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Does information sharing reduce the role of collateral as a screening device?

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Abstract

Information sharing and collateral are both devices that help banks reduce the cost of adverse selection. We examine whether they are likely to be used as substitutes (information sharing reduces the need for collateral) or complements. We show that information sharing via a credit bureaus and registers may increase, rather than decrease, the role of collateral: it can be required in loans to high-risk borrowers in cases when it is not in the absence of information sharing. Higher adverse selection makes the use of collateral more likely both with and without information sharing. Our results are in line with recent empirical evidence.

Keywords: Bank competition, information sharing, collateral

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1. Introduction

Adverse selection is an important issue facing banks (Stiglitz and Weiss [43]). Not all borrowers and projects applying for bank loans should be funded; however, since banks do not have the same information as their applicants, deciding which of them are creditworthy can be difficult. In this paper, we look at two instruments that banks can use to select their borrowers: collateral requirements and credit records.

Collateral can be used to reduce adverse selection since high-quality borrowers are more likely to pledge assets and thus signal their creditworthiness. This is a well-established result in the theoretical literature (Bester, [9]; Chan and Kanatas [18]; Besanko and Thakor [8]). Collateral requirements are widespread in practice (Avery, Bostic, and Samolyk [1]) and have a long history (Bodenhorn, [11]). Empirical studies have found that there is an inverse relationship between collateral and interest rates (Berger, Espinosa-Vega, Frame and Miller [5]; Berger, Frame and Ioannidou [4]; Cerqueiro, Ongena and Roszbach [16]), and that collateral does indeed seem to be used to select borrowers ex ante (Jiménez, Salas and Saurina [32]; Berger, Espinosa-Vega, Frame and Miller [5]; Berger, Frame and Ioannidou [4]). Collateral requirements therefore have an important role in credit allocation.

Another useful tool for reducing adverse selection is the information acquired during the lending relationship (Boot [12]). Borrowers' performance over successive loans, for instance, can be used to update the bank's assessment of their value as a client. Low-quality borrowers will gradually be eliminated from the pool of loan applicants.

Some of the information acquired during lending relationships, such as repayment histories, is made available to competing banks through credit bureaus and credit registers (Djankov, McLiesh and Shleifer [22]; Miller [37]). As a result, banks can use the data received from other lenders to select their potential borrowers (Jappelli and Pagano [31]). The role and geographical spread of information sharing arrangements have significantly increased in recent years. In a survey of Latin American banks Miller Miller [37] reports that 93 percent of the banks used credit information for their commercial loans (84 percent did so for consumer loans and 100 percent for mortgage loans).

Both the information received through credit bureaus and registers and the more traditional collateral can be used to select loan applicants. Indeed, while credit bureaus are a more recent development in most countries (Djankov, McLiesh and Shleifer [22]) the frequency of their use in lending decisions has become comparable. Miller Miller [37] finds that, while collateral still remains important in granting loans, most bank managers consider payment history as the number one important factor in credit decisions. Information sharing seems to be associated with better credit allocation (Houston, Lin, Lin and Ma [29]).

Due to potential liquidation costs (Gorton and Kahn [25]; Chen [19]; Benmelech and Bergman [2]) and fluctuations in market value (Bernanke and Gertler [6]; Cerqueiro, Ongena, and Roszbach [16]), the use of collateral can be expensive for banks and borrowers. The availability of additional data via information sharing arrangements may provide a potentially cheaper alternative for borrower selection. When collateral is costly, banks may prefer to reduce the amount required, while still attracting high-quality borrowers. As a result, it may be interesting to check whether the increasing use of shared credit records is likely to reduce the incidence of collateral requirements.

We analyze the use of collateral and credit records in lending decisions. We find that the overall picture is quite different from a simple substitution story. Indeed, we show that information sharing may lead to the use of collateral in circumstances where it would not be required in the absence of a credit bureau. The reason is that information sharing allows banks to distinguish between borrowers with different credit histories. Some borrowers will have a good record, but others will have a poor one. We show that under information sharing there may be a higher incidence of collateral as a result of its concentrated use for borrowers with bad credit histories.

We build a two-period model with two banks competing for high- and low-quality borrowers. The banks compete in interest rates and may use collateral to select loan applications. The use of collateral obviously improves the average borrower quality, but is also costly because of liquidation costs. As in Gehrig and Stenbacka Gehrig and Stenbacka [24], borrowers face switching costs when moving from one bank to another.

Borrowers' history of successful repayments or default also provides information about their creditworthiness. Under information sharing, these credit histories become available to the bank that has not had a lending relationship with a particular borrower.

Whether information is shared or not, liquidation costs imply that collateral will only be used if adverse selection is important enough. However, information sharing does have an important effect on the use of collateral, since it allows outside banks to distinguish between pools of borrowers of different quality.

In the absence of information sharing, banks faced with unknown borrowers can choose to require collateral, and face liquidation costs in case of default. In the presence of a credit bureau, banks faced with outside borrowers can distinguish between those with a good credit history, and those with bad credit events on their record. We show that borrowers with a bad credit history are more likely to be faced with collateral requirements than they would be in the absence of information sharing. As a result, the introduction of a credit bureau or a credit register may increase the observed incidence of collateral requirements.

Our theoretical results are consistent with and provide a theoretical explanation for the empirical results in Doblas-Madrid and Minetti Doblas-Madrid and Minetti [21]. Using contract-level data from a U.S. credit bureau, they find that information sharing does not reduce the incidence of collateral, and that the incidence actually increases for low-quality borrowers.

We also find that, under both information regimes, higher adverse selection makes the use of collateral more likely. Moreover, higher adverse selection also creates incentives for banks to share information and make selective use of collateral, and the two work together - if information sharing is not feasible, then the likelihood of collateral use is lower.

Our study analyzes the bank's choice of instruments to reduce adverse selection. This is an area that has received relatively little attention in the literature. An important exception is Manove, Padilla, and

Pagano Manove, Padilla, and Pagano [36], showing that the availability of collateral may reduce banks' screening incentives. We look at another pair of selection instruments, collateral and credit histories, and also use the idea of cost minimization. The importance of this criterion has been confirmed by the empirical literature: "the evidence suggests that collateral pledging decisions are generally consistent with borrowing cost minimization" (Booth and Booth [13]).

