Lending Booms and Lending Standards*

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October 20, 2003

Abstract

This paper examines how the informational structure of loan markets interacts with banks’ strategic behavior in determining lending standards, lending volumes, and the aggregate allocation of credit. In a setting where banks obtain private information about their clients’ creditworthiness, we show that banks may loosen lending standards when information asymmetries vis-à-vis other banks are low, such as when the proportion of borrowers with unknown projects in the market increases. In equilibrium this leads to a deterioration of banks’ portfolios, a reduction in their profits, and an aggregate credit expansion. Furthermore, we show that although these low standards may maximize aggregate surplus, they increase the risk of financial instability. We therefore provide an explanation for the sequence of financial liberalization, lending booms, and banking crises that have occurred in many emerging markets. Finally, we examine the effects of information sharing and bank market structure in this context.

JEL: D82, G21

Keywords: Banking Competition, Lending Standards, Asymmetric Information.

*A previous version of this paper was presented in April 2000 at the Wharton-CFS conference on bank competition. We would like to thank Patrick Bolton, Tito Cordella, Gianni De Nicolo, Paolo Fulghieri, Ilan Goldfajn, Pietro Garibaldi, Carmen Reinhart, and conference participants for their useful suggestions. Part of this work was completed while Marquez was visiting the Wharton School of Business, whose support is gratefully acknowledged. All remaining errors are ours. The views expressed in this paper are those of the authors and do not necessarily represent those of the IMF or CEPR. Address for correspondence: Giovanni Dell’Ariccia, IMF, 700 19th Street, NW, Washington DC 20431. E-mail: gdellariccia@imf.org.
1 Introduction

Banks perform an important role of limiting adverse selection problems in the economy by screening out applicant borrowers that do not meet satisfactory lending standards. Failure to perform this function leads to riskier portfolios and weaker balance sheets, with potentially negative consequences for credit market stability. However, since screening is costly, banks’ adherence to adequate lending standards must be compensated by benefits stemming from reductions in the losses associated with bad loans. It is crucial, therefore, to understand how changes in factors that determine profitability strengthen or weaken banks’ incentives to screen borrowers. This paper examines how the informational structure of loan markets interacts with banks’ strategic behavior in determining lending standards, lending volumes, and the aggregate allocation of credit.

Our analysis is motivated in part by recent empirical studies highlighting the link between lending booms and episodes of financial distress (see, for example, Gourinchas et al., 2001, or Tornell and Westermann, 2001). We show that a reduction in information asymmetries across banks will often lead to an increase in the volume of lending (a “lending boom”) and an easing of lending standards, and will consequently be accompanied by a deterioration of bank portfolios. A banking crisis can therefore occur solely as a result of changes in the information structure of the market without necessarily involving a negative shock to an economy’s fundamentals.

To study these issues, we present a model where banks have private information about the creditworthiness of some borrowers (“known” borrowers) but not about others (“unknown” borrowers), and use collateral requirements to screen the latter group and sort good from bad applicant borrowers. First, we show that the existence of an equilibrium where banks screen borrowers by offering each a different contract is associated with low proportions of unknown borrowers in the market. In this equilibrium, the imposition of a collateral requirement leads only good borrowers to obtain credit, since the contract’s terms are unappealing to bad borrowers. Second, we show that an equilibrium that pools all borrowers arises when the proportion of unknown borrowers is high. In this case, banks offer a contract without a collateral requirement and all borrowers obtain financing on the same terms.
An implication of these findings is that, since banks shift their lending strategies as the number (or proportion) of unknown borrowers increases, the switch to offering the same terms to all borrowers leads to a credit expansion beyond the increase in the demand for credit. In other words, it leads to a lending boom. At the same time, however, the accompanying reduction in lending standards results in a banking system with a deteriorated loan portfolio and, thus, more prone to financial distress when the economy hits a downturn.

The intuition is the following. Banks are approached by entrepreneurs with either 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, when the proportion of new/untested projects in the market increases, the distribution of borrowers applying to each bank improves as well. Banks may therefore find it profitable to attract customers by reducing collateral requirements, attempting to trade off borrower quality for an increased market share. A corollary to this is that borrower screening is increasing in the amount of information the aggregate banking system possesses about some subset of customers, since it is precisely then that adverse selection problems arising from competition for customers are greatest.

Notably, in our model pooling equilibria are always (second-best) efficient from the point of view of maximizing aggregate surplus, since they prevail exactly when the costs associated with collateral liquidation exceed those associated with the financing of bad borrowers. However, while the average quality of the entrepreneurs in the economy remains unchanged, the reduction in screening when all borrowers are pooled results in increased credit, deteriorated bank portfolios, and lower bank profitability. This deterioration in banks’ portfolios makes them more susceptible to aggregate shocks, such as increases in their own cost of borrowing. We thus establish the existence of a trade-off between the efficiency and the stability of the banking system.

Our results continue to hold even if banks are allowed to share information about borrowers, such as the history of past defaults. This case of “black information” sharing is of particular interest since this information is often available through credit bureaus. We show that, although this kind of information sharing always increases aggregate output, it does not always emerge endogenously since in many instances it reduces bank profitability.
Furthermore, policies that make it mandatory for banks to collect and disseminate black information, by reducing bank profitability and increasing lending volume, may increase the probability of banking crises. We also examine the relationship between bank market concentration and borrower screening. We show that an increase in the number of active banks increases adverse selection, and therefore increases the benefit from screening borrowers.

The analysis in this paper is relevant for regulatory and competition policy, as it suggests that policies that bring new categories of borrowers to credit markets may induce a reduction in bank screening and increase the probability of systemic financial distress. It also highlights possible negative aspects of expansionary phases of a business cycle when more firms may be seeking credit. In both of these instances, the proportion of unknown borrowers (or projects) in a market increases. This induces banks to reduce their lending standards and expand credit, increasing aggregate surplus but, at the same time, increasing the probability of a banking crisis. 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 were not accompanied by the strengthening of regulatory and supervisory frameworks (see, e.g., Gourinchas et al., 2001). In Section 6, we examine in greater detail the testable implications of our model and their support in recent empirical literature.

From a theoretical perspective, this paper establishes a link between the notion that the willingness of banks to screen borrowers depends on the distribution of these potential borrowers and the idea that, under asymmetric information, competition among banks generates an adverse selection problem for banks. This paper’s contribution is twofold. First, it relates changes in bank lending standards and screening behavior to changes in credit demand and the informational structure of the market. Importantly, the changes to bank behavior we identify arise purely from a reduction in information asymmetries vis-à-vis other banks. As such, it is clear that the exact mechanism banks use for screening is not crucial, and similar issues arise if instead of collateral requirements we focused on costly

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1Asea and Blomberg (1998) find empirical evidence of a systematic tendency for bank lending standards to vary over the cycle. During contractions, banks tend to charge higher risk premia and collateral, while during expansions, banks tend to charge lower risk premia, grant larger loans and require less collateralization.

