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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 reduce adverse selection costs, but are costly for lenders. When a bank learns more about the types of its rival's borrowers through information sharing (e.g., credit bureaus), it might seem that this information should substitute the role of collateral in screening their types. We instead show that information sharing may increase, rather than decrease, the role of collateral, which can be required in loans to high-risk borrowers in cases when it is not in the absence of information sharing. We extend to show that ex ante screening can substitute both collateral and information sharing.

Keywords: Bank competition, information sharing, collateral

JEL classification numbers: G21, L13

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1 Introduction

It has for long been recognized that financial intermediaries play a key role in borrower screening, production of information and alleviation of adverse selection. Information provides competitive advantage and acts as an important source of bank profits by allowing for more accurate credit decision. In the meantime, banks can use collateral in debt contracts to overcome information asymmetries, in particular arising from ex-ante adverse selection (Berger et al. 2011, Bester, 1985; Besanko and Thakor 1987). To the extent that both information and collateral address to reduce adverse selection between borrowers and lenders, it is interesting to study the interaction between the two.

The production and availability of information have been significantly affected in the banking industry, where the entry of credit bureaus and credit registers has allowed for exchange of lenders' databases on their borrowers' repayment history, and thus reduced informational asymmetries (Djankov et al. 2007, Miller 2003). Both public registers and private credit bureaus provide information about credit histories by consolidating the information available to member institutions. In a survey of Latin American banks Miller (2003) 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). While collateral still remains important in granting loans, most bank managers consider payment history as the number one important factor in credit decisions (Miller, 2003). When collateral is costly for the bank (e.g., liquidation costs) and more is known about borrower's type, competing banks may prefer to reduce collateral requirements (and rather increase interest rates): therefore, it is natural to think that the role of collateral as a device to screen high and low type borrowers is reduced as sharing information on borrowers may substitute for that role.

In this paper we study whether information sharing reduces use of collateral and show instead that information sharing may give rise to collateral requirements. We build on a location model reminiscent of Gehrig and Stenbacka(2007), with two banks competing for borrowers across two periods. Banks compete by choosing interest rates and collateral to screen entrepreneurs' riskiness. Similar to Bester (1995), banks decide upon the rate of interest and the collateral of their credit offers simultaneously rather than separately. The model therefore allows to use different contracts as a self-selection mechanism. Contrary to first intuition, we show that collateral may in fact complement information sharing and arise as an optimal covenant of loan contracts in cases when it does not in the absence of information sharing. The intuition of this result is as follows: if the borrower type is unknown, collateral can be beneficial allowing for self-selection between the two types of risks. However, because collateral has liquidation costs, banks may prefer not to impose collateral whenever they know borrower type and the project they undertake. [1] Therefore, borrowers switching to an outside bank (offering credit first time) may as well not be required to pledge collateral if it is too costly, i.e. liquidation costs from requiring collateral from switching borrowers surpass adverse selection costs of loans to high-risk switching borrowers. Nevertheless, in the presence of information sharing, previous repayment history may reveal type-specific information to the outside bank, and the latter can restrict its collateral requirements to only high-risk. Thus by allowing to fine-tune collateral requirements to subsets of borrowers and reducing total liquidation costs, lenders may require collateral (from the high-risk subset of the population) along with information sharing, while it is not required in the absence of it. Under parameter values where liquidation costs from collateralized loans to all switching borrowers are lower than adverse selection costs, collateral will be required in the absence of information sharing. In this case, collateral requirements will shrink to only high-risk borrowers under information sharing.

The use of collateral in debt contracts is costly for both lenders and borrowers. Lenders incur costs of monitoring the pledged assets, liquidation and disposal expenses. More importantly,

[1] This is because any bank can increase its expected rents by decreasing collateral and increasing interest rate leaving the borrower as better off.

borrowers' credit availability may change along with the value of the pledged assets. When this value is correlated across borrowers, this can amplify the procyclicality in access to credit.

Given the costly nature of collateral, we look how its role changes when information sharing is introduced. In our model past repayment history will reduce total liquidation costs of collateral, since banks can target the subset of borrowers with bad repayment history. This is consistent with the evidence on positive relationship between collateral and past repayment (Chakraborty and Hu (2006), Jimenez et al. (2006)). Collateral as a self selection mechanism was studied in Bester (1985). The paper assumes that banks decide upon the rate of interest and the collateral of their credit offers simultaneously rather than separately. Therefore, it becomes possible to use different contracts as a self-selection mechanism. It is shown that investors with a low probability of bankruptcy are more inclined to accept an increase in collateral requirements for a certain reduction in the rate of interest than those with a high probability of failure.[2]The same screening feature is present in our paper, and we show how it changes when lenders exchange information.