While the use of collateral induced by information sharing may increase welfare in our model, we show that the surplus accruing to high-quality borrowers may actually decrease. This welfare tradeoff is not necessarily a desirable feature (Gehrig and Stenbacka [24]). It can also be noted that, in addition to the liquidation costs we model directly in our paper, lenders face the costs of monitoring the pledged assets (Cerqueiro, Ongena and Roszbach [16]). Moreover, borrowers' credit availability may change along with the value of the pledged assets (Gan [23]). When this value is correlated across borrowers, this can amplify the procyclicality of access to credit (Bernanke and Gertler [6]; Holmstrom and Tirole [28]; Kiyotaki and Moore [35]). From this angle, our results could be seen as worrying. We find that information sharing and collateral can be complements: information sharing may increase the likelihood of collateral requirements, and that increase will actually occur for borrower groups faced with higher adverse selection issues. Thus, while both information sharing and collateral are tools that help lending decisions, their mixing may lead to undesirable effects.

We focus on ex ante adverse selection issues rather than ex post moral hazard problems in lending. Both collateral (Chan and Thakor [18]; Boot and Thakor [12]; Rajan and Winton [41]; Berger, Frame, and Ioannidou [4]) and information sharing (Padilla and Pagano [38]; Padilla and Pagano [39]) can be used to reduce moral hazard in lending. Banks' choice between the two as ex post instruments may be an interesting issue for further research.

The closest paper to ours in the area of information sharing is Gehrig and Stenbacka Gehrig and Stenbacka [24]. Looking at a potential downside of credit bureaus, they show that information sharing reduces the returns from establishing banking relationships, and thus weakens competition for the formation of banking relationships. The result may be higher interest rates for young firms without an established credit record. In our paper, we identify another potential pitfall of information sharing: the increase in costly collateral requirements for borrowers faced with significant adverse selection issues.

The rest of the paper is organized as follows. Section II describes the model. Section III and IV solve for the equilibria under information sharing and in the absence of it, respectively. Section V concludes.

2. The Model

We model the two-period competition between two banks, A and B. They compete for loan contracts with borrowers who live for two periods, period 1 and 2. Banks raise (unlimited) capital at a fixed cost r_0 per dollar in both periods. In each period they offer a one-period loan contract.

Borrowers form a continuum of length 1. Each of them requires one unit of capital to start a project. Since they have no funding of their own, they have to borrow the capital from one of the banks. There are two types of borrowers, high (H) and low (L). High-type borrowers have access to a project that returns a verifiable amount R with probability p and 0 otherwise. Low-type borrowers have a zero probability of success, but they derive a non-verifiable amount of utility from the business equal to c. In addition, all borrowers have assets in place of amount $C > c$, that can be pledged as collateral. The proportion of $H-$type ($L-$type) borrowers is λ $(1-\lambda)$ and is common knowledge. We assume that borrowers can only borrow from one of the banks in each period, but they can borrow from one bank in the first period and from the other in the second period. We call the bank a given customer has borrowed from during the first period the "inside" bank for that borrower; the other bank is the "outside" bank.

Before contracting in the first period, banks and borrowers have no information about any of the borrowers' type[1]. The first period thus represents the initial stage of a business, where entrepreneurs still have much to learn about their business abilities and banks also have relatively little information to draw on when examining them.

By the end of the first period, however, the inside bank has learned its borrowers' true type[2]. Borrowers also discover their type during the first-period lending relationship. This information is private and relationship-specific and cannot be communicated credibly to the other bank.

At the end of the first period banks also observe their borrowers' repayment history. This history can be made available to the competitor bank under an information sharing arrangement[3].

The outside bank can require collateral in the second period to separate high- and low-type borrowers. Collateral has a proportional liquidation cost L, so that inside banks will never want to require positive collateral from the high-type borrowers they lend to[4]. Since an amount of collateral c is enough to screen borrowers, it is clear that the poaching outside bank will never impose a higher collateral. As borrowers do not know their type at that point, banks will never require collateral in the first period.

At the beginning of the second period each bank j announces the interest rate r_2^j for its high-type first-period borrowers. (It does not lend to low-type borrowers, since they are obviously not creditworthy.) It also announces the interest rate i_2^j that it offers to the first-period customers of the other bank, as well as possible collateral requirements for them (c_2^j). Under information sharing, the successful and defaulting first-period customers of the competing bank can be offered different contracts.

When borrowers switch to the outside bank, they may bear certain costs due to the cessation of the relationship with the inside bank. Following Gehrig and Stenbacka [24], we model this as an idiosyncratic

[1]The assumption that borrowers do not initially know their own type is similar to Manove, Padilla, and Pagano Manove, Padilla, and Pagano [36]. The implication is that very young firms are less likely to pledge collateral, a fact which is confirmed empirically by Avery, Bostic and Samolyk Avery et al. [1].

[2]This learning captures the feature of the relationship bank whereby the (incumbent) bank gradually builds its knowledge of the borrowers' abilities and their projects. We assume that this learning is perfect. See Sharpe Sharpe [42], Gehrig and Stenbacka Gehrig and Stenbacka [24] for similar models of bank learning.

[3]Gehrig and Stenbacka Gehrig and Stenbacka [24] assume all relationship-specific information can be shared. While our model is robust to this change, we assume that only verifiable hard information can be shared, i.e. the repayment history. See Petersen Petersen [40] for a detailed discussion on hard and soft information.

[4]It has been shown that the use of collateral is less likely as bank relationships get older and banks presumably learn more about their customers (Berger and Udell [3]; Bodenhorn [11]; Chakraborty and Hu [17]; Bharath, Dahiya and Saunders [10]). Our assumption captures this stylized fact in a simple way.

switching cost that is distributed uniformly on the interval $[0, S]$. The switching costs may, for example, reflect the costs of another application procedure at a competitor bank, or the financial costs of transferring funds from the previous bank. Moreover, as Gehrig and Stenbacka [24] argue, switching costs can vary largely across customers (see Shy [44]; Kim et al [34], Stango [45]). The switching costs are private information of the borrowers and are revealed to the borrower at the beginning of period 2. The initial choice of bank is therefore independent of the switching cost (Gehrig and Stenbacka [24]). As in Sharpe Sharpe [42], Padilla and Pagano Padilla and Pagano [38], Gehrig and Stenbacka Gehrig and Stenbacka [24], we assume that successful borrowers will consume their first-period revenues at the end of period 1.