2For models along these lines, see, for example, Hellwig (1987), Besanko and Takor (1987), and Dasgupta and Maskin (1986).

3See, for example, Broecker (1990), Dell’Ariccia (2001), Marquez (2002), and von Thadden (2001).
information acquisition, for instance. Second, we provide a simple mechanism linking lending booms and banking crises to the quality of the projects financed by banks. Changes in the size and quality of bank portfolios are the outcome of banks’ strategic screening behavior and do not rely on exogenous changes in the overall quality of borrowers in a market, or on limits on banks’ ability to screen or monitor large numbers of borrowers.

Recent work has investigated the issue of credit cycles and variable credit standards. In Rajan (1994), bank managers with short-term concerns choose the bank’s credit policies. When most borrowers are doing well, bank managers relax credit standards in an attempt to hide losses on bad loans and protect their own reputation. When a common negative shock hits a sector, reputational considerations diminish and bank managers tighten credit standards. In this paper we obtain switches in banks’ screening behavior without assuming changes in the creditworthiness of borrowers. 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, however, the quality of bank loans does not vary over the cycle. In our model, credit swings occur even if borrower quality or collateral value remain unchanged, and are rationalized purely by changes in the distribution of information. Furthermore, we link the average creditworthiness of banks’ portfolios to the volume of credit that banks extend. A more closely related model is that of Manove, Padilla and Pagano (2001) on “lazy banks”, which shows 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 fall in lending standards and leads to a credit boom.

The paper proceeds as follows. Section 2 presents a model where banks compete for both known and unknown borrowers. Section 3 solves the model and examines its welfare implications. The implications of the analysis for banking crises is studied in Section 4. Section 5 extends the analysis to incorporate information sharing and the role of bank market structure. Section 6 discusses some of the empirical findings and concludes.

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4Our 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.
2 Model

Consider an economy where there is a continuum of entrepreneurs of mass $1 + \lambda$, each of which has a known end-of-period endowment $W$. Each entrepreneur is endowed with a project that requires a capital inflow of $1$. There are two types of entrepreneurs: good and bad, with probability of success $\theta_g$ and $\theta_b$, respectively, with $\theta_g > \theta_b$. Each project gives a return of $\tilde{y} = y > 0$ in case of success, and $\tilde{y} = 0$ in case of failure. We assume that good entrepreneurs are creditworthy while bad ones are not. Formally, this means $\theta_g y > \bar{d}$, 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.

The market for loans is composed 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; unknown borrowers are those whose type is unknown to any bank. Both of these groups have the same distribution over types, with a fraction $\alpha$ of good projects, and a fraction $1 - \alpha$ of bad projects. When first approached by an applicant borrower, banks are unable to distinguish an unknown borrower from one that has been evaluated and whose type is therefore known to some competitor bank. (We relax this assumption in Section 5.1.)

There are $N$ banks competing for borrowers. We consider the symmetric case where each bank possesses private information about a mass $\frac{1}{N}$ of borrowers, but the borrowers each bank knows is different. Therefore, each bank privately knows the type of a share $\frac{1}{N}$ of all the “known” borrowers, where these shares do not overlap.

We consider a three stage game. At stage 1, banks compete for the pool of customers whose type is unknown to them. Banks can offer applicant borrowers a menu of loan contracts $\{(R^k, C^k), k = g, b\}$, where $R$ represents the repayment a bank obtains when the project succeeds, and $C$ is the collateral a bank can liquidate when a project fails. This liquidation of collateral comes at a cost, so that the total value of the collateral to the bank

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5From now on, we will use the terms entrepreneur, project, and borrower interchangeably.
6This is a convenient way of introducing informational asymmetries among financial intermediaries. See Dell’Ariccia, 2001, and Marquez, 2002, for models with a similar setup.
7For each bank, this pool consists of all the unknown entrepreneurs on the market seeking financing (mass $\lambda$), and the entrepreneurs known to competitor banks (mass $\frac{N-1}{N}$).
is $(1 - \delta) C$, with $\delta < 1$. The assumption of a positive liquidation cost reflects a setting where assets are more productive in use than under liquidation, and allows us to exclude the unrealistic case where banks pool borrowers by offering a contract with zero interest rate but sufficiently high collateral.

At stage 2, each bank observes the realization of stage 1 and can offer competitive contracts to the borrowers whose type is known to them. Borrowers choose their preferred contract among those offered. This timing assumption captures the idea that borrowers are able to observe market offers made by all banks and can use them to bargain for better conditions from the bank that knows them. Finally, at the third stage, banks have the opportunity to reject borrowers’ loan applications. In case more than one bank offers the same contract to a group of borrowers, the following tie-break procedure is implemented: all the borrowers that would choose a contract offered by more than one bank are randomly allocated to one of these banks.\(^8\)

Entrepreneurs are risk neutral and seek to maximize profit. The expected profit of a borrower accepting a contract $(R, C)$ is

$$E \left[ \Pi^k \right] = \theta_k (y - R) - (1 - \theta_k) C; \text{ for } k = g, b. \quad (1)$$

Finally, for simplicity, we assume that the reservation utility of the borrowers is zero, as they have no access to non-bank financing. The individual rationality (IR) constraints can therefore be written as

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

### 3 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 accepting a given contract is too low to provide non-negative profits. Borrowers, choosing their preferred loan contract, cannot then coordinate on a contract in a way that would yield losses for the

\(^8\)The general structure of our model is as in 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.
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.

At stage two, banks observe the realization of stage one and choose to whom they should make competitive offers among the borrowers whose type is known to them. For each bank $i$, define $(R^{-i}, C^{-i})$ as the contract that good borrowers prefer among those offered by the competitors of bank $i$ at stage one and which 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 $(R^i_g, 0)$, where $R^i_g$ is such that good borrowers are indifferent between $(R^i_g, 0)$ and $(R^{-i}, C^{-i})$; ii) each bank $i$ will deny credit to its known bad borrowers.