The role of other self-selection mechanisms has been widely studied. It has been shown that these mechanisms will improve credit allocation and decrease costs of lending. Webb (1992) considers a setting in which lenders sequentially invest in two projects with reporting of cash flows and costly auditing in each period. If the terms of loan contract in the second period is conditional on first period cash flow, ex-post auditing can be reduced as truth telling increases in the first period, and the long term lending will dominate short-term lending because of lower expected auditing costs. We instead concentrate on ex-ante adverse selection and show that if second period contracts are dependent on first period repayment, adverse selection is mitigated via collateral requirements. Finally, unlike these papers, we model both collateral and information sharing, and to the best of our knowledge this is the first attempt to look at the interaction of

[2]There is recent evidence supporting the negative relationship between collateral and interest rates (Cerqueiro et al. 2012). Such relationship is consistent with ex-ante models of collateral, where it is used for unknown borrower population (Berger et al. 2011)

the two.

Our paper adds to the literature on information sharing. Extant work has provided several mechanisms showing how information sharing promotes credit market efficiency with benefits for the whole economy. The existence of credit bureaus has been shown to decrease adverse selection (Jappelli and Pagano (1993)) and induce higher effort from borrowers (Padilla and Pagano (1997) and Padilla and Pagano (2000)). At the same time, information sharing may be used to reduce competition between banks (Gehrig and Stenbacka (2007)). The establishment of information sharing arrangements is more likely if borrower mobility is higher (Jappelli and Pagano (1993)), and if asymmetric information problems are more important (Brown and Zehnder (2010)). Empirically, information sharing is associated with better access to credit (Jappelli and Pagano (1993)), especially in developing countries with bad creditor rights (Djankov et al. (2007), Brown et al. (2009)), but lower lending to low-quality borrowers (Hertzberg et al. (2011)). The closest paper on information sharing is Gehrig and Stenbacka (2007). Looking at its dark side, they show that information sharing reduces the returns from establishing banking relationships, and thus weakens competition for the formation of banking relationships. Thus they show that the institution of information sharing is a mechanism for redistribution of surplus from talented entrepreneurs to banks and that the implied anti-competitive effects reduce the social returns of information sharing.To the best of our knowledge, we are the first to look at the interaction between collateral and information sharing.

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 two period banking 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 in both periods. In each period they offer a one period contract.

Borrowers require one unit of capital to start a project, which they borrow from one of the banks since they have no funding of their own. There are two types of borrowers, high and low type ones. $H-$type borrowers have access to a project that returns a verifiable amount R with probability p and 0 otherwise. $L-$type borrowers have a 0 probability of success, but they derive a non-verifiable amount of utility from the business equal to c.In addition, borrowers have assets in place of amount $C > c$, that can be pledged as collateral. Before lending in the first period, banks and borrowers have no information about any of the borrowers' types. The proportion of $H-$type ($L-$type) borrowers is λ $(1-\lambda)$ and is common knowledge. Banks learn the true types of their borrowers at the end of the first period (after the repayment).[3]This information is private and relationship-specific and cannot be communicated credibly to the other bank. By end of period one banks also observe borrowers' repayment history which can be shared with the competitor bank under an information sharing arrangement[4]

During second period competition each bank j announces contracts including collateral and two interest rates, (r_2^j, i_2^j, c_2^j) for its existing H-type borrowers that patronized the bank in period $1(r_2^j)$, and for new borrowers that switched from the competitor bank to bank j (i_2^j), respectively. When a borrower switches to the outside bank, the type information the incumbent has accumulated is lost. For the poaching bank the only way to recover information on the borrower and

[3]This learning captures the feature of the relationship bank whereby the (incumbent) bank has the expertise to evaluate the borrowers' abilities and their projects. We assume that this learning is perfect. See Sharpe (1990), Gehrig and Stenbacka (2007).