In sum, at the beginning of the first period lenders announce interest rates for a risky borrower population. At the beginning of the first period, banks may share information and they announce interest rates and collateral requirements for their existing and potential borrowers. When moving from the inside to the outside bank at that point, borrowers are faced with switching costs.

The timeline of the bank competition can be summarized as follows:

First period:

1. Banks decide whether or not to share default information.
2. Banks offer interest rates and borrowers choose a bank to borrow from. At the end of the period, borrowers repay if they can.

Second period:

1. Banks share default information if they have decided to do so.
2. Banks announce inside and outside interest rates and collateral. Borrowers may switch banks if they are better off doing so.
3. Borrowers repay whenever they can. Pledged collateral is seized if the borrower defaults.

The timeline is illustrated in figure 1.

INSERT FIGURE 1 HERE

We analyze the resulting equilibrium below, first without and then with information sharing.

3. No information sharing

We start by examining the case where banks have decided not to share information. We derive the subgame perfect Nash Equilibrium via backward induction.

3.1. Equilibrium in the second period

In the second period, banks will try to retain their own first-period high-type borrowers and to "poach" those of the competing bank.

Let $0 \leq \mu_i \leq 1$ denote the market share of bank i, $i = A, B$, acquired in the first period. The inside bank has acquired information about its first-period borrowers' true types. It only lends to high-type borrowers in the second period, and its expected return per loan is $pr_2^i - r_0$.

The outside bank could use the collateral requirement (c_2^j) to distinguish among the borrowers it tries to poach. A high-type borrower may switch from bank i to bank j if the switching cost $s \in [0, S]$ and the poaching rate i_2^j are low enough: $pi_2^j + (1-p)c_2^j + s < pr_2^i$. The marginal borrower's switching cost is $s^* = pr_2^i - pi_2^j - (1-p)c_2^j$. High-type borrowers that have switching costs above s^* will stay with their first-period bank, while the rest will switch.

Alternatively, the outside bank can decide not to require collateral. In that case, it will lend to both high- and low-type borrowers with relatively low switching costs. The switching cost of the marginal borrower will be $s^* = pr_2^i - pi_2^j$.

The inside bank's second-period profits under no information sharing are given by

$$\mu_i \lambda (pr_2^i - r_0) \frac{1}{S} \int_{s^*}^{S} ds$$

where where s^* will depend on the outside bank's choice to use collateral or not.

If bank j tries to poach without collateral, then its poaching profits are given by:

$$\mu_i \lambda (pi_2^j - r_0) \frac{1}{S} \int_{0}^{pr_2^i - pi_2^j} ds - r_o \mu_i (1-\lambda)$$

The first term in the equation represents the profits earned on the high-type entrepreneurs successfully poached from rival bank i. The second term represents the losses from lending to low-type poached borrowers. Bank i cannot separate these borrowers without collateral.

The losses from lending to low-type borrowers can be avoided if the poaching bank j imposes collateral. In this latter case its profits are given by:

$$\mu_i \lambda (pi_2^j + (1-p)c_2^j - r_0 - (1-p)l) \frac{1}{S} \int_{0}^{pr_2^i - pi_2^j - (1-p)c_2^j} ds$$

where $Lc_2^j \equiv l$ represents the liquidation cost of collateral. In order to avoid unnecessary liquidation costs, the outside bank will set collateral requirements to the minimal level $c_2^j = c$.

Summing up, in the absence of information sharing the total second-period profit of bank i is equal to

$$\Pi_2^i = \mu_i \lambda (pr_2^i - r_0) \frac{1}{S} \int_{pr_2^i - pi_2^j}^{S} ds + (1-\mu_i)\lambda (pi_2^i - r_0) \frac{1}{S} \int_{0}^{pr_2^i - pi_2^j} ds - r_o (1-\mu_i)(1-\lambda)$$

when collateral is not required, and

$$\Pi_2^{i,c} = \mu_i \lambda (pr_2^i - r_0) \frac{1}{S} \int_{pr_2^i - pi_2^j - (1-p)c_2^j}^{S} ds + (1-\mu_i)\lambda (pi_2^i + (1-p)c_2^i(1-L) - r_0) \frac{1}{S} \int_{0}^{pr_2^i - pi_2^j - (1-p)c_2^j} ds$$

when collateral is required from the first-period customers of bank j.

Banks will choose interest rates and collateral requirements to maximize their second-period earnings. The resulting equilibrium is described in the following propositions.

Lemma 1. *If collateral is required from outside borrowers, the equilibrium interest rate offered to inside and outside borrowers are given by* $r_2 = \frac{1}{3p}\big(2S + 3r_0 + (1-p)l\ \big)$ *and* $i_2 = \frac{1}{3p}\big(S + 3r_0 + (1-p)(2l - 3c)\big)$*, respectively. Without collateral, the interest rates are given by* $r_2 = \frac{1}{3p}\big(2S + 3r_0\big)$ *and* $i_2 = \frac{1}{3p}\big(S + 3r_0\big)$*. High-type borrowers with switching costs below* $s^* = \frac{S}{3}$ *(*$s^* = \frac{S}{3} - \frac{2(1-p)l}{3}$ *if collateral is required) switch to the outside bank.*

Proof. See Appendix.

We can see from the expressions above that whenever $S > 2(1-p)l$ (i.e., $r_2^i > pi_2^j + (1-p)c$) there is positive switching under contracts with collateral. (There is less switching in the presence of collateral requirements.) In what follows we will assume that this relationship holds.

Theorem 2. *If collateral is required from outside borrowers, the total second-period profits of bank* i*,* $i = A, B$*, are given by* $\Pi_2^{i,c} = \mu_i\lambda\frac{1}{9S}\big(2S + (1-p)l\big)^2 + (1-\mu_i)\lambda\frac{1}{9S}\big(S - (1-p)l\big)^2$*. If collateral is not required, then total second-period profits are* $\Pi_2^i = \mu_i\lambda\frac{4}{9}S + (1-\mu_i)\big(\lambda\frac{1}{9}S - (1-\lambda)r_0\big)$*.*

Proof. See Appendix.