**Proof.** First, since the bank knows the type of these borrowers, it has no reason to include a costly collateral requirement in the contract. $R_g$ is the highest interest rate the bank can charge these known good borrowers without losing them to the competition. Second, the expected return on bad borrowers is always negative. Hence, under no conditions will a bank lend to known bad borrowers. ■

We can now solve stage one. Lemma 1 implies that when choosing their strategy for stage one, banks have to take into account two facts. First, they will not be able to poach profitably from the pool of borrowers 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 where banks are symmetric, we limit our analysis to the case of a symmetric equilibrium. As described in Besanko and Thakor (1987), a Nash equilibrium here is a profile of sets of contracts such that: (1) each bank makes non-negative profits on each contract; and (2) there exists no other set of contracts that, if offered in addition to the original set, earns positive profits in the aggregate and non-negative profits individually. We will additionally require that the equilibrium be “robust” in the sense of satisfying the stability criterion of Kohlberg and Mertens (1986), and will restrict attention to pure strategy equilibria. With that in mind, 9

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9In principle, other (weaker) refinements of the equilibrium could be used and would deliver the same results, as the stable equilibrium we derive is unique.
let us examine the conditions for the existence of a pure-strategy screening equilibrium, in which borrowers are sorted by the contracts they choose to accept.

### 3.1 Equilibrium with Borrower Screening

We first show that, for certain parameter values, the only stable equilibrium is one with screening, in which only high quality borrowers obtain credit, and all banks offer the same contract. (We use the terms “separating” and “screening” equilibrium interchangeably.) In this separating equilibrium, banks try to attract good borrowers and to screen out bad borrowers by offering a menu of contracts that satisfies the incentive compatibility (IC) and IR constraints for the borrowers. If a set of contracts \((R^k, C^k), k = g, b\), are offered, the IC constraints can be expressed as

\[
\begin{align*}
\theta_g (y - R^g) - (1 - \theta_g) C^g &\geq \theta_g (y - R^b) - (1 - \theta_g) C^b \\
\theta_b (y - R^b) - (1 - \theta_b) C^b &\geq \theta_b (y - R^g) - (1 - \theta_b) C^g
\end{align*}
\]

In our particular case, the IC constraint for the bad type is the same as its IR constraint, since no alternative contract is offered to bad borrowers as their projects have negative expected value. Hence, to find the competitive separating contract we need to satisfy only the IC constraint for the bad borrowers, which we do by setting their IR constraint to be satisfied with equality. Since we have competitive banks, we impose a zero profit condition for the banks. Formally, the competitive separating contract \(\left(\hat{R}_s, \hat{C}_s\right)\) is the solution to the following equations:

\[
\begin{align*}
\theta_g R - \overline{d} + (1 - \theta_g) \delta C &= 0 &\text{(Zero profit for banks)} \\
\theta_b (y - R) - (1 - \theta_b) C &= 0 &\text{(IC for bad borrowers)}
\end{align*}
\]

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. The IC constraint guarantees that no bad borrower has an incentive to apply to this contract. Solving the two equations, we obtain \(\hat{R}_s = \frac{(1 - \theta_b)\overline{d} - \delta (1 - \theta_g) \theta_b y}{(1 - \theta_b)\theta_g - \delta (1 - \theta_g) \theta_b}\) and \(\hat{C}_s = \frac{\theta_b (y - \theta_g - \overline{d})}{(1 - \theta_b)\theta_g - \delta (1 - \theta_g) \theta_b}\). Note that this is a valid solution since the IR constraint for the good type is always satisfied by this contract.
An additional requirement for a strategy profile where all banks offer the contract \((\hat{R}_s, \hat{C}_s)\) that screens borrowers to be an equilibrium is that no bank can make positive profits by offering some other contract \((\bar{R}, 0)\) in which all borrowers are pooled. To check this, first consider that, since bad borrowers’ projects have a negative expected value, to be profitable any pooling contract must attract unknown good borrowers. This is accomplished by setting the repayment on the loan, \(\bar{R}\), sufficiently low that \(\theta_g (y - \hat{R}) > \theta_g (y - \hat{R}_s) - (1 - \theta_g) \hat{C}_s \Leftrightarrow \hat{R} < \hat{R}_s + \left(\frac{1 - \theta_g}{\theta_g}\right) \hat{C}_s\).

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 \(\lambda (\bar{R} - \bar{d}) + (1 - \alpha) \left(\frac{N - 1}{N}\right) (\theta_b \bar{R} - \bar{d}) \geq 0 \Leftrightarrow \bar{R} \geq \bar{d} \left(\frac{N - 1}{N}\right) (1 - \alpha) + \lambda \left(\frac{N - 1}{N}\right) \theta_b + \lambda \theta_b\),

where \(\bar{d}\) is the average credit-worthiness of all borrowers in the market: \(\bar{d} = \alpha \theta_g + (1 - \alpha) \theta_b\). Hence, we can write the necessary and sufficient condition for the strategy profile where all banks offer the single (separating) contract \((\hat{R}_s, \hat{C}_s)\) to be a Nash equilibrium as

\[
\bar{R} \geq \bar{d} \left(\frac{N - 1}{N}\right) (1 - \alpha) + \lambda \left(\frac{N - 1}{N}\right) \theta_b + \lambda \theta_b\,
\]

where \(\bar{d}\) is the average credit-worthiness of all borrowers in the market: \(\bar{d} = \alpha \theta_g + (1 - \alpha) \theta_b\). Hence, we can write the necessary and sufficient condition for the strategy profile where all banks offer the single (separating) contract \((\hat{R}_s, \hat{C}_s)\) to be a Nash equilibrium as

\[
\bar{R} \geq \frac{(N - 1)}{(N - 1) (1 - \alpha) \theta_b + \lambda \theta_b N} \geq \hat{R}_s + \left(\frac{1 - \theta_g}{\theta_g}\right) \hat{C}_s\,
\]

Note that condition (4) establishes a link between the proportion of unknown borrowers in the economy and the existence of a pure-strategy equilibrium where borrowers are screened. As the distribution of applicant borrowers faced by a deviating bank improves with \(\lambda\), the viability of this equilibrium depends on \(\lambda\) as well. If, as the adverse selection problems caused by informational asymmetries among banks vanish, which occurs as \(\lambda \to \infty\), it is profitable to deviate from the separating equilibrium, then the equilibrium set will depend on \(\lambda\). Otherwise, the strategy profile with the separating contract will be always an equilibrium, as it is not profitable to offer a pooling contract. By letting \(\lambda \to \infty\) in condition (4) we can state the condition for the equilibrium set to depend on \(\lambda\) as

\[
\frac{\bar{d}}{\theta} < \hat{R}_s + \left(\frac{1 - \theta_g}{\theta_g}\right) \hat{C}_s\,
\]
Note that for \( \lambda \) sufficiently close to zero, condition (4) is always satisfied and offering the separating contract is an equilibrium: at the limit there are no unknown borrowers in the market, so that by offering a pooling contract each bank would attract only those bad borrowers rejected by its competitors. As this would always incur losses, no such equilibrium is possible and banks must instead screen borrowers. We can now state the following result.