[4]Gehrig and Stenbacka (2007) 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 (2004) for a detailed discussion on hard and soft information.

learn borrowers' types is to impose collateral as a screening device; when high type borrowers have higher expected cash flow than low type borrowers, there exists a level of collateral that creates incentives for truth telling by low type (i.e., it is not incentive compatible for the low type). We assume high type borrowers have higher expected gains, than low type borrowers, i.e., $c < p(R - i_2) - S$, so that an outside bank offering a contract with collateral c will screen out low type borrowers.[5] Furthermore, collateral has liquidation cost l, so that inside banks will never want to require positive collateral from high type borrowers (and will not offer credit to low type ones). This is because the expected gains from captive high type borrowers with a contract $(r_2, c_2 = c)$ is equal to $pr_2 + (1-p)c - (1-p)l$ and can be raised to $pr_2 + (1-p)c$ with a contract $(r_2 + \frac{1-p}{p}, 0)$. Since collateral amount c is enough to screen borrower type, it is also clear that the poaching outside bank will never impose a higher collateral. For the same reason, since borrowers do not know their type, banks will never require collateral in the first period.

When borrowers switch, they may suffer costs due to the cessation of the relationship with the incumbent. Costs of switching between banks may be incurred since borrowers typically face inconveniences and lose some relationship benefits if they change their credit supplier. Following Gehrig and Stanbacka (2007), we model this as an idiosyncratic 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 (2007) argue, switching costs can vary largely across customers (see Shy 2001, 2002, Kim et al 2003, Stango 2002). The switching are private information of the borrowers and are revealed to the borrower at the beginning of period 2. As argued by , borrowers themselves may not be well aware of the inconveniences of switching until they do so. Thus the initial choice of bank is independent of the switching cost (Gehrig and Stenbacka, 2007). As in Sharpe (1990), Padilla and Pagano (2000), Gehrig and Stenbacka (2007),

[5]More precisely, we assume the high type borrower with the highest switching cost has still higher expected payoff than the low type borrower with the lowest, null switching cost.

we assume that successful borrowers will consume their period 1 revenues at the end of period 1. In sum, lenders announce interest rates in period one for a risky borrower population. At stage two each bank announces an interest rate and collateral pair for its own period one customers, and for its rival's customers, respectively.

3 No Information sharing

3.1 The game and timing

We derive the subgame perfect Nash Equilibrium via backward induction. Let $0 \leq \mu_i \leq 1$ denote the market share of bank j , $j = A, B$, acquired in the first period. The incumbent bank acquires informational monopoly over its first period borrowers by learning their true types, while the outside bank does not learn about the type type, but observes the repayment history under only information sharing. The expected return from lending to H-type borrower is equal to $pr_2^i - r_0$ for the incumbent bank. During the second period outside banks may also require collateral (c_2^j) to screen untalented borrowers: collateral has liquidation cost share l. Talented borrower b may switch from bank A to B if switching cost $s_b \in [0, S]$ and poaching rate i_2^B are low enough: $pi_2^B + (1-p)c_2^B + s_b < pr_2^A$. Marginal borrower's switching is $s^* = pr_2^A - pi_2^B - (1-p)c_2^B$. For the outside bank

Timeline

First period.

1.Banks decide whther or not shar default informaiton

2.Banks offer interest rates and borrowers choose a bank to borrow. They repay if they can.

Second period:

1.Banks share default information if they decided to do so

2.Banks announce interest rates (incumbency and poaching) and collateral. Borrowers may switch banks if they are better off

3.Borrowers repay whenever they can. Pledged collateral is seized if the borrower defaults

The timeline is illustrated in figure 1.

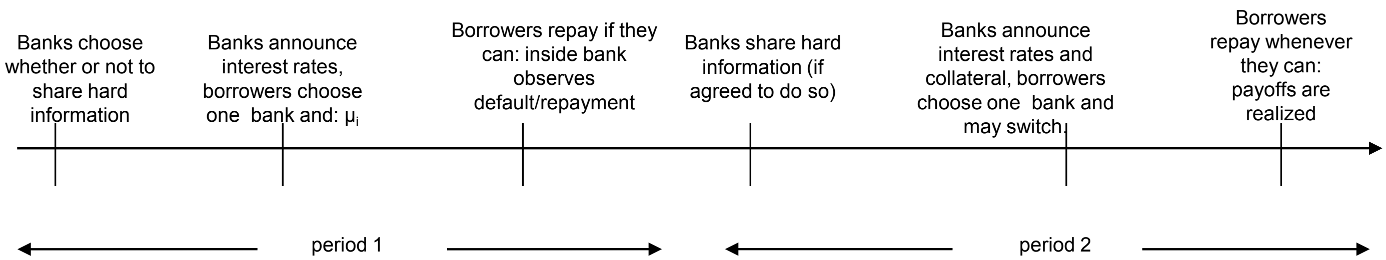

Figure 1: Timeline of the game

3.2 Equilibrium in period 2.

Under no information sharing the poaching bank has no type-specific information and no information on previous repayment history. However, the poaching bank can still use collateral to screen high type borrowers from low type ones. Because collateral is costly, the incumbent bank, however, will never use collateral as it has liquidation costs. The incumbent bank's second period profits under no information sharing are given by