It can be seen from the proposition that, if liquidation costs are high, the banks' poaching profits can be lower when poaching is achieved with collateral. The decision concerning collateral requirements is presented in the following proposition.

Theorem 3. *In the absence of information sharing banks will prefer to impose collateral whenever cost of adverse selection is high enough:* $\frac{r_0(1-\lambda)}{\lambda} > \frac{2S(1-p)l-(1-p)^2l^2}{9S}$.

Proof. The proof follows immediately from comparing the expressions for profits from poaching with and without collateral.

Intuitively, if the adverse selection costs are lower than the total expected liquidation costs of collateral, then banks will prefer to offer contracts without collateral and with higher interest rates. As we will see in the next section, information sharing may reduce total liquidation costs, and collateral may then be preferred by lenders.

3.2. Equilibrium in the first period

At the beginning of the first period, banks are faced with a population that consists of both high- and low-type borrowers. The two types cannot be separated by requiring collateral, since borrowers initially do not know their own type. Banks will charge an interest rate r_1 that maximizes their intertemporal (two-period) profits ($\Pi^i = \Pi_1^i + \Pi_2^i$, where $\Pi_1^i = \mu_i(\lambda p r_1^i - r_0)$, and $i = A, B$; we assume a discount factor of 1 between the two periods).

Theorem 4. *In the subgame perfect equilibrium first-period interest rates are given by* $r_1^{i,c} = \frac{1}{\lambda p}\Big(r_0 - \lambda\frac{4}{9S}\big(S+(1-p)l\big)^2 + \lambda\frac{1}{9}\big(S-(1-p)l\big)^2\Big)$ *if collateral is used in the second period and* $r_1^i = \frac{1}{\lambda p}\Big(r_0 - (\lambda\frac{S}{3} + (1-\lambda)r_0)\Big)$ *if it is not.*

Proof. See Appendix.

The two banks will charge the same first-period interest rate and share the market equally, whether they anticipate they are going to use collateral later on or not ($\mu_A = \mu_B$).

Theorem 5. *Banks' intertemporal total profits are given by* $\lambda\frac{1}{9}\big(S-(1-p)l\big)^2$ *if collateral is required, and by* $\frac{\lambda S}{9} - (1-\lambda)r_0$ *if it is not.*

Proof. The proof follows immediately from plugging the first-period interest rate into the expression for total intertemporal profits.

Due to the existing of switching costs, bank are always able to secure positive intertemporal rents. While all profits coming from incumbency rents in the second period are dissipated in the first period competition for customers, positive profits are secured due to the existence of the poached customers. This result is similar to that in Gehrig and Stenbacka (2007).

4. Information sharing

We now present the equilibrium interest rates, profits and criterion for using collateral in the case of information sharing.

In the presence of a credit bureau, lenders commit to reveal the identity of their first-period defaulting borrowers to competitors. As a result, outside banks can use switching customers' previous repayment history in their lending decisions. Borrowers that have successfully repaid their first-period loan are obviously high-type borrowers; defaulting borrowers are a mix of high- and low-type borrowers. We analyze below the two possible cases: where the defaulting borrowers are not creditworthy on average, and where they are.

4.1. Bank competition when defaulting borrowers are not creditworthy

Suppose first that defaulting borrowers are not creditworthy (that is, $\frac{\lambda(1-p)p}{\lambda(1-p)+1-\lambda}R - r_0 < 0$). In this case, the outside bank's options are either to require collateral from defaulting, switching borrowers, or not to lend to them at all. At the same time, successful borrowers are obviously high-type, and the outside bank will lend to them without collateral. The inside bank will only lend to high-type borrowers, regardless of their credit histories.

The profits of the inside bank i are given by

$$\lambda p\mu_i(pr^i_{2,N} - r_0)\frac{1}{S}\int_{s^*_N}^{S} + \lambda(1-p)\mu_i(pR - r_0)\frac{1}{S}\int_{s^*_D}^{S}$$

where the first term represents profits on successful borrowers (which are offered the competitive rate $r^i_{2,N}$) and the second term represents profits on defaulting, but high-type borrowers (who are offered the monopoly rate R since the outside bank does not try to poach them).

Suppose first that the outside bank j does not bid for the other bank's first-period defaulting customers. It will only bid for successful borrowers, who are obviously high-type. As a result, its profits from poached customers will be given by:

$$\lambda p\mu_i(pi^j_{2,N} - r_0)\frac{1}{S}\int_0^{s^*_N}$$

This represents the expected profit earned on customers who have succeeded. It differs from the respective expression in the absence of information sharing in two ways: the adverse selection cost coming from lending to low-type borrowers is absent, and the amount of creditworthy, high-type borrowers is now reduced (by a factor of p).

Suppose next that collateral is imposed by the outside bank for defaulting, switching borrowers. Because low-type borrowers prefer not to borrow, the outside bank will get only the high-type borrowers among them. Poaching profits earned on contracts with collateral are thus given by

$$\lambda p\mu_i(pi^j_{2,N} - r_0)\frac{1}{S}\int_0^{s^*_N} ds + \lambda(1-p)(1-\mu_i)(pi^j_{2,D} + (1-p)c^j_2(1-l) - r_0)\frac{1}{S}\int_0^{s^*_D} ds$$

where the first term represents profits earned on customers who have previously repaid successfully: the outside bank does not impose collateral on these customers as they are high type by virtue of their repayment history. The second term represents expected profits earned on customers who are high ability but who have defaulted, and are now required to post collateral.