**Proposition 1** If condition (5) holds, then there exists a \( 0 < \tilde{\lambda} < \infty \) such that: i) for \( \lambda \leq \tilde{\lambda} \), the strategy profile where all banks offer the contract \( (\tilde{R}_s, \tilde{C}_s) \) is the unique stable pure-strategy equilibrium of the game; ii) for \( \lambda > \tilde{\lambda} \), no stable pure-strategy separating equilibrium exists.

**Proof.** See Appendix.

For \( \lambda \) higher than \( \tilde{\lambda} \), the distribution of unknown applicant borrowers faced by each individual bank becomes too creditworthy for a separating equilibrium to exist, as each bank suffers relatively less from the adverse selection of financing other banks poor credit risks. 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 to the extent that liquidation costs are positive. This inefficiency can be seen as the cost of sorting, and if the average creditworthiness of applicant borrowers is good enough (as is the case for \( \lambda > \tilde{\lambda} \)), this cost of sorting exceeds its benefits. In that case, the proposed separating contract is strictly dominated by some pooling contract \((R_p, 0)\), and no stable separating equilibrium exists.\(^{10}\) We discuss this contract in the next section. It is worth noting that changes in \( \lambda \) do not affect the average quality of the total pool of borrowers, only that faced in equilibrium by each bank. Overall, borrower quality remains constant and all the effects are driven purely by reductions in information asymmetries.

### 3.2 The Pooling Equilibrium

It is easy to verify that the same conditions that precluded the existence of a pure-strategy separating equilibrium guarantee the existence of an equilibrium that pools all borrowers and

\(^{10}\)This is as in Rothschild and Stiglitz (1976), Wilson (1977), and Hellwig (1987).
offers everyone credit on the same terms. Consider the break-even pooling contract \((\widehat{R}_p, 0)\), with

\[
\widehat{R}_p = 7 d \frac{(N-1)}{N} \frac{(1 - \alpha) + \lambda}{(N-1)(1 - \alpha) \theta_b + \lambda \theta}.
\]

**Proposition 2** If condition (5) holds, then, for \(\lambda > \widehat{\lambda}\), the strategy profile where all banks offer the contract \((\widehat{R}_p, 0)\) is the unique stable pure-strategy equilibrium of the game.

**Proof.** See Appendix.

As before, when condition (4) is violated, there exists a pooling contract which good borrowers prefer to the zero-profit screening contract and such that, were a bank the only one to offer it, that bank would make positive profits. Hence, there is no stable separating equilibrium. However, there is a stable pooling equilibrium, as no contract of the form \((\widehat{R}, \widehat{C})\) can represent a profitable deviation from the pooling equilibrium \((R_p, 0)\), since all applications to \((\widehat{R}, \widehat{C})\) would need to be rejected in the third stage as they would fail to draw a better-than-average pool of borrowers.\(^{11}\)

The analysis from now on is based on the two equilibria characterized in Propositions 1 and 2. We can now compute banks’ equilibrium profits, which are just the profits banks make on the pool of borrowers whose type is known to them, since, as we just showed, banks make zero profits on unknown borrowers. We have the following result:

**Proposition 3** In the pooling equilibrium:

i) Banks’ profits are lower than in the separating equilibrium;

ii) The average quality of banks’ portfolios is lower than in the separating equilibrium;

iii) Aggregate credit is larger than in the separating equilibrium, even on a per-applicant borrower basis (after dividing by \(1 + \lambda\)).

**Proof.** See Appendix.

The intuition for this result is the following. Each bank’s market power is linked to its informational capital, since profits stem solely from the adverse selection each bank

\(^{11}\)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 where the zero-profit pooling contract is also the only solution.
generates for its competitors. Essentially, each bank is able to extract rents from borrowers whose type is known to it, because of these borrowers’ difficulty in credibly signaling their type to rival banks. When the proportion of unknown borrowers in the market increases, adverse selection becomes less severe and, hence, banks’ market power on their pool of known borrowers decreases.

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 the good type borrowers obtain financing, so it is clear that the average quality of bank portfolios will be higher than in a pooling equilibrium, where credit is extended to all but a small fraction \((1/N)\) of bad borrowers. As we discuss in the next section, this does not necessarily imply that aggregate welfare will be lower, but it may lead to a more fragile banking system.

The same considerations also imply that aggregate credit is larger when pooling than when screening, even controlling for differences in market size. For instance, all results so far continue to hold if \(\lambda\) instead represents the fraction of unknown borrowers out of a fixed market size of 1. In this case, \(1 - \lambda\) would represent the mass of known borrowers. Note as well that banks’ strategic behavior has a multiplier effect on the demand for credit. When demand is low \((\lambda < \lambda)\), only good borrowers get financing, so that aggregate credit increases linearly with demand. However, if demand increases enough \((\lambda > \lambda)\), the switch in equilibrium strategies from screening to pooling generates a credit boom with not only good but also bad borrowers obtaining financing.

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, banks’ strategic interaction may cause both a lending boom and a deterioration of bank portfolios 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 where only good borrowers are financed and banks’ profits are higher. We discuss this issue further in Section 4.
3.3 Welfare Analysis

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

\[ W_s = \alpha (\theta_g y - \bar{d}) + \lambda \alpha (\theta_g y - (1 - \delta) (1 - \theta_g) \bar{C}_s - \bar{d}) . \]

In a pooling equilibrium, collateral requirements are zero, so that expected total surplus is just the sum of the expected return of all borrowers who get financed. This can be written as

\[ W_p = \alpha (\theta_g y - \bar{d}) + \left( \frac{N - 1}{N} \right) (1 - \alpha) (\theta_b y - \bar{d}) + \lambda (\alpha \theta_g y + (1 - \alpha) \theta_b y - \bar{d}) . \]

Note that in both cases there is no welfare loss associated with financing known good borrowers, as 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 output.

**Proposition 4** If condition (5) is satisfied, then there will exist a \( \lambda_w \) such that: i) \( W_p < W_s \Leftrightarrow \lambda < \lambda_w \); ii) \( \lambda_w < \bar{\lambda} \).

**Proof.** See Appendix.

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, the other due to the financing of unknown bad borrowers. While the latter grows linearly with \( \lambda \), the former is constant, with its weight tending to zero as \( \lambda \) tends to infinity. On the other hand, the welfare loss when screening takes place consists entirely of the collateral liquidation cost, which grows linearly with \( \lambda \).
As a result of condition (5), 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 $\lambda$ such that the loss associated with collateral liquidation costs exceeds that associated with financing bad borrowers.

