2011 | 23

Working Paper

Financial Stability, Research Department

Information sharing and information acquisition: Ownership and coverage

Artashes Karapetyan and Bogdan Stacescu

NB NORGES BANK

Working papers fra Norges Bank, fra 1992/1 til 2009/2 kanbestilles over e-post:
servicesenter@norges-bank.no

Fra 1999 og senere er publikasjonene tilgjengelige på www.norges-bank.no

Working papers inneholder forskningsarbeider og utredninger som vanligvis ikke har fått sin endelige form. Hensikten er blant annet at forfatteren kan motta kommentarer fra kolleger og andre interesserte. Synspunkter og konklusjoner i arbeidene står for forfatternes regning.

Working papers from Norges Bank, from 1992/1 to 2009/2 can be ordered by e-mail:
servicesenter@norges-bank.no

Working papers from 1999 onwards are available on www.norges-bank.no

Norges Bank's working papers present research projects and reports (not usually in their final form) and are intended inter alia to enable the author to benefit from the comments of colleagues and other interested parties. Views and conclusions expressed in working papers are the responsibility of the authors alone.

ISSN 1502-8143 (online)
ISBN 978-82-7553-646-2 (online)

Information Sharing and Information Acquisition: Ownership and Coverage*

Artashes Karapetyan† and Bogdan Stacescu‡

December 21, 2011

Abstract

We examine the conditions required for the existence of private credit bureaus, their ownership and coverage. Our model implies that bank consortia will most likely be preferred by banks, but that they will lead to restricted coverage. Independent credit bureaus have higher coverage, but they require good institutions. This implies an important role for public credit registers in developing countries with weak institutions. Our empirical findings largely support the implications of our model.

JEL classification: G20, D82, L12

Keywords: Information sharing; Credit markets; Default; Adverse selection

*We would like to thank Christian Ewerhart, Anke Gerber, Michel Habib, Ulrich Hege, Rene Stultz, Lucy White, seminar participants at the European Financial Association Doctoral Workshop (2006), European Economic Association (2007), Harvard University (2007), Harvard Business School (2007), Swiss Doctoral Workshop in Gerzensee (2007), European Financial Management Association (2008), Portuguese Financial Network (2008). All remaining errors are ours.

†Norges Bank, Bankplassen 2, P.O. Box 1179 Sentrum, Norway. Tel: + 47 22 31 62 52

‡Norweian School of Business, Nydalsveien 37, 0484 Oslo. Tel: +47 46 41 05 19

1 Introduction

Information is a crucial input in the banking industry. When making lending decision, banks have to know their potential borrowers well. Banks collect useful unique information about borrowers which provides a competitive advantage and a source of profits over the lifetime of the banking relationship.

Credit bureaus allow banks to get information about the credit history of a potential borrower, thus allowing them to better select their borrowers. At the same time, borrowers can benefit from an increased competition between banks, since they can take their credit history to other banks within the credit bureau.

While it is well known that information asymmetries are still a major problem, less well known is how the information sharing arrangements function. Why do some countries have credit bureaus while other do not? Why do we observe lender-owned bureaus as well as bureaus owned by outside firms? Where credit bureaus exist, why do some lenders participate, while others do not? Which ownership provides larger coverage? The aim of this paper is to identify the determinants underlying the extent of information sharing and the existence of various ownership structures. We attempt to define the conditions under which consortia (lender-owned credit bureaus) or independent agencies (bureaus owned by outside firms) can exist, and the coverage associated with each type of arrangement.

The motivation of our paper comes from the fact that in many countries information sharing includes only a small part of the business or consumer sector or it does not exist at all, while in other countries shared information is much more pervasive. The importance of past credit information is well known. As has been argued in much of the literature, there are benefits from large scale sharing of information. For instance, a recent survey by the World Bank in Latin American countries reveals that most managers agree that the most important input in deciding credit terms is the borrower's past history, rather than collateral (Miller, 2003). It is therefore important to understand the reasons for this variation[1].

[1]Limited information sharing particularly refers to developing countries, where until recently information sharing was almost nonexistent or was confined to a public credit registry. Public registries operate on the principle of mandatory participation. Together with improving credit information sharing activities, one of their main objectives is to strengthen the supervision and regulation of financial institutions. In most countries, public registers only collect information on large loans, since their main focus is on the overall stability of the banking system. However, full information sharing is not ubiquitous in developed world either. For instance, in Switzerland the local consortium (Zentralstelle fur Kreditinformation) has a coverage of 23.4%. The coverage numbers refer to the share of individuals and small businesses covered by the bureau. Source: World Bank, Doing Business Project, www.doingbusiness.org. In Italy, CRIF manages positive and negative information for consumers and small businesses: it covers about 90% of Italian consumer credit market, and only around 10% of the business sector. The Irish Credit Bureau covers about 80% of the Irish business market, and 100% of the consumer credit market (Jappelli and Pagano, WP 35). In Poland , the coverage of the local consortium is 38.1%, while in US, UK, Canada independent agencies cover 100% of small businesses, providing both negative and positive information. Thus, there are considerable differences in terms of coverage in both developing and developed countries.