Theorem 6. *Second-period profits under the contract with and without collateral are given by, respectively,* $\Pi^{i,c}_2 = \mu_i\lambda pS\frac{4}{9} + \mu_i\frac{\lambda(1-p)}{9S}(2S + (1-p)l)^2 + (1-\mu_i)\frac{\lambda pS}{9} + (1-\mu_i)\frac{\lambda(1-p)}{9S}(S-(1-p)l)^2$*, and* $\Pi^i_2 = \mu_i\lambda(1-p)(pR - r_0) + \mu_i\lambda p\frac{4}{9}S + (1-\mu_i)\frac{\lambda p}{9}S$*, where* $i = A, B$*. High-type borrowers with switching costs below* $s^* = \frac{S}{3} - frac2(1-p)l3$ *switch to the outside bank if collateral-based loans are available.*

First-period interest rates are given by $r_1^{i,c} = \frac{1}{\lambda p}\Big(r_0 - \lambda\frac{S}{3} + \frac{2\lambda(1-p)^2 l}{3}\Big)$ *and* $r_1^i = \frac{1}{\lambda p}\Big(r_0 - \lambda p\frac{S}{3} - \lambda(1-p)(pR - r_0)\Big)$*, respectively.*

Two-period (intertemporal) profits are $\frac{\lambda pS}{9} + \frac{\lambda(1-p)}{9S}(S-(1-p)l)^2$ *when collateral is used to poach defaulting borrowers, and* $\frac{\lambda p}{9}S$ *when it is not.*

Proof. See Appendix.

By comparing the two possible expressions for second-period earnings one can see that banks will always prefer to require collateral in the presence of a credit bureau. This was not the case in the absence of information sharing. The reason is that in the latter case liquidation costs of collateral may outweigh those of the adverse selection for the poaching bank. However, because previous default information sharing has revealed type specific information about borrowers, the costs of collateral are reduced by imposing it only on the high risk (bad history) population. Thus, rather than substituting, collateral may complement the role of information sharing.

4.2. Bank competition when defaulting creditors are creditworthy

In the previous subsection we have assumed that default information is informative enough to identify a group of uncreditworthy borrowers. We now look at the case where unsuccessful borrowers are still creditworthy on average. (In that case there are enough defaulting but high-type borrowers so that $\frac{\lambda(1-p)p}{\lambda(1-p)+(1-\lambda)}R - r_0 > 0$.) In this case, the outside bank also has the option of lending to defaulting borrowers without requiring collateral.

The second-period profits of the inside bank i are given by

$$\lambda p\mu_i(pr_{2,N}^i - r_0)\frac{1}{S}\int_{s_N^*}^{S} + \lambda(1-p)\mu_i(pr_{2,D}^i)\frac{1}{S}\int_{s_D^*}^{S}$$

where $r_{2,N}^i$ and $r_{2,D}^i$ are the second-period interest rates for successful (non-defaulting) and defaulting borrowers respectively, and s_N^* and s_D^* are the marginal switching costs.

If the outside bank j lends to defaulting borrowers without requiring collateral, its second-period profits are given by

$$\lambda p\mu_i(pi_{2,N}^j - r_0)\frac{1}{S}\int_0^{s_N^*} ds + \lambda(1-p)\mu_i(pi_{2,S}^j - r_0)\frac{1}{S}\int_0^{s_D^*} -(1-\lambda)r_0,$$

where $i_{2,N}^j$ is the interest rate charged to successful first-period borrowers of the inside bank, and $i_{2,S}^j$ the rate offered to defaulting ones.

If the outside bank requires collateral from defaulting borrowers, then the expression for second-period profits is the same as under the assumption that defaulting borrowers are not creditworthy:

$$\lambda p\mu_i(pi_{2,N}^j - r_0)\frac{1}{S}\int_0^{s_N^*} ds + \lambda(1-p)(1-\mu_i)(pi_{2,D}^j + (1-p)c_2^j(1-l) - r_0)\frac{1}{S}\int_0^{s_D^*} ds.$$

We present the banks' second-period profits, first-period interest rates and intertemporal profits below.

Theorem 7. *Second-period profits under the contract with and without collateral are given by, respectively,* $\Pi_2^{i,c} = \mu_i \lambda p S \frac{4}{9} + \mu_i \frac{\lambda(1-p)}{9S}(2S+(1-p)l)^2 + (1-\mu_i)\frac{\lambda p S}{9} + (1-\mu_i)\frac{\lambda(1-p)}{9S}(S-(1-p)l)^2$*, and* $\Pi_2^i = \mu_i \lambda \frac{4}{9} S + (1-\mu_i)\Big(\frac{\lambda}{9}S - (1-\lambda)S\Big)$*, where* $i = A, B$*.*

First-period interest rates are given by $r_1^{i,c} = \frac{1}{\lambda p}\Big(r_0 - \lambda\frac{S}{3} + \frac{2\lambda(1-p)^2 l}{3}\Big)$ *and* $r_1^i = \frac{1}{\lambda p}\Big(r_0 - \lambda\frac{S}{3} + (1-\lambda)r_0\Big)$*, respectively.*

Intertemporal profits under the contract with and without collateral are given by, respectively, $\Pi^{i,c} = \frac{\lambda p S}{9} + \frac{\lambda(1-p)}{9S}(S-(1-p)l)^2$*, and* $\Pi^i = \frac{\lambda S}{9} - r_0(1-\lambda)$*.*

Proof. See Appendix.

We then summarize the decision to require collateral from defaulting borrowers.

Theorem 8. *Banks prefer to offer contracts with collateral under information sharing and without collateral in the absence of information sharing whenever* $\frac{(1-p)l}{9S}(2S-(1-p)l) > \frac{r_0(1-\lambda)}{\lambda} > \frac{(1-p)^2 l}{9S}(2S-(1-p)l)$*. If there the cost of adverse selection is very high (*$\frac{r_0(1-\lambda)}{\lambda} > \frac{(1-p)l}{9S}(2S-(1-p)l)$*), then collateral is required under both information sharing regimes; when they are very low (*$\frac{r_0(1-\lambda)}{\lambda} < \frac{(1-p)^2 l}{9S}(2S-(1-p)l)$*), then there are no collateral requirements under either regime.*

Proof. The result is obvious when second-period poaching profits are compared.

Intuitively, when liquidation costs are so high that offering collateral contracts to all borrowers is not justified to eliminate adverse selection, information sharing (even though it is partially informative) may justify use of costly collateral by allowing to use it for part of the population based on repayment history. When the cost of adverse selection is very low compared to the liquidation costs entailed by collateral requirements, no collateral will be required under either regime; when the liquidation costs are very low, then collateral will be required under both regimes. However, in the intermediate case, collateral requirements will be observed under information sharing, but not in its absence.