Proposition 4 also proves that if information asymmetries are sufficiently low that 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 equilibrium, but bad borrowers are obviously better off under the pooling equilibrium.

4 Macroeconomic Shocks and Banking Crises

The results in the previous section demonstrate that strategic interaction among banks creates a relationship between market information structure, the aggregate amount of credit in the economy, bank portfolio quality, and bank profitability. Here we show that an additional implication of this analysis is the existence of a possible link between market information structure and the probability of a banking crisis. To study this link we first introduce a measure of aggregate uncertainty into the model.

One important function identified for the banking system is the transformation of short-term deposits into longer-term loans. However, there is an inherent risk associated with this maturity transformation function, as the availability, as well as the cost, of banks’ liabilities may fluctuate even as their assets are tied up in commitments with longer-term maturity. A natural way to define aggregate uncertainty in this model, therefore, is as an interest rate shock to banks’ liabilities. Formally, assume 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 $F(d)$. 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 either banks commit themselves to provide a loan before the deposit market has cleared, so that the realized interest rate on deposits is unknown. Alternatively, this assumption captures the notion that the deposit rate, which is short term,
can change before loans are repaid, and banks need to rollover their liabilities.

We assume that banks have unlimited liability. The behavior of banks is therefore fully characterized by the distribution of the average of the cost of funds. Hence, all results obtained in the previous sections hold in expectation.\(^\text{12}\) However, since there is a degree of aggregate uncertainty in the economy, the realized outcome may differ from the expected one. We define a banking crisis as a situation where the aggregate banking system makes negative profits.\(^\text{13}\) This leads us to the main result of this section.

**Proposition 5** The probability of a banking crisis is non decreasing in the proportion of unknown borrowers in the market, \(\lambda\).

**Proof.** See Appendix.

The intuition for this result is straightforward. When the proportion of unknown borrowers, \(\lambda\), in the economy increases, adverse selection problems become less severe, credit markets become more competitive, and banks lose some of their market power. This lowers banks’ profits on known borrowers, thus reducing their ability to withstand negative shocks. At the same time, when \(\lambda\) increases enough, we move from an equilibrium where banks screen borrowers to one where they pool all borrowers. The resulting larger volume of credit extended to unknown borrowers increases the banks’ exposure to shocks to their cost of funds. Indeed, since banks make on average zero profits on unknown borrowers, the sensitivity of total profits to changes in the cost of funds is larger the greater is the volume of credit extended to these borrowers.

It bears emphasizing that the result in Proposition 5 holds even though there is no change in the aggregate quality as \(\lambda\) increases. The result stems purely from the fact that banks are better able to withstand macroeconomic downturns when more profitable and when granting loans to fewer, but relatively better, borrowers than when financing all borrowers

\(^{12}\) Issues arising from limited liability for the bank are immaterial in the context of this model, as there is no moral hazard problem for banks. Limited liability would only play a role here in case the projects are unsuccessful. In that case, we have that either \(\delta C > \bar{d}\), or that \(\delta C < \bar{d}\). In the first case, the discounted value of collateral is greater than the cost of deposits, so limited liability is not binding. In the latter case, there is insufficient collateral to pay depositors, in which case collateral plays no role for the bank, since its recovery in the bad states is just 0.

\(^{13}\) Alternatively, we could define a banking crisis as a situation where one or more banks makes ex-post losses. The main results would be the same.
indiscriminately and earning lower profits. This will be the case when $\lambda$ is sufficiently low that banks retain some market power from their existing information and therefore find it optimal to screen additional borrowers by offering them different contracts. An increase in $\lambda$ reduces adverse selection along with the incentives to screen, implicitly generating greater competition, an expansion in credit, and lower profits. We therefore have an increased probability of a crisis for purely strategic reasons, even with rational and competitive banks. In other words, the credit expansion and greater possibility of a banking crisis emerge as pure information-based phenomena.

This result highlights a trade-off between the output derived from the banking system and its stability. While pooling equilibria yield higher aggregate output, in the presence of aggregate uncertainty they are also associated with a higher probability of banking crises. Moreover, if banking crises involve an aggregate welfare loss beyond that suffered by the banking system, this logic suggests that there may be scope for policy intervention. For instance, a social planner averse to volatility is confronted with a trade-off between enhancing either output or the stability of the banking system when in the presence of a large proportion of unknown borrowers and low information asymmetries. In that context, policies like risk-based capital requirements which link banks’ costs to the riskiness of their portfolio may help extend the region where screening (the separating equilibrium) is worthwhile and feasible and thus reduce the probability of a crisis.\footnote{In addition, it is easy to show that in a model where banks have some market power in the market for unknown borrowers, policies aimed at limiting banks' lending capacity would have a similar effect.} Minimum collateral requirements on bank lending would have a similar effect, but would likely introduce a distortion if regulators are less informed than banks about market conditions.

We note that $\lambda$, the upper bound for the existence of an equilibrium with screening, is an increasing function of $\delta$, or in other words that markets with lower liquidation costs can sustain screening equilibria in the presence of relatively higher proportions of unknown borrowers. To the extent that borrower screening is desirable because it allocates credit efficiently, reforms aimed at improving bankruptcy laws and clarifying property rights should also decrease the likelihood of pooling equilibria by reducing liquidation costs. Furthermore, by reducing the cross-subsidization that occurs under a pooling equilibrium, efficiency is
enhanced and the overall cost of borrowing can be reduced.

Finally, it is worth noting that other explanations and models of financial crises have recently been proposed that may explain the phenomenon highlighted in this section. Examples can be found in the work by Kiyotaki and Moore (1998) and related work on financial accelerators. Most of these alternatives identify a small change in fundamentals as the initial catalyst, which then becomes amplified through the financial system. When the value of durable assets used as collateral increases, credit constraints are loosened and leverage increases. Because of the high leverage, the system becomes vulnerable to small shocks, and a small drop in the price of collateral may turn the boom into a crisis.

In this context the contribution of our paper is two-fold. First, our model proposes a fully rational bank-lending mechanism for a crisis that arises for purely informational reasons. In other words, changes in underlying macroeconomic conditions are not necessary to generate an increased probability of a (rational) banking crisis, and our model identifies one straightforward rationale for this outcome. Second, and more importantly, we provide a simple mechanism that links booms and crises to the quality of the projects financed by banks.

5 Extensions

5.1 Information Sharing

The existence of information asymmetries among banks is one key assumption of the framework presented in this paper. However, recent literature has emphasized that information sharing is a common element in credit markets.\footnote{For example, see Pagano and Jappelli (1993), and Padilla and Pagano (1997).} In this section, we study some implications of allowing banks to share information about borrowers.