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

where $s^* = pr_2^A - pi_2^B - (1-p)c_2^B$ is the switching cost of the marginal borrower. Assuming that the private benefit is higher than the maximal cost of switching, low type borrowers will always want to switch. If bank B tries to poach without collateral, then its poaching profits are given by:

$$\mu_A\lambda(pi_2^B - r_0)\frac{1}{S}\int_0^{pr_2^A - pi_2^B - (1-p)c_2^B} ds - r_o\mu_A(1-\lambda)$$

The first term in equation represents the profits earned on the high type entrepreneurs successfully poached from rival bank B. The last term represents the adverse selection caused by extending credit to all low type borrowers in the pool of poached customers. Bank B cannot separate these low type borrowers from the high type ones without collateral. These borrowers will, however not borrow, if the poaching bank imposes collateral. In the latter case its profits are given by:

$$\mu_A\lambda(pi_2^B + (1-p)c_2^B - r_0 - (1-p)l)\frac{1}{S}\int_0^{pr_2^A - pi_2^B - (1-p)c_2^B} ds$$

where $Lc \equiv l$ represents the liquidation cost of collateral. Thus, in the absence of information sharing the total profits of bank A in second period from its first period market and from poached borrowers is equal to

$$\Pi_2^A = \mu_A\lambda(pr_2^A - r_0)\frac{1}{S}\int_{pr_2^A - pi_2^B - (1-p)c_2^B}^{S} ds + (1-\mu_A)\lambda(pi_2^A - r_0)\frac{1}{S}\int_0^{pr_2^A - pi_2^B - (1-p)c_2^B} ds - r_o(1-\mu_A)(1-\lambda)$$

without collateral, and

$$\Pi_2^{A,c} = \mu_A\lambda(pr_2^A - r_0)\frac{1}{S}\int_{pr_2^A - pi_2^B - (1-p)c_2^B}^{S} ds + (1-\mu_A)\lambda(pi_2^A + (1-p)c_2^A(1-L) - r_0)\frac{1}{S}\int_0^{pr_2^A - pi_2^B - (1-p)c_2^B} ds$$

with collateral.

Lemma 3.1 *Conditional on collateral, the equilibrium interest rate of the incumbent and poaching banks are given by* $\frac{1}{3p}\big(2S + 3r_0 + (1-p)l\ \big)$ *and* $\frac{1}{3p}\big(S + 3r_0 + (1-p)(2l - 3c)\big)$*, respectively. Without collateral, the interest rates are given by* $\frac{1}{3p}\big(2S + 3r_0\big)$ *and* $\frac{1}{3p}\big(S + 3r_0\big)$*.*

Thus, whenever $S > (1-p)l$ (i.e., $r_2^A > pi_2^B + (1-p)c$), there is positive switching under contracts with collateral. In what follows we will assume that this relationship holds.

Proposition 3.2 *Profits under the contract with collateral and without are given by, respectively,* $\Pi_2^{A,c} = \mu_A\lambda\frac{4}{9S}\big(S + (1-p)l\big)^2 + (1-\mu_A)\lambda\frac{1}{9}\big(S - (1-p)l\big)^2$*, and* $\Pi_2^A = \mu_A\lambda\frac{4}{9}S + (1-\mu_A)\big(\lambda\frac{1}{9}S - (1-\lambda)r_0\big)$

Proof. See Appendix.

It can be seen from the proposition that banks' poaching profits can be lower when poaching is achieved with collateral. This is because poaching becomes more costly for the borrower (due to expected liquidiation costs) and therefore the incumbent bank can afoord a higher incumbency rate.