4.3. Endogenous information sharing

So far we have taken the information sharing regime as given. In many countries, the existence of credit registries is the result of decisions made by governments and/or central banks, and thus at least to some extent exogenous to commercial bank decisions. However, we also frequently observe voluntary information sharing, and it may be interesting to see when banks choose to do that given the potential for collateral requirements.

Theorem 9. *If adverse selection is very low (*$\frac{r_0(1-\lambda)}{\lambda} < \frac{(1-p)^2 l}{9S}(2S-(1-p)l)$*), then banks are indifferent between the two information sharing regimes if defaulting borrowers are creditworthy, and do not share information if they are not. If adverse selection is very high (*$\frac{r_0(1-\lambda)}{\lambda} > \frac{(1-p)l}{9S}(2S-(1-p)l)$*), then banks prefer to share information provided that switching costs are high enough (*$S > \frac{(1-p)l}{2}$*). In the intermediate case (*$\frac{(1-p)l}{9S}(2S-(1-p)l) > \frac{r_0(1-\lambda)}{\lambda} > \frac{(1-p)^2 l}{9S}(2S-(1-p)l)$*), banks prefer to share information.*

Proof. We get the decision rules by comparing intertemporal profits.

Intuitively, when adverse selection issues are low and defaulting borrowers are creditworthy, banks will not try to separate borrowers, and they will have the same profits under both regimes. This is because under both information regimes they try to poach among all first-period borrowers of the competing banks without requiring collateral. If defaulting borrowers are not creditworthy, then under information sharing banks do not try to attract their competitors' defaulting borrowers, and given relatively low adverse selection this is worse than not sharing information and bidding for the entire pool of borrowers.

When adverse selection issues are important and liquidation costs are low, banks will choose to use collateral under both regimes. Profits will be higher in that case under information sharing if it is difficult for borrowers to switch, since increased switching by successful borrowers may otherwise reduce bank profits. Finally, in the intermediate case, banks will prefer information sharing and require collateral only from defaulting borrowers.

As in Gehrig and Stenbacka Gehrig and Stenbacka [24], if we have more than two banks and there is competition for poaching the other banks' first-period borrowers, information sharing becomes an issue of indifference. However, it can be shown that our main result - a higher incidence of collateral under information sharing - survives in that case.

4.4. Welfare

We have seen in the previous subsection that under moderate adverse selection, the use of collateral will be observed under information sharing, but not in the absence of a credit bureau. Moreover, if banks are the ones making the choice about sharing information, they will prefer to do so, since that brings them higher profits. We can check whether this choice is associated with higher or lower overall welfare, and see how the surplus is shared between banks and borrowers.

Theorem 10. 1. *In the presence of moderate adverse selection ($\frac{(1-p)l}{9S}(2S-(1-p)l) > \frac{r_0(1-\lambda)}{\lambda} > \frac{(1-p)^2 l}{9S}(2S-(1-p)l)$), welfare is higher under information sharing (when collateral is required), then in its absence (when collateral is not required).*

2. *In the presence of moderate adverse selection ($\frac{(1-p)l}{9S}(2S-(1-p)l) > \frac{r_0(1-\lambda)}{\lambda} > \frac{(1-p)^2 l}{9S}(2S-(1-p)l)$), the surplus of high-type borrowers is higher under information sharing than in its absence if $\frac{c}{S} < \frac{3-8L}{(1-p)(8-6L)}$.*

Although information sharing increases welfare in this case (and will be preferred by banks if they have the possibility to choose), creditworthy borrowers are not necessarily better off. This is more likely if switching costs are higher, liquidation costs are lower, and the private benefits of low-type borrowers are lower. The less favorable conditions for high-quality borrowers can be seen as a disadvantage per se; moreover, it indicates that marginally worthwhile projects may be abandoned as a result of frictions such as the liquidation cost of collateral[5].

[5] Total bank profits will of course be zero over the two periods. However, in the second period, the collateral-based contract will be preferred under information sharing. The proof is available upon request.

5. Conclusion

Banks have several alternative instruments that can be used to reduce adverse selection costs. We examine two such devices in our paper: collateral and information sharing. While both serve the basic purpose of selecting borrowers, we show that they may be complements rather than substitutes: information sharing makes it more likely that collateral is required from borrowers with poor credit histories.

Given the cost of pledging collateral, and indeed its unavailability to many borrowers, our result points to a potential downside of information sharing. This can be therefore added to the list on which we already have the high initial interest rates (Gehrig and Stenbacka [24]) and the potential for "excessive" memory (Vercammen [46]).

Our finding about the high use of collateral can be related to the results in Manove, Padilla and Pagano [36], where they show that if the average quality of a borrower pool is too low collateral may replace screening. We believe the interaction between borrower selection mechanisms is a promising area for future research.

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6. Appendix

Proof of lemma 1

Consider the segment of borrowers that borrowed from bank i ($i = A, B$)in period 1. This population has a mass of μ_i.

Suppose first that the outside bank j does not use collateral. The inside bank chooses an interest rate r_2^i for its (high-type) borrowers, and the outside bank chooses an interest rate i_2^j for the inside bank's first-period customers. High-type borrowers with relatively low switching costs ($s^* < pr_2^i - pi_2^j$) will switch to the outside bank. Low-type borrowers will also switch to the outside bank, since the outside bank has no information that would allow it to reject them.

The inside bank will choose its interest rate to maximize its profits on first-period borrowers:

$$\max_{r_2^i} \mu_i \lambda (pr_2^i - r_0) \frac{1}{S} \int_{s^*}^{S} ds$$

The outside interest rate i_2^j will be chosen to maximize profits on poached borrowers:

$$\max_{i_2^j} \mu_i \lambda (pi_2^j - r_0) \frac{1}{S} \int_0^{pr_2^i - pi_2^j} ds - r_o \mu_i (1 - \lambda).$$

The first-order conditions are:

$$r_2^i = \frac{pi_2^j + r_0 + S}{2p}$$
$$i_2^j = \frac{pr_2^i + r_0}{2p}$$

Solving, we get $r_2^i = \frac{3r_0 + 2S}{3p}$ and $i_2^j = \frac{3r_0 + S}{3p}$.