Under full information sharing, where banks provide each other with all relevant information concerning their known customers, banks would always offer the pooling contract to unknown borrowers and the break-even contract \((\frac{\theta}{\theta_g}, 0)\) 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 leads to an equilibrium with zero profits as
banks compete more aggressively when information is symmetric. Similarly, the exchange of information about the type of a random subset of known borrowers also hurts bank profits by reducing adverse selection, both in a pooling equilibrium, where it decreases the lending rate, as well as in a separating equilibrium, where it has no direct effect on rates, but may move the equilibrium toward one with borrower pooling, thus again reducing profits.

In a recent paper, Bouckaert and Degryse (2001) show that the strategic disclosure of some, but not all, information may enhance profits in settings where 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 which, although good in type, were unlucky and defaulted. The overall 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. We show that though a trade-off similar to that found in Bouckaert and Degryse (2001) exists in this model, the main results from the previous sections continue to hold.

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 (different) mass $\frac{1}{N}$ of borrowers, and as a consequence learns their type. Borrowers invest in a project, which is independent and identical to that described for stages 1 to 3, that succeeds with probability $\theta_i$, $i \in \{g, b\}$, and 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 was successful ($\tilde{y} = y$) or resulted in failure ($\tilde{y} = 0$), so that the loan was not repaid. We now characterize the resulting equilibrium for stages 1 to 3, as before.

**Proposition 6** Under “black information” sharing, there exists some $\tilde{\lambda}^* < \infty$ such that: i) for $\lambda \leq \tilde{\lambda}^*$, the unique stable equilibrium involves screening; ii) for $\lambda > \tilde{\lambda}^*$, the unique stable
equilibrium involves the pooling of borrowers; iii) banks always offer unknown “black-listed” borrowers a screening contract \((R_s, C_s)\); and iv) \(\bar{\lambda}^* < \hat{\lambda}\).

**Proof.** See Appendix.

This proposition extends the main result of this paper to the case where 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 make non-negative profits on this segment of the market, since other banks, which know these borrowers’ exact type, will match any viable offer made to good borrowers, but will let bad borrowers go. In the other segment are 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: \(\bar{\lambda}^* < \hat{\lambda}\).

We can now 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. This is equivalent to ascertaining the conditions under which banks would lobby for regulation forcing all banks to participate in an information sharing agreement.

First, note that since bank profits depend on the offers that known borrowers obtain from uninformed banks, the result above suggests that information sharing has important effects on bank profitability. This leads to the next result.

**Proposition 7** i) Bank 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.
From Proposition 6, we know that information sharing lowers the threshold required for a pooling equilibrium to exist. Therefore, there is a range of values for $\lambda$ for which, absent information sharing, only an equilibrium where borrowers are screened exists, but where with information sharing banks no longer find it feasible to screen and instead we have pooling. 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 6 and 7 imply that, when information sharing among banks emerges endogenously, it also increases the aggregate surplus. However, there are values of $\lambda$ for which, although information sharing does not emerge endogenously, it would still increase the aggregate surplus either by expanding the region where a pooling equilibrium exists (for $\lambda \in \left(\lambda^*, \hat{\lambda}\right)$), or by reducing the portion of bad borrowers financed in equilibrium whenever the pooling of borrowers is viable (for $\lambda \in \left(\hat{\lambda}, \lambda^*\right)$). 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 surplus. When information sharing among banks emerges endogenously, it increases bank profitability and reduces the volume of credit being allocated to bad projects, thereby reducing the probability of a banking crisis if funding costs are random such as in the previous section. However, when such policies do not emerge endogenously among banks, forcing banks to disseminate black information may reduce the volume of credit extended to bad borrowers, but also reduces banks’ profits, and therefore carries the risk of an increased probability of a crisis. In the notation of the model, one can show that for $\lambda \in (\lambda^* - \Delta, \lambda^*)$, for some positive $\Delta$, such policy would not only increase the aggregate surplus, but also reduce the probability of a crisis since for values of $\lambda$ just below $\lambda^*$, bank profits are only marginally affected by information sharing, but the improvement in credit allocation is of first order. However, for $\lambda$ in a neighborhood of $\hat{\lambda}$, forced information sharing has the opposite effect, since it moves the equilibrium away from one where banks screen their borrowers,

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16 A similar result is in Pagano and Jappelli (1993).
to one where all borrowers are pooled. Associated with this is a reduction in bank profits and an increase in the volume of credit to bad borrowers, and therefore an increase in the probability of a crisis.

5.2 The Role of Market Structure

Recent literature has emphasized how changes in financial markets over the last decade have had broad implications for the banking industry, with consequent changes to banks’ behavior and profitability. These changes often lead to changes in the structure of the industry, through increased incentives for entry or for consolidation. In this section, we analyze how bank market structure interacts with the informational characteristics of the market in determining banks’ strategies. Specifically, we study how changes in the number of symmetric banks affects the threshold proportion of unknown borrowers on the market above which a pooling equilibrium exists.

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: $\lambda(N) < \lambda(N + 1)$.

Proof. See Appendix.

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 would be able to grasp increases. There is consequently an increased incentive to reduce lending standards by not screening borrowers. Since in equilibrium banks make zero profits on unknown borrowers, the first effects prevails, so that the threshold value $\lambda$ increases with $N$. In other words, markets characterized by lower bank concentration require a larger proportion of unknown borrowers to sustain a pooling equilibrium.

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17 Empirically, this has been studied in Berger and Mester (2003) and Petersen and Rajan (2002), among others. See Boot and Thakor (2000) for a theoretical analysis of the effects of competition on banks’ lending practices.
It is also straightforward to see, from inspection of equation (3), that whenever the equilibrium involves the pooling of borrowers the equilibrium lending rate will be increasing in the number of banks. This somewhat counter-intuitive result is the combined product of Bertrand competition and the adverse selection caused by the informational asymmetry among banks. Since each bank has less information in less concentrated markets, the information cost is larger when there are a large number of banks, thus raising the interest rate banks must charge. This finding is consistent with recent results in Broecker (1990) and Marquez (2002) on competition in lending markets, as well as with empirical evidence that banks’ portfolios deteriorate when the number of competing banks increases (Shaffer, 1998).

6 Discussion and Conclusions

This paper presented a framework where bank strategic behavior interacts with market information structure in determining bank lending standards, which are here represented by the use of collateral requirements. Adverse selection problems stemming from informational asymmetries among lenders induce banks to screen applicant customers to avoid financing borrowers 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 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 which are well in line with existing empirical literature. First, the model predicts a negative relationship between new loan demand and lending standards (in the form of loan collateralization). This has been established indirectly in Asea and Blomberg (1998), who find that in the U.S. lending standards tend to vary systematically over the cycle, with the probability of collateralization increasing during contractions and decreasing during expansions.