3.3 Equilibrium in period 1.

In period one banks compete in prices under symmetric information for borrowers in the overall population. The information is symmetric since banks have not yet learnt borrowers' types nor their repayment history. The competition in period one maximizes banks' intertemporal profits over the two periods. These intertemporal profits are given by the sum of the profits over two periods, assuming the discount factor is 1: $\Pi^A = \Pi_1^A + \Pi_2^A$, where $\Pi_1^A = \mu_A(\lambda p r_1^A - r_0)$ and the equilibrium second period profits are characterized above. Since bororwers donot know their type in the first period, collateal is too costly to use, so that $\Pi^{A,c} = \Pi_1^A + \Pi_2^{A,c}$.

Proposition 3.3 *In the subgame perfect equilibrium first period interest rates are given by* $r_1^{A,c} = \frac{1}{\lambda p}\Big(r_0 - \lambda \frac{4}{9S}\big(S + (1-p)l\big)^2 + \lambda \frac{1}{9}\big(S - (1-p)l\big)^2\Big)$ *for loans with collateral in the second period and* $r_1^A = \frac{1}{\lambda p}\Big(r_0 - \big(\lambda \frac{S}{3} + (1-\lambda)r_0\big)\Big)$.

Proof. See Appendix.

Proposition 3.4 *Banks' intertemporal total profits are given by* $\lambda \frac{1}{9}\big(S - (1-p)l\big)^2$.

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

Thus due to the existing of the switching costs, bank are always able to secure positive intertemporal rents with collateral, as long as liquidation costs arenot too high. While all profits coming from incumbency market in the second period are dissipated in the first period competition for first period customers, positive profit are secured due to the existence of the poached customers

Proposition 3.5 *In the absence of information sharing banks will prefer not to impose collateral whenever cost of adverse selection is not high enough:* $\frac{2S(1-p)l-(1-p)^2l^2}{9S} > \frac{r_0(1-\lambda)}{\lambda}$.

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

Intuitively, if the adverse selection costs from low type population are lower than the total expected liquidation costs of collateral requirements from all borrowers, 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.

4 Information Sharing

In the presence of information sharing lenders commit to share the default information with their rivals. We assume that both lenders commit to exchange this information. As a result, rival banks can use switching customers' previous repayment history in their lending decisions. While previous repayment history does not reveal all information about borrowers' types, it still may assist the bank get a better picture about the population quality of the switching borrowers. In particular, while defaulting borrowers are not necessarily low type (since high type borrowers can also default due to bad luck), successful borrowers are always high type, and as argued above the rival bank will not find it optimal to impose collateral on the successful borrowers. Thus, the rival bank will only want to impose collateral on defaulting borrowers. As a result, information sharing allows, first, to reduce adverse selection costs because defaulting borrowers on average are not creditworthy and hence the bank will not want to extend credit to them.

The expression for incumbency profits remains unchanged. The profits on poached customers without collateral are given by

$$p\mu_A\lambda(pi_2^A - r_0)\frac{1}{S}\int_0^{s^*} ds$$

These represent expected profits earned on customers who have succeeded.[6]. It differs from the respective expression in the absence of information sharing in two ways: the adverse selection

[6] We assume for the moment that default rules out all defaulting customers from the market. In other words, default information is informative enough, and returns from defaulting but high type borrowers are outweighed by the losses from defaulting and low type borrowers. We relax this assumption in the next section.

cost is absent, and the proportion of creditworthy borrowers is now reduced (by a factor of p). This actually changes whenever collateral is imposed, however. Because low type borrowers prefer not to borrower, banks will also lend to defaulting borrowers and will get only the high type borrowers from the defaulting population. Thus, poaching profits earned on contracts with collateral are given by

$$p\mu_A\lambda(pr_2^A - r_0)\frac{1}{S}\int_0^{s^*} ds+$$
$$(1-\mu_A)(pi_2^A + (1-p)c_2^A(1-l) - r_0)\frac{\lambda(1-p)}{(1-p)\lambda+1-\lambda}(1-\lambda p)\frac{1}{S}\int_0^{s^*} ds$$

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.

Proposition 4.1 *Profits under the contract with collateral and without are given by, respectively,* $\Pi = \mu_A\lambda\frac{4}{9}S + (1-\mu_A)\big(p\lambda\frac{1}{9S}\big(S-(1-p)l\big)^2 + (1-p)\lambda\frac{1}{9S}\big(S-(1-p)l\big)^2$, *and* $\Pi = \mu_A\lambda\frac{4}{9}S + p(1-\mu_A)\big(\lambda\frac{1}{9}S\big)$. *Period 1 interest rates are given by* $r_1^{A,c} = \frac{1}{\lambda p}\Big(r_0 - \lambda\frac{4}{9S}\big(S+(1-p)l\big)^2 + \lambda\frac{1}{9}\big(pS + (1-p)\big(S-(1-p)l\big)^2\big)\Big)$ *and* $r_1^A = \frac{1}{\lambda p}\big(r_0 - \lambda\frac{S}{3}\big)$, *respectively.*

Proof. See Appendix.