Variations in coverage in various countries may well be associated with differences in the type of private credit bureau ownership. We examine the interaction between the two dimensions, as well as the conditions that may favor one private credit bureau structure over the other. This is an important issue that has not yet been addressed in the literature.

We focus on two models of private Credit Bureau ownership structures that are prevalent across different countries.

First, we model the **lender-owned consortium**, where lenders share information to maximize their individual profits. The members use the shared information directly to improve their lending decisions, and they operate under the principle of reciprocity. We find that bank consortia will generally lead to less than full coverage. The reason for this is that the addition of a new bank will lead to both an increase in information and an increase in competition within the consortium. While for a low number of banks the positive effect of additional information is larger than the decrease in profits generated by more intense competition, beyond a certain size of the consortium adding one more bank decreases the profits of the consortium. Therefore, inside banks will prefer to block the entry of new banks and the size of the credit bureau will be limited. Moreover, for a large number of banks, outside banks will be unable to make side payments in order to gain access to the bureau.

Bank consortia can, of course, also lead to collusion, supported by the repeated interaction between their members. One can even imagine the situation where inside banks coordinate in order to extract "monopoly"[2] interest rates. An increase in the number of banks in the consortium will also increase the incentives to deviate from the collusive strategies, however. Thus the potential for collusion may add another, even more stringent, limit on the size of the consortium.

Second, we determine the equilibrium size of the credit bureau when the bureau database is managed by an **independent agency**. We first examine the case when only one outsie bureau is available. The agency is not owned by lenders, but is rather an outside enterprise that collects and then distributes credit information. It acquires the information from lenders and then gives access to the comprehensive reports to these insiders for a fee.

In the case of an independent agency, the problem of limited entry is absent. The agency gets its profits from selling credit reports, and a higher number of participating lenders will increase the value of its reports. On the banks' side, participation in the credit bureau will obviously enhance the quality of their information and may increase bank profits compared no information sharing. In equilibrium full coverage will obtain whenever a monopolistic independent bureau is available.

[2]The interest rate charged by the inside banks may be limited by that of less informed outside banks. Thus under some parameter values the outcome may be closer to limit pricing.

We then discuss and compare the two ownership structures when independent bureaus compete for banks to collect their information. We show that in this case coverage and bank profits are the same under the two ownership structures.

We then look at the role of credit report prices. We show, that if bureaus decide to charge a fee for each credit report, then report prices are higher under bank-owned consortia. In this context we discuss the role of credit report price regulation. If the latter is binding, then bank consortia may only obtain constrained maximum and lower profits per member compared to independent bureau case. Finally, in the case of competitive independent bureau, regulation may result in lower coverage of bank-owned consortia compared to outside ownership

The existence of the independent credit bureau can however be undermined by the potential for collusion between the independent credit agency and individual banks. One can think of the scenario in which one of the banks gets unrestricted access to the entire database and thus has the possibility to capture (an important share) of the other banks' market. The independent agency may be willing to collaborate in this deviation if it gets a share of the one-period rents. If contract enforcement is weak, this type of potential collusion may deter the formation of independent credit bureau. Indeed, the IFC Credit Bureau Knowledge Guide notes that "in most cases, lenders are reluctant to share information with an independent credit bureau because of a lack of trust."

Summing up, our model implies that independent credit agencies can provide higher coverage. While this is likely to be socially beneficial, banks will typically prefer consortium (under no regulation). Due to the potential for opportunistic behavior on the side of the independent agency, such an arrangement will not always be possible. Bank consortia are a potential alternative which is less sensitive to institutional quality. There is nevertheless a downside to this type of credit bureau: inside banks may not be interested in extending the size of the consortium and information sharing will generally be limited. Collusion between banks is possible within the consortium, and is more likely in fragmented banking systems.

We take the predictions of the model to the data. We look at the ownership structure and coverage in a cross-section of countries. We also examine the interaction between the existence and features of credit bureaus and the institutional environment, the existence of public registers, as well as other factors. Our findings largely support our hypotheses. Consortia have significantly lower coverage, while independent credit bureaus provide high coverage, but also require better institutions.