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 are exactly the findings 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, 2001). Also consistent with the model’s prediction is the evidence in Harhoff and Korting (1998), who 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 in Germany.

Finally, our model predicts that episodes of financial distress are likely to follow 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, Demirguc-Kunt and Detragiache (1998) find evidence that lending booms precede banking crises. Gourinchas, Valdes, and Landerretche (2001) examine a large number of episodes characterized as lending booms and find that the probability of having 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, it is only for increases in lending large enough to induce a change in lending strategies that the probability of a banking crisis increases.
A Proofs

Proof of Proposition 1: The contract \((\widehat{R}_s, \widehat{C}_s)\) was obtained as the solution to the system

\[
\theta_g R - \overline{d} + (1 - \theta_g) \delta C = 0 \quad \text{(Zero Profit)}
\]
\[
\theta_b (y - R) - (1 - \theta_b) C = 0 \quad \text{(IC)}
\]

With this contract, we find that good borrowers’ IR constraint is slack,

\[
\theta_g \left( y - \widehat{R}_s \right) - (1 - \theta_g) \widehat{C}_s > 0 \quad \text{(IR)},
\]

which implies that \(y > \widehat{R}_s + \left( \frac{1 - \theta_g}{\theta_g} \right) \widehat{C}_s\), and, as by assumption we have \(y < \frac{\overline{d}}{b_s}\), it follows that \(\frac{\overline{d}}{b_s} > \widehat{R}_s + \left( \frac{1 - \theta_g}{\theta_g} \right) \widehat{C}_s\). Then, from condition (4), this in turn implies that at \(\lambda = 0\), we always have a separating equilibrium. Now, it is easy to see that the LHS of the inequality in (4),

\[
\frac{\overline{d} \left( N - 1 \right) \left( 1 - \alpha \right)}{(N - 1) \left( 1 - \alpha \right) \theta_b + \lambda \theta N},
\]

is continuous and decreasing in \(\lambda\), and tends to \(\frac{\overline{d}}{\theta}\) as \(\lambda \to \infty\). Hence, if condition (5) holds, there must exist a \(\lambda > 0\) such that a separating equilibrium exists if and only if \(\lambda \leq \lambda^*\).

Now, assuming condition (4) holds, no bank can profitably deviate from the zero-profit separating contract by offering a pooling contract, and the zero-profit condition guarantees that no bank can profitably deviate by offering a different separating contract. If condition (4) is violated then no pure-strategy separating equilibrium exists because of the standard Rothschild-Stiglitz argument.

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 \((\widehat{R}_p, 0)\), with

\[
\widehat{R}_p = \overline{d} \frac{(N - 1) \left( 1 - \alpha \right) + \lambda}{(N - 1) \left( 1 - \alpha \right) \theta_b + \lambda \theta}.
\]

At stage 3, the rationing rule implies that one bank finances all borrowers. This bank makes zero profits on this contract, and so do all the other banks, which end up not financing any new borrowers. The bad borrowers known to the winning bank are the only ones that do
not get financing. It is obvious that no contract \((R, 0)\) with \(R < \tilde{R}_p\) can make non-negative profits. Similarly, no contract \((R, 0)\) with \(R > \tilde{R}_p\) can make positive profits, as such a contract would not attract any borrowers. It remains to be shown that no contract of the form \((\tilde{R}, \tilde{C})\) can be profitable.

First, consider that, since for \(\lambda > \tilde{\lambda}\) condition (4) is violated, good borrowers prefer \((\tilde{R}_p, 0)\) to the zero-profit separating contract \((\tilde{R}_s, \tilde{C}_s)\). Hence, any viable contract \((\tilde{R}, \tilde{C})\) preferred to \((\tilde{R}_p, 0)\) by good borrowers would have to violate the bad borrowers’ IC constraint in the absence of \((\tilde{R}_p, 0)\). 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 three. 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 \((\tilde{R}_p, 0)\), as that contract just breaks-even with the average population. However, considering that fact, 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, \((\tilde{R}_p, 0)\) constitutes an equilibrium. Moreover, again as in Hellwig (1987), an application of the stability criterion (Kohlberg and Mertens, 1986) establishes that this is the uniquely stable equilibrium. ■

**Proof of Proposition 3:** i) First, note that because of competition between the banks, all banks make zero profits on new borrowers, under either the pooling or the separating equilibrium. Their profits therefore stem solely from their known borrowers. Denote the rate charged to each good known borrower as \(R^j_g\), \(j = s, p\) (separating or pooling). Following Lemma 1, each bank’s profits on known borrowers can be written as

\[
\Pi_k (R_g) = \frac{\alpha}{N} (\theta_g R_g - d),
\]

where \(R_g = R^s_g = \tilde{R}_s + \left(\frac{1-\theta_g}{\theta_g}\right) \tilde{C}_s\) in the separating equilibrium, and \(R_g = R^p_g = \tilde{R}_p\) in the pooling equilibrium. From Proposition (2), we know that \(\tilde{R}_s + \left(\frac{1-\theta_g}{\theta_g}\right) \tilde{C}_s > \tilde{R}_p\) for \(\lambda < \tilde{\lambda}\), as in order to have a pooling equilibrium, the zero profit separating contract needs to be dominated by the pooling one. Hence, \(\Pi_k (R^p_g) < \Pi_k (R^s_g)\).
ii) and iii) trivial, since all unknown borrowers obtain financing.

**Proof of Proposition 4:** First, since at $\lambda = 0$ we have $W_p < W_s$, $W_p - W_s$ is continuously increasing in $\lambda$, and $\lim_{\lambda \to -\infty} (W_p - W_s) = +\infty$, there must exist a $\lambda^w > 0$ such that $W_p < W_s \iff \lambda < \lambda^w$. To see this, consider that

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

and

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

Condition (5) can be written as

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

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

Now consider

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

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

Hence, $W_s < W_p \iff$

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

Now, we can rewrite $\lambda \alpha \left( \theta_g y - (1 - \delta) (1 - \theta_g) \hat{C}_s - \bar{d} \right) = \frac{\alpha \lambda (\theta_g - \theta_b) \hat{C}_s}{\theta_b}$. Hence, $W_s \leq W_p \iff$

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

(6)

From condition (4), we know that for a pooling equilibrium to exist, it must be that

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

(7)