By comparing the two profits under information sharing one can see that banks will always prefer to put collateral in the presence of information sharing. Nevertheless, this was not the case in the absence of information sharing. The reason is that in the former 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, costs of collateral are reduced by imposing it only on the high risk population, i.e. on defaulting borrowers, allowing to extend credit to some of them thereby reducing type 2 error under and increasing credit level under information sharing. Thus, rather than substituting, collateral may complement the role of information sharing.

Proposition 4.2 *If adverse selection cost is high enough* $\left(\frac{r_0(1-\lambda)}{\lambda} > (1-p)\frac{2S(1-p)l-(1-p)^2l^2}{9S}\right)$, *the two-stage game has a uniqe subgame perfect Nash equilibrium, in which banks prefer to share information and use collateral to screen boorrowers.*

Proof. The proof follows from comparing $\Pi^{A,c}$ under informaiton sharing with Π^{A} in the absence of information sharing.

Thus, information sharing and collateral will arise at the same time (or both will be absent). While this may contradict the first intution that the two may be substitutes, the result is straightforward: by allowing to target only high risk borrowers (i.e., defaulting) with costly collateral, information sharing may justify collateral and the two will avoid banks' losses from low type borrowers.

Proposition 4.3 *First period interest rate will be lower in equilibrium provided adverse selection cost is not too high* $\left(\frac{4}{9S}(2S(1-p)l+(1-p)^2l^2)+(1-p)\frac{2S(1-p)l-(1-p)^2l^2}{9S} > \frac{r_0(1-\lambda)}{\lambda} > (1-p)\frac{2S(1-p)l-(1-p)^2l^2}{9S}\right)$.

Proof. The proof follows from comparing $r_1^{A,c}$ under informaiton sharing with r_1^{A} in the absence of information sharing.

Intutively, because banks' incumbency profits are higher when poaching is achieved with collateral (which is the optimal contract in the presence of information sharing), banks will want to be more agressive in bidding for borrowers in the first period. This is different from the "dark-side" result obtained in Gehrig and Stenbacka (2007) in which first period interest rates are higher under information sharing due to the fact that (full type-revealing) information sharing may reduce informational rents that first period borrowers may deliver in the future. Under the more realistic assumption that only hard information can be shared, our result adds an additional insight, i.e., that collateral can increase informational rents by ammeliorating competition from the poaching bank and thus ensure cheaper access to finance for creditworthy borrowers in the first period. Moreover, colalteral reduce type-1 errors.

4.1 Collateral, information sharing and screening

In this section we assume banks are able to add value to the project's success by screening the borrowers ex-ante. Even though banks do not observe the borrower's try type, they can still provide a screening function and improve the quality of borrower population. We assume screening is costly and provides a good (G) or a bad (B) signal about a borrower's type such that $P(screening = G/type = H) = P(screening = B/type = L) = \phi > 0.5$.However the cost of the signal is increasing in its precision, ϕ, and is given by the convex function $z\phi^2$. Conditional on screening the updated probability of high type borrowers that the bank will face in period one given by

$$P(H/screening = \phi) = \frac{\lambda\phi}{\lambda\phi + (1-\lambda)(1-\phi)} \equiv \lambda_1$$

which the bank can ensure by investing $z\phi^2$. Finally, we assume z is low enough so that bad signal borrowers are never creditworthy, i.e. , $\lambda_1(pR - r_0) - (1-\lambda_1)r_o < 0$.

The timing of the game is the same as before, with the additional screening decision before lending in the first period.

Timeline

First period.

1. Banks decide whether or not share default informaiton

2. Banks decide on the amount of screening

3. Banks offer interest rates and borrowers choose a bank to borrow. They repay if they can.

Second period:

1.Banks share default information if they decided to do so

2.Banks announce interest rates (incumbency and poaching) and collateral. Borrowers may switch banks if they are better off

3.Borrowers repay whenever they can. If collateral is pledged, it is seized and liquidated when the borrower defaults

Before solving for the equilibirum of the above game we first analyze the game given information sharing.