Our approach is largely positive: we are trying to understand the mechanisms governing credit information sharing as seen in practice. However, our work also has normative implications. For instance, it suggests that the need for public registers based on mandatory information sharing for all lenders is highest in developing countries with underdeveloped banking systems and weak institutions. This is in agreement with the findings of Djankov, McLiesh and Shleifer (2006), who find a significant in-

crease in credit availability following the establishment of public registers in developing countries with French legal origin.

The paper proceeds as follows: In section 2 I provide the model set-up, describe the game and motivate borrowers' choice of multiple lenders. Section 3 analysis the main building block of the model- the proportion function of improving borrower population due to information sharing. Section 4 and 5 describe banks' profits and consortium size, while section 6 solves for borrowers' choice of multiple bank relationship, as they take into account banks' optimal response. Section 7 links the testable implications to existing empirical work. Section 8 concludes.

2 Related Literature

Credit bureaus are a relatively new area for research. The existing papers have examined the effect of information sharing on loan volumes, prices and quality, the role of credit bureaus in reducing moral hazard, and the optimal extent of information to be shared. There has been very little work on the various institutional arrangements underlying credit bureaus.

In an adverse selection model, Pagano and Jappelli (1993) show that information sharing decreases defaults and reduces the average interest rate. In this model, each lender has informational monopoly over the local borrowers, but no information about immigrants, who therefore face adverse selection. If lenders exchange their private information, they learn about immigrants and can lend to them safely, so the default rate decreases. However, the effect on lending is ambiguous: when lenders exchange information about borrowers' types, the implied increase in lending to creditworthy borrowers may not be enough to compensate for the reduction in lending to risky types. Banking competition, in turn, will increase the volume of lending by reducing informational rents.

In a moral hazard model, Padilla and Pagano (1997) show how borrowers' incentives to perform increase with information sharing in a setup where each lender initially possesses informational monopoly over its local borrowers. This informational monopoly creates a hold-up problem in the credit market if there is no information sharing; borrowers understand that in the absence of information exchange the monopolistic holder of the information will grab information rents, and thus borrowers will be exploited via high interest rates. Anticipating such an outcome, borrowers are not willing to exert any effort in the first place, and therefore, the credit market may collapse. However, if lenders are able to commit to sharing information, competition between lenders will lower interest rate to competitive level, thus increasing borrowers incentives to exert higher effort. This in turn supports the well-functioning of the credit market, increases volume of lending and social welfare. The assumption of initial informational monopoly is a main building block and is one of the peculiar features of

the work. Its setup differs from the 2000 paper, in that in the latter all profits have been competed away ex-ante.

Padilla and Pagano (2000) show that incentives to perform exist even when there is no ex-ante informational monopoly. In this model, when banks share default information, rather than information about borrowers' types, both the adverse selection and disciplinary effect may be alleviated. When default information is shared, past defaults become a sign of bad quality not only for the lender-bank, but also for all other banks, with whom information is shared. Realizing this adverse reputation effect, borrowers are encouraged to exert more effort.

In this model disclosing information about borrowers' types does not carry any effect on default and interest rates. Ex-ante competition has competed away lenders' profits anyway, so that their customer's interest rates cannot be reduced any further. As a result, when information about their characteristics is shared, borrowers do not have any incentive to perform better.

Vercammen (1995) shows that full information sharing about a particular borrower may not be optimal in a dynamic set-up: a mechanism that limits access to the information exchanged between lenders can lead to higher welfare. Vercammen uses a multi-period model with adverse selection and moral hazard to show that a certain level of adverse selection is required in a credit market in order to give rise to borrower reputation incentives in every period and thus increase aggregate welfare. He concludes that a system of full information sharing may be less efficient than one designed to preserve some level of asymmetric information, such as limiting the length of borrower data that is maintained.

Jappelli and Pagano (2002) offer the first empirical investigation of the existence and impacts of credit bureaus in various economies around the world. They find that the presence of private credit bureaus or public credit registries is associated with broader credit markets and lower credit risk. They find no differential effect between public and private institutions on credit market performance, and argue that public credit registries are more likely to arise where there is no preexisting private credit bureau and creditor rights are poorly protected. Similar empirical results are obtained by Djankov, McLiesh and Shleifer (2006), who use macro level data from 129 countries and find that credit rises after improvements in information sharing. Kallberg and Udell (2003) and Love and Mylenko (2003), using micro level data, support the finding that information sharing adds value by enhancing credit availability.