Suppose next that the outside bank decides to require collateral. In that case it will lend at the interest rate i_2^j to high-type borrowers with low switching costs ($s < s^* = pr_2^i - pi_2^j - c_2^j$), and will receive the value of the collateral pledged by those borrowers, net of liquidation costs, in case of failure:

$$\mu_i \lambda (pi_2^j + (1 - p)c_2^j - r_0 - (1 - p)l) \frac{1}{S} \int_0^{pr_2^i - pi_2^j - (1-p)c_2^j} ds$$

Borrowers will be required to pledge an amount of collateral equal to their private benefit c. This is the minimal amount that allows the separation of high- and low-type borrowers; the banks will not require more than that given the cost of liquidating collateral. By assumption, borrowers have the required collateral (their assets in place C are higher than c).

The incumbent bank lends at the interest rate r_2^i to high-type borrowers with high switching costs, and gets profits equal to $\mu_i \lambda (pr_2^i - r_0) \frac{1}{S} \int_{pr_2^i - pi_2^j - (1-p)c_2^j}^{S} ds$.

The first-order conditions are:

$$r_2^i = \frac{pi_2^j + (1-p)c_2^j + r_0 + S}{2p}$$
$$i_2^j = \frac{pr_2^i - 2(1-p)c_2^j + (1-p)l + r_0}{2p}$$

Solving, we get $r_2^i = \frac{3r_0+2S+(1-p)l}{3p}$ and $i_2^j = \frac{3r_0+S+2(1-p)l-3(1-p)c}{3p}$.

Proof of Proposition 2

If collateral is not used for poaching, then total second-period profits for bank i are equal to:

$$\Pi_2 = \mu_i \lambda (pr_2^i - r_0)\frac{1}{S}\int_{s^*}^{S} ds + \mu_j \lambda (pi_2^i - r_0)\frac{1}{S}\int_0^{pr_2^j - pi_2^i} ds - r_o \mu_j (1-\lambda).$$

Using the expressions for equilibrium interest rates derived in the previous lemma, we get that the second-period profits can be written as:

$$\Pi_2 = \mu_i \lambda \frac{4}{9} S + (1-\mu_i)\big(\lambda \frac{1}{9} S - (1-\lambda) r_0\big).$$

If collateral is required from borrowers that want to switch to the outside bank, then second-period profits are given by:

$$\Pi_2 = \mu_i \lambda (pr_2^i - r_0)\frac{1}{S}\int_{s^*}^{S} ds + \mu_j \lambda (pi_2^i + (1-p)c_2^i - r_0)\frac{1}{S}\int_0^{pr_2^j - pi_2^i} ds.$$

Using the expressions for equilibrium interest rates derived in the previous lemma, we get that the second-period profits can be written as:

$$\Pi_2 = \mu_i \lambda \frac{1}{9S}\big(2S + (1-p)l\big)^2 + (1-\mu_i)\lambda \frac{1}{9}\big(S - (1-p)l\big)^2.$$

Proof of Proposition 4

The intertemporal profits are given by the sum of the profits over two periods: $\Pi_i = \Pi_i^1 + \Pi_i^2$, where $\Pi_i^1 = \mu_i(\lambda p r_1^i - r_0)$ and the equilibrium second-period profits are characterized above. These total profits are linear in the market share μ_i and are expressed (for instance in the case where collateral required in the second period) by

$$\mu_i\Big(\lambda p r_1^i - r_0 + \lambda \tfrac{4}{9S}\big(S + (1-p)l\big)^2 - \lambda \tfrac{1}{9}\big(S - (1-p)l\big)^2\Big) + \lambda \tfrac{1}{9}\big(S - (1-p)l\big)^2$$

The first term in brackets expresses profits resulting from the market share of that bank i acquires in period 1. If those profits are positive, the other bank can charge a slightly lower first-period interest rate r_1 and take over the entire market. Therefore initial competition will drive these profits to zero, so that for instance $r_1^i = \frac{1}{\lambda p}\Big(r_0 - \lambda \frac{4}{9S}\big(S + (1-p)l\big)^2 - \lambda \frac{1}{9}\big(S - (1-p)l\big)^2\Big)$ when collateral is used in the second period.

Proof of Proposition 6

Suppose first that the outside bank j does not use collateral. In that case, it does not lend to defaulting borrowers and chooses an interest rate $i^j_{2,N}$ to maximize its second-period profits from successful, switching borrowers $\lambda p \mu_i (p i^j_{2,N} - r_0) \frac{1}{S} \int_0^{s^*_N}$, where $s^*_N = p r^i_{2,N} - p i^j_{2,N}$. The inside bank i will charge the maximal rate R for loans to high-type, defaulting borrowers, and will choose an interest rate for defaulting borrowers $r^i_{2,N}$ to maximize its profits on successful borrowers $\lambda p \mu_i (p r^i_{2,N} - r_0) \frac{1}{S} \int_{s^*_N}^{S}$. Solving the two profit maximization problems, we get $r^i_{2,N} = \frac{3r_0 + 2S}{3p}$ and $i^j_{2,N} = \frac{3r_0 + S}{3p}$, with a marginal switching cost $s^*_N = \frac{S}{3}$. Entering these interest rates in the expressions for inside and outside profits we get the total second-period profits.

Next, if the outside bank uses collateral to select switching, defaulting borrowers, it will choose an interest rate $i^j_{2,D}$ and collateral to maximize profits on those borrowers $\lambda(1-p)(1-\mu_i)(p i^j_{2,D} + (1-p)c^j_2(1-l) - r_0) \frac{1}{S} \int_0^{s^*_D} ds$, where $s^*_D = p r^i_{2,D} - p i^j_{2,D} - (1-p)c^j_2$. It will also choose an interest rate $i^j_{2,N}$ to maximize profits on successful switching borrowers as shown above. The inside bank will choose an interest rate $r^i_{2,D}$ to maximize its profits on high-type, defaulting borrowers $\lambda(1-p)\mu_i(pR - r_0) \frac{1}{S} \int_{s^*_D}^{S}$, and an interest rate $r^i_{2,N}$ to maximize profits on successful borrowers, as above. Solving, we get that $i^j_{2,D} = \frac{3r_0 + S - (1-p)(3c - 2l)}{3p}$ and $r^i_{2,D} = \frac{3r_0 + 2S + (1-p)l}{3p}$, with $s^*_D = \frac{S}{3} + (1-p)c - \frac{1}{3}(1-p)l$. Entering these interest rates in the expressions for inside and outside profits we get the total second-period profits.