Lemma 4.4 *In the presence of information sharing banks will find it optimal to require collateral. Optimal screening is given by* $\phi^* = \frac{1}{z}\Big(p\frac{\partial\lambda_1}{\partial\phi}\frac{S}{9} + (1-p)\frac{\partial\lambda_1}{\partial\phi}\frac{1}{9S}\big(S-(1-p)l\big)^2\Big)$*, and is higher when collateral is pledged.*

Proposition 4.5 *Unless screening cost* z *is too low, banks choose to share information, require collateral and screen* ϕ^**. With low enough screening cost, banks choose to screen more intensely at* $\phi^{**} = \frac{\partial\lambda_1}{\partial\phi}\frac{S}{9} + r_0\frac{\partial\lambda_1}{\partial\phi}$ $(>\phi^*)$*, not to share information and not to pledge collateral.*

Intuitively, if screening costs are very low, screening all borrowers ex-ante and reducing adverse selection to a minimum will be optimal; in this case banks need not share information or require costly collateral, since adverse selection costs are now lower.

4.2 Extension: Partially informative information

So far we have assumed that default information is informative enough, in the sense that on average defaulting borrowers are not creditworthy: once it is shared, rival banks will not extend credit without collateral. We now relax the assumption and examine the effect of information sharing in this intermediate case, when the default history does not necessarily render the borrower uncreditworthy.

Proposition 4.6 ?? *Profits under the contract with collateral and without are given by, respectively,* $\Pi = \mu_A \lambda \frac{4}{9} S + (1-\mu_A)\big(p\lambda \frac{1}{9} S + (1-p)\lambda \frac{1}{9S}\big(S-(1-p)l\big)^2$*, and* $\Pi = \mu_A \lambda \frac{4}{9} S + (1-\mu_A)\big(\lambda \frac{1}{9} S - (1-\lambda) r_0\big)$

Proof. See Appendix.

Proposition 4.7 *Banks prefer to offer contracts with collateral under information sharing and without collateral in the absence of information sharing whenever liquidation cost satisfies* $\big(p\lambda \frac{1}{9S} + (1-p)\lambda \frac{1}{9S}\big(S-(1-p)l\big)^2 > \lambda \frac{1}{9S} - (1-\lambda) r_0 > \lambda \frac{1}{9S}\big(S-(1-p)l\big)^2$.

Proof. Obvious and omitted.

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. It can be easily that in this case, too, banks will choose a higher screening level under information sharing.

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6 Appendix

Proof of lemma 3.1 Consider the segment of borrowers that borrowed from bank A in period 1. This population has a mass of μ_A. The bank can get incumbency profits from this population for the subset of borrowers who have high enough switching costs given the banks choice of the second period interest rate $r_{2,}^A$ and the poaching bank's interest rate $q_2^B$for the same population,

$$\max_{r_2^A} \mu_A \lambda (pr_2^A - r_0) \frac{1}{S} \int_{pr_2^A - pi_2^B - (1-p)c_2^B}^{S} ds$$

while poaching bank B's profits in the same population for borrowers is given by

$$\mu_A \lambda (pi_2^B + (1-p)c_2^B - r_0 - (1-p)l) \frac{1}{S} \int_0^{pr_2^A - pi_2^B - (1-p)c_2^B} ds - r_o \mu_A (1 - \lambda)$$

Given the poaching rate i_2^B and the incumbent's rate r_2^A, poaching profits are generated from borrowers who have low enough switching cost $s < pr_2^A - pi_2^B - (1-p)c_2^B$. Since borrowers have at least as much assets to pledge as their private benefit $(C > c)$, they will be required to pledge in the amount of their private benefit c, which will be enough to screen low type borrowers. Given the fixed amount of collateral, the first order conditions from the poaching and incumbent banks' maximization problems are given by, respectively

$$-pr_2^A + 2pi_2^B + 2(1-p)c = r_0 + (1-p)l$$

$$2pr_2^A - pi_2^B - (1-p)c = S + r_0$$

It then immediately follows

$$3pr_2^A = 2S + 3r_0 + (1-p)l$$

$$3pi_2^B + 3(1-p)c = S + 3r_0 + 2(1-p)l$$

Thus,

$r_2^A = \frac{1}{3p}(2S + 3r_0 + (1-p)l)$ and $i_2^B = \frac{1}{3p}\big(S + 3r_0 + (1-p)(2l - 3c)\big)$.

