{\lambda} < \lambda$. Hence, it must be that $\lambda^* > \hat{\lambda}$.

Now at $\lambda = \hat{\lambda}$, (A29) becomes

$$\Pi^{sharing} - \Pi = \frac{\alpha\theta_g}{N}(\Pi(\hat{R}_p^*) - \Pi(\hat{R}_p)) < 0. \quad (A31)$$

In addition, it is easy to see that the difference is increasing in λ , since $\frac{d\hat{R}_p}{d\lambda} < 0$ and $\frac{d(\hat{R}_p^* - \hat{R}_p)}{d\lambda} < 0$. Also,

$$\lim_{\lambda \rightarrow \infty} (\hat{R}_p^* - \hat{R}_p) = 0, \quad (A32)$$

and hence,

$$\lim_{\lambda \rightarrow \infty} (\Pi^{sharing} - \Pi) = \frac{\alpha(1-\theta_g)}{N} \left(\Pi(R_g^s) - \Pi\left(\frac{\bar{d}}{\bar{\theta}}\right) \right) > 0, \quad (A33)$$

which implies that there exists a λ^* such that $\Pi^{sharing} - \Pi > 0$ if and only if $\lambda \geq \lambda^*$. Q.E.D.

Appendix B: An Alternative Model of Information Acquisition

As an alternative to screening via the use of collateral requirements, we consider a variant of the model in which we instead allow banks to obtain information about borrowers directly by conducting creditworthiness tests. Suppose that at a cost of k , banks can conduct a creditworthiness test that perfectly and privately reveals the type of the borrower. As before, banks are competitive, and

they offer contracts that specify a promised repayment, R , as well as whether or not a credit screen will be conducted. If a screen is conducted, the bank incurs the screening cost k and the borrower receives a loan at the promised terms only if the screen reveals him to be of the good type, θ_g .²⁵ Otherwise, no test is performed. Formally, this means that banks offer contracts (R, η) , where $\eta = 1$ if a credit screen is conducted, and 0 otherwise. We assume that a borrower who is indifferent between being rejected for a loan and not applying will simply choose to not apply. This set of borrower choices can be easily justified by assuming that there is some (infinitesimally) small cost of applying that a borrower must bear, such as the time and effort of filling out an application, or some reputation (i.e., nonpecuniary) loss to a borrower of being identified as a bad type.

Note that, since banks are competitive and only a borrower revealed to be of the good type will receive a loan if he is screened, the equilibrium rate that must be charged if screening takes place is the break-even rate for a good borrower, which must also compensate the bank for the cost of screening: $R_g = \frac{\bar{d} + k}{\theta_g}$. We maintain the same assumption as before regarding the tie-breaking rule, and assume that all the borrowers that would choose a contract offered by more than one bank are randomly allocated to one of these banks. The equilibrium contract is therefore $(R_g, 1)$, with only good borrowers obtaining financing and paying the cost of screening, k .

We can now show that, as in the model we provide in the main text, banks maintain high lending standards when the information asymmetries vis-a-vis each other's customers are severe, and low standards otherwise. In other words, we proceed to show that for high λ , banks move away from assessing borrowers' creditworthiness and toward granting credit to all borrowers indiscriminately. We start by showing that conducting a creditworthiness test can only be optimal if no bank has an incentive to offer credit without incurring the cost of information acquisition k . Suppose that some bank offers some other contract $(\tilde{R}, 0)$ in which no credit screen is conducted and therefore no information is acquired. It is clear that this contract can only be successful in attracting good borrowers (and bad ones as well) if the rate offered is lower than what is offered by the contract that screens borrowers, that is,

$$\tilde{R} < \frac{\bar{d} + k}{\theta_g}. \quad (\text{B1})$$

At the same time, the contract must not make losses for the bank that offers it, even assuming that all the unknown borrowers plus the bad borrowers rejected by competitor banks are financed. That is, $\lambda(\bar{\theta} \tilde{R} - \bar{d}) + (1 - \alpha)(\frac{N-1}{N})(\theta_b \tilde{R} - \bar{d}) \geq 0 \Leftrightarrow$