The first-period interest rate r_1 will set the two-period profits from acquiring a market share μ_i to zero. If collateral is not used for poaching in the second period, we have that $\mu_i \Big(\lambda p r_1 - r_0 + \lambda p \frac{S}{3} + \lambda(1-p)(pR - r_0) \Big) = 0$, thus the first-period interest rate is $r_1 = \frac{1}{\lambda p} \Big(r_0 - \frac{\lambda p S}{3} - \lambda(1-p)(pR - r_0) \Big)$. If collateral is used, $\mu_i \Big(\lambda p r_1 - r_0 + \frac{1}{3}\lambda p S + \frac{\lambda(1-p)}{9S}(2S + (1-p)l)^2 - \frac{\lambda(1-p)}{9S}(S - (1-p)l)^2 \Big) = 0$, therefore $r_1 = \frac{1}{\lambda p} \Big(r_0 - \frac{\lambda S}{3} - \frac{2\lambda(1-p)^2 l}{3} \Big)$.

Proof of proposition 7

If defaulting borrowers are creditworthy, they will receive a loan from the outside bank even in the absence of collateral. In that case, the inside bank i chooses an interest rate $r^i_{2,N}$ to maximize profits from lending to successful borrowers $\lambda p \mu_i (p r^i_{2,N} - r_0) \frac{1}{S} \int_{s^*_N}^{S}$, and an interest rate $r^i_{2,D}$ to maximize its profits accruing from loans to defaulting high-type borrowers $\lambda(1-p)\mu_i(p r^i_{2,D}) \frac{1}{S} \int_{s^*_D}^{S}$. The outside bank chooses an interest rate $i^j_{2,N}$ to maximize profits from switching successful borrowers $\lambda p \mu_i (p i^j_{2,N} - r_0) \frac{1}{S} \int_0^{s^*_N} ds$ and a rate $i^j_{2,D}$ to maximize profits on switching defaulting borrowers $\lambda(1-p)\mu_i(p i^j_{2,S} - r_0) \frac{1}{S} \int_0^{s^*_D} - (1-\lambda) r_0$. The cutoff switching costs are $s^*_N = p r^i_{2,N} - p i^j_{2,N}$ and $s^*_D = p r^i_{2,D} - p i^j_{2,D}$ respectively. Solving, we get $r^i_{2,N} = r^i_{2,D} = \frac{3r_0 + 2S}{3p}$ and $i^j_{2,N} = i^j_{2,D} = \frac{3r_0 + S}{3p}$. Using these expressions we get the second-period profits stated in the proposition. The first-period interest rate r_1 can be calculated as in the proof of Proposition 6.Intertemporal profits are therefore $\frac{\lambda S}{9} - (1-\lambda) r_0$.

When collateral is used, then expression for bank profits will be the same as in the case where defaulting borrowers are not creditworthy.

Proof of proposition 10

If $\frac{(1-p)l}{9S}(2S-(1-p)l) > \frac{r_0(1-\lambda)}{\lambda} > \frac{(1-p)^2 l}{9S}(2S-(1-p)l)$, collateral will be required under information sharing and it would not be required under information sharing.

Under information sharing, overall welfare is

$$W = \lambda(pR - r_0) - \lambda(1-p)\frac{\frac{S-2(1-p)l}{3}}{S}l - \frac{\lambda(1-p)}{S}\int_0^{\frac{S-2(1-p)l}{3}} sds - \frac{\lambda p}{S}\int_0^{\frac{S}{3}} sds,$$

that is, the surplus generated by lending to high-type borrowers, less the liquidation costs if collateral in case of default, less the switching costs of high-type borrowers.

Without information sharing, overall welfare is

$$W = \lambda(pR - r_0) - (1-\lambda)r_0 - \frac{\lambda}{S}\int_0^{\frac{S}{3}} sds - \frac{(1-\lambda)}{S}\int_0^{S} sdS,$$

that is, the surplus generated by lending to high-type borrowers, less losses from lending to low-type borrowers, less the switching costs of both high- and low-type borrowers.

Welfare is higher under information sharing if

$$\frac{1-\lambda}{\lambda}r_0 > (1-p)\frac{(2S(1-p)l - (1-p)^2 l^2}{9S} - \frac{(1-p)^2 l(S+3(1-p)l)}{9S} - (1-\lambda)\frac{S}{2}.$$

This is a weaker condition than the condition for this case:

$$\frac{1-\lambda}{\lambda}r_0 > (1-p)\frac{(2S(1-p)l - (1-p)^2 l^2}{9S},$$

therefore welfare is always higher under information sharing.

In the same case, when collateral is required under information sharing and not without information sharing, we have a higher surplus for high-type borrowers under information sharing if

$$\begin{aligned}
&\frac{2}{3}p^2\Big(R - \frac{3r_0+2S}{3p}\Big) + \frac{1}{3}p^2\Big(R - \frac{3r_0+S}{3p}\Big) - p\frac{S}{18} + p(1-p)\Big(R - \frac{3r_0+2S+(1-p)l}{3p}\Big)\frac{S - \frac{S-2(1-p)l}{3}}{S}\\
&+ p(1-p)\Big(R - \frac{3r_0+S+2(1-p)l-3(1-p)c}{3p}\Big)\frac{S-2(1-p)l}{3S}\\
&- (1-p)\frac{(s-2(1-p)l)^2}{18S} - (1-p)^2 l\frac{s-2(1-p)l}{3S}\\
&> \frac{2}{3}p\Big(R - \frac{3r_0+2S}{3p}\Big) + \frac{1}{3}p\Big(R - \frac{3r_0+S}{3p}\Big) - \frac{S}{18}.
\end{aligned}$$

This condition can be rewritten as

$$\frac{c}{S} < \frac{3-8L}{(1-p)(8-6L)}.$$