Proof of Proposition 3.2 Poaching profits of bank A are given by

$(1-\mu_A)\Big(p\frac{1}{3p}i_2^A - (1-p)l - r_0\Big)\frac{1}{S}\int_0^{pr_2^A - pi_2^B - (1-p)c_2^B} = (1-\mu_A)\Big(p\frac{1}{3p}\big(S + 3r_0 + 2(1-p)l\big) - (1-p)l - r_0\Big)\frac{1}{3S}\big(S - (1-p)l\big) = (1-\mu_A)\lambda\frac{1}{9S}\big(S - (1-p)l\big)^2$

Similarly, incumbency profits are equal to

$\mu_A\lambda\frac{1}{S}\Big(p\frac{1}{3p}(2S + 3r_0 + (1-p)l) - r_0\Big)\Big(S - \frac{1}{3}(S - (1-p)l\Big) = \mu_A\lambda\frac{4}{9S}\big(S + (1-p)l\big)^2$.

Thus, total profits are equal to

$\Pi_2^A = \mu_A\lambda\frac{4}{9S}\big(S + (1-p)l\big)^2 + (1-\mu_A)\big(\lambda\frac{1}{9S}\big(S - (1-p)l\big)^2$

The first term in equation represents the profits earned on the high type entrepreneurs successfully poached from rival bank B.

Proof of Proposition 3.3 These intertemporal profits are given by the sum of the profits over two periods, assuming the discount factor is 1: $\Pi_A = \Pi_A^1 + \Pi_A^2$, where $\Pi_A^1 = \mu_A(\lambda pr_1^A - r_0)$ and the equilibirum second period profits are characterized above. These total profits are linear in the market share μ_A and are expressed by

$$\mu_A\Big(\lambda pr_1^A - r_0 + \lambda\frac{4}{9S}\big(S + (1-p)l\big)^2 - \lambda\frac{1}{9}\big(S - (1-p)l\big)^2\Big) + \lambda\frac{1}{9}\big(S - (1-p)l\big)^2$$

The first term in brackets expresses profits acquired from the market share of those entrepreneurs that bank A patronizes in period 1. Whenever these profits ar epositive, the bank can increase profits further by offering slightly lower period-one interest rate. Thus, the bank will continue to offer lower rates until the term in the brackets equals to zero, i.e., $r_1^A = \frac{1}{\lambda p}\Big(r_0 - \lambda\frac{4}{9S}\big(S+(1-p)l\big)^2 - \lambda\frac{1}{9}\big(S-(1-p)l\big)^2\Big)$.

Proof of Proposition 4.1 We have already seen that $\mu_A\lambda(pr_2^A - r_0)\frac{1}{S}\int_{pr_2^A-pi_2^B-(1-p)c_2^B}^{S} ds = \mu_A\lambda\frac{4}{9S}\big(S+(1-p)l\big(^2$ and also that $(1-\mu_A)(pi_2^A + (1-p)c_2^A(1-l) - r_0)\frac{1}{S}\int_0^{pr_2^A-pi_2^B-(1-p)c_2^B} ds = (1-\mu_A)\lambda\frac{1}{9S}\big(S-(1-p)l\big)^2$. It is immediate to see the result now.

Proof of proposition 4.4 Denote $\frac{\partial\lambda_1}{\partial\phi} \equiv d > 0$. Optimal screening with collateral is given by maximizing net profits w.r.t δ, i.e., $p\lambda_1\frac{S}{9} + (1-p)\lambda_1\frac{1}{9S}\big(S-(1-p)l\big)^2 - \int_0^\delta zxdx$. Thus, $\delta^* = \frac{1}{z}\Big(pd\frac{S}{9} + (1-p)d\frac{1}{9S}\big(S-(1-p)l\big)^2\Big)$. Similarly, $\delta = pd\frac{S}{9}$ without collateral.

Proof of proposition 4.5 From proposition and from noting that derivative of Π^A under no sharing w.r.t λ_1 is higher than that of $\Pi^{A,c}$ in the absence of information sharing. As z approcahes infinity, banks choose not to screen at all, so that the proof is analogous to proof of . As z starts to decrease, optimal screening and net profits are higher under no sharing with no collateral; when z approaches 0, optimal screening approaches one, and $\lambda_1 = 1$, while profits with no sharing are the highest, i.e., $\frac{S}{9} > (pd\frac{S}{9} + (1-p)d\frac{1}{9S}\big(S-(1-p)l\big)^2$.