²⁵ The allocation of the cost of the test to either the bank or the borrower has no effect on the equilibrium incentive to screen a borrower. Specifically, all results go through exactly as stated if instead we assume that the borrower must pay the cost k of the credit screen.

$$\bar{R} \geq \bar{d} \frac{\left(\frac{N-1}{N}\right)(1-\alpha) + \lambda}{\left(\frac{N-1}{N}\right)(1-\alpha)\theta_b + \lambda\bar{\theta}}. \quad (\text{B2})$$

(Note that (B2) specifies the exact same condition for the existence of an equilibrium with no information acquisition as that specified by condition (4) in the text.) Therefore, much as before, we can now state a necessary and sufficient condition for the strategy profile in which all banks acquire information by offering the contract $(R_g, 1)$ to be a Nash equilibrium by combining conditions (B1) and (B2), which yields

$$\bar{d} \frac{(N-1)(1-\alpha) + \lambda N}{(N-1)(1-\alpha)\theta_b + \lambda\bar{\theta}N} \geq \frac{\bar{d} + k}{\theta_g}. \quad (\text{B3})$$

We note that as λ converges to zero, condition (B3) becomes $\frac{\bar{d}}{\theta_b} > \frac{\bar{d} + k}{\theta_g} \Leftrightarrow k < \bar{d}(\frac{\theta_g - \theta_b}{\theta_b})$.

Letting $\lambda \rightarrow \infty$ in condition (B3), we can now state a condition for equilibrium information acquisition to depend on λ as

$$\frac{\bar{d}}{\bar{\theta}} < \frac{\bar{d} + k}{\theta_g}. \quad (\text{B4})$$

Condition (B4) will be satisfied if and only if $k > \bar{d}(\frac{\theta_g - \bar{\theta}}{\bar{\theta}})$.

We can summarize this discussion with the following proposition, which extends the results from the text to the setting in which banks can acquire information directly by conducting a credit screen. The proposition states that as long as the cost of screening is neither too large nor too small, banks will apply high standards in their lending decisions and will grant no loans without first conducting a credit screen on each loan applicant when information asymmetries are high (low values of λ). These standards, however, will decrease as information asymmetries decrease (λ increases), in which case banks will prefer to save on the cost of conducting the screen and therefore obtain no information prior to lending. The proof of this result follows along the lines of Propositions 1 and 2 and is therefore omitted.

PROPOSITION 11: *If the cost of screening $k \in (\bar{d}(\frac{\theta_g - \bar{\theta}}{\bar{\theta}}), \bar{d}(\frac{\theta_g - \theta_b}{\theta_b}))$, then there exists $0 < \lambda' < \infty$ such that: i) the strategy profile in which all banks acquire information by offering the contract $(R_g, 1)$ is the unique stable pure-strategy equilibrium if and only if $\lambda \leq \lambda'$; and ii) the strategy profile in which all banks offer the contract $(\bar{R}_p, 0)$ is the unique stable pure-strategy equilibrium if and only if $\lambda > \lambda'$.*

Note that, since known borrowers do not have to be screened, each bank can obtain positive profits in equilibrium by offering their known good borrowers a loan package that offers a rate higher than R_g but that requires no screening,

with the rate set such that the borrower is indifferent between this contract and that offered by another lender.

Finally, Proposition 11 shows that an increase in adverse selection leads to increased screening. This differs from other models of bank competition wherein screening is often a decreasing function of adverse selection. In those models the incentive to screen derives from the rents each bank can obtain by acquiring private information, which are decreasing in the degree of adverse selection (see, e.g., Thakor (1996)). In the present model, while banks obtain informational rents from their own known borrowers, competitive screening of unknown borrowers does not provide banks additional rents.

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