After a substitution, we can write

$$\hat{R}_s + \left( \frac{1 - \theta_g}{\theta_g} \right) \hat{C}_s = y - \frac{(\theta_g - \theta_b) \hat{C}_s}{\theta_g \theta_b \hat{C}_s}.$$
We can now express condition (7) as
\[
\frac{(N-1)}{N} (1 - \alpha) \left( \theta y - \bar{d} \right) + \lambda \left( \bar{y} - \bar{d} \right) \geq \frac{\theta_g - \theta_b}{\theta_g\theta_b} \hat{C}_s
\]  
(8)

Note that we can now also rewrite condition (6) as
\[
\frac{(N-1)}{N} (1 - \alpha) \left( \theta y - \bar{d} \right) + \lambda \left( \bar{y} - \bar{d} \right) \geq \frac{\theta_g - \theta_b}{\theta_g\theta_b} \hat{C}_s,
\]
which, since
\[
\frac{N - 1}{N} (1 - \alpha) \theta_b + \lambda \theta > \alpha \lambda \theta_g,
\]
implies that if condition (7) is satisfied, so will be (6), or in other words \( \lambda^u < \hat{\lambda} \).

**Proof of Proposition 5:** First, define \( d_j^*, j = s, p \), as the 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 \( 1 - F(d^*) \).

We can write the ex-post total profits of the banking system as
\[
\Pi^s(d) = \alpha \left( \theta g R_s^* - d \right) + \lambda \alpha \left( \theta g \hat{R}_s + \delta (1 - \theta g) \hat{C}_s - d \right)
\]
for the separating equilibrium, and
\[
\Pi^p(d) = \alpha \left( \theta b \hat{R}_p - d \right) + \lambda \alpha \left( \theta b \hat{R}_p + \delta (1 - \theta b) \hat{C}_p - d \right)
\]
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. Then, as the zero profit condition on untested 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 \( d \), and it is easy to verify that \( \left| \frac{\partial \Pi^s(d)}{\partial d} \right| < \left| \frac{\partial \Pi^p(d)}{\partial d} \right| \). Therefore, because of linearity, we can write
\[
d_s^* = \bar{d} + \frac{\Pi^s(\bar{d})}{\left| \frac{\partial \Pi^s(d)}{\partial d} \right|},
\]
\[
d_p^* = \bar{d} + \frac{\Pi^p(\bar{d})}{\left| \frac{\partial \Pi^p(d)}{\partial d} \right|}.
\]
so that \( d_s^* > d_p^* \), which implies \( 1 - F(d_s^*) < 1 - F(d_p^*) \).
Proof of Proposition 6: First, in equilibrium, since the market for unknown borrowers is now segmented, borrowers who defaulted are offered the separating contract \((\widehat{R}_s, \widehat{C}_s)\). Moreover, this is the only contract that can be part of a stable equilibrium, as for this market segment no pooling contract can make non-negative profits, since there are no untested borrowers.

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

\[
\widehat{R}_p^* = d \frac{(N - 1)(1 - \alpha) \theta_b + \lambda N}{(N - 1)(1 - \alpha) \theta_b^2 + \lambda \theta N},
\]

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

Proof of Proposition 7: Start with the case where \(\lambda < \lambda^* < \lambda\), 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 \(R^*_g = \widehat{R}_s + \left(\frac{1 - \theta_g}{\theta_g}\right) \widehat{C}_s\) is the rate charged to these borrowers in equilibrium.

Second, consider the case where \(\lambda^* < \lambda < \lambda\), so that both cases 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 (6) that \(\widehat{R}_p^* < \widehat{R}_p\) and then \(R^*_g < R^*_g\), where \(R^*_g\) refers to the matching contract offered 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 \(R^*_g > \widehat{R}_p = R^*_p\). For each bank, the difference in profits will be

\[
\Pi^{sharing} - \Pi = \frac{\alpha \theta_g}{N} \left( \Pi \left( \widehat{R}_p^* \right) - \Pi \left( \widehat{R}_p \right) \right) + \frac{\alpha (1 - \theta_g)}{N} \left( \Pi \left( R^*_g \right) - \Pi \left( \widehat{R}_p \right) \right). \tag{9}
\]

Finally, for \(\lambda^* < \lambda < \lambda\), 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
\[
\Pi^{sharing} - \Pi = \frac{\alpha \theta_g}{N} \left( \Pi \left( \hat{R}_p - R_g^s \right) - \Pi \left( R_g^s - R_g^s \right) \right) + \frac{\alpha (1 - \theta_g)}{N} \left( \Pi \left( R_g^s - R_g^s \right) \right)
\]
\[
= \frac{\alpha \theta_g}{N} \left( \Pi \left( \hat{R}_p - R_g^s \right) - \Pi \left( R_g^s \right) \right) < 0.
\]

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

Now at \(\lambda = \hat{\lambda}\), Eq. (9) becomes
\[
\Pi^{sharing} - \Pi = \frac{\alpha \theta_g}{N} \left( \Pi \left( \hat{R}_p - R_g^s \right) - \Pi \left( R_g^s \right) \right) < 0.
\]

In addition, it is easy to see that the difference is increasing in \(\lambda\), since \(\frac{d R_g}{d\lambda} < 0\) and \(\frac{d \left( R_g - \hat{R}_p \right)}{d\lambda} < 0\). Also,
\[
\lim_{\lambda \to \infty} \left( \hat{R}_p^* - \hat{R}_p \right) = 0,
\]
and hence,
\[
\lim_{\lambda \to \infty} \left( \Pi^{sharing} - \Pi \right) = \frac{\alpha (1 - \theta_g)}{N} \left( \Pi \left( R_g^s \right) - \Pi \left( \frac{d \lambda}{\theta} \right) \right) > 0,
\]
which implies that there exists a \(\lambda^*\) such that \(\Pi^{sharing} - \Pi > 0\) if and only if \(\lambda \geq \lambda^*\).

**Proof of Proposition 8:** The RHS of condition (4) does not depend on \(N\), but the LHS clearly does. Define \(\hat{\lambda}_N\) as the proportion of untested borrowers at which (4) 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
\[
\frac{(N - 1) (1 - \alpha) + \hat{\lambda}_N N}{(N - 1) (1 - \alpha) \theta_b + \hat{\lambda}_N \theta N} = \frac{N (1 - \alpha) + \hat{\lambda}_N (N + 1)}{N (1 - \alpha) \theta_b + \hat{\lambda}_{N+1} \theta (N + 1)},
\]
which, after some rewriting, becomes
\[
\hat{\lambda}_N = \hat{\lambda}_{N+1} \frac{N^2 - 1}{N^2},
\]
thus establishing that \(\hat{\lambda}\) is increasing in \(N\).
References