3 Model

We model an economy with N distinct banks and B borrowers, where $N < B$. A proportion λ of the borrowers are high-type, while the remaining $1 - \lambda$ are low-type. Banks know λ but do not obseve the borrower's type. Borrowers live for two periods and banks are infinitely lived. The banks' cost of funds each period is equal to $\bar{R}$.

High-type borrowers are always successful in the projects they decide to undertake. Their individual demand given the interest rate R is equal to $k - sR$, where k and s are constants. The intuition here is that as the interest rate increases, the number of positive NPV projects goes down.

The first-period cash flows of the bad-type borrowers are uniformly distributed over the interval $[0, a]$. Thus, while some low-type borrowers can be "lucky" and repay the loan, others will default. Each borrower can only afford to sign contracts with at most m banks. This is the cost of the relationship until the time the funds become fully available rather than an upfront cost. Finally, we assume for simplicity that low-type borrowers that get credit in the second period are unable to pay anything (they have a cash flow of 0).

The returns are summarized in the table below.

	H-type, λ		L-type, $1-\lambda$	
	Return	Probability	Return	Probability
1st Period	R^*	1	[0; a]	$U \in [0; a]$
2nd Period	R^*	1	0	0

First period lending is based on no information, After the first period, banks observe their own borrowers' repayment. In addition, if they decided to join a consortium, it will allow them to exchange this information with member banks in the consortium.

We assume that banks are price-takers on their "input" (i.e. deposit) market. They only decide on the quantity of deposits they need for lending. On the "output" (i.e. loans) market, banks can set their interest rates. Borrowers choose their banks based on the interest rates they anticipate.

3.1 The first period

In the first period, banks have no information that can help them distinguish between borrowers of different qualities. Firms have therefore equal chances of being accepted by any bank - and all banks compete for all borrowers.

We assume that the borrowers have initial funds that only allow them to maintain banking relationships with at most m banks. As we shall see later, borrowers will want to have multiple relationships in order to enhance information sharing and competition among banks.

The timing of the bank competition is as follows:

1. Banks decide on the funds they need for lending and acquire these funds at cost $\bar{R}$.
2. Borrowers approach the banks and apply for loans. Banks lend the funds they have at their disposal.
3. Borrowers repay

4. Banks decide on the existence and size of credit bureau and its size
5. Borrowers choose a bank, invest and repay if they can

In the first period, all banks compete for all borrowers, since there are no informational asymmetries between banks and borrowers can freely move between banks. Banks will decide on the funds they are going to lend and then borrowers will choose the banks that provide the lowest interest rates. The demand for loans from high-type borrowers will depend on the interest rate they can get. Low-type borrowers will mimic the good type and ask for loans of a similar size. In equilibrium, the market interest rate will be uniform across banks and borrowers and will balance the demand and supply of funds[3].

Proposition 3.1 *In the first period banks will choose an amount of deposits*

$$D_j = \frac{\lambda Bk - Bs\bar{R}}{\lambda(N+1)}$$

and the first-period interest rate for all borrowers will be

$$R_1 = \frac{k\lambda + Ns\bar{R}}{s(N+1)}.$$

The per-bank profits will be equal to

$$\Pi_1 = \frac{B}{s\lambda}\frac{(\lambda k - \bar{R})^2}{(N+1)^2}.$$

Proof See Appendix.

We can see that the first-period interest rate and bank profits are decreasing in the number of banks N, which is associated with the intensity of competition. Both are also decreasing in the sensitivity of the demand for loans to interest rate levels s, as well as the cost of funds $\bar{R}$.

3.2 No information sharing

In the absence of information sharing, bank will only know the credit history of their own first-period borrowers. If they observe any defaulting borrowers in their portfolio, they can safely remove them, since they are obviously low-type and will not reimburse any money lent in the second period. If they observe successful repayments, they can update the probability of those borrowers being a high type to a higher level. If they are faced with loan demand from firms that have not had a lending relationship

[3]Our setup for bank competition is to some extent related to the game described by Kreps and Scheinkman (1983).

with them in the first period, banks will not have any additional information to help them distinguish between high- and low-type borrowers.

In order to keep things simple, we assume that banks will not find it worthwhile to finance "unknown" borrowers. That is, the expected payoff from lending to a borrower that did not receive a loan from the bank in the first period is negative[4]. They will do that if the proportion of high-types among unfamiliar borrowers is high enough. Under these circumstances, banks will only lend to their own first-period borrowers that have successfully repaid their initial loans.

Each bank will be competing with $m-1$ other banks for each of its successful borrowers. In equilibrium, all the m banks will offer the same interest rate, and good borrowers will split their demand among banks[5].

The demand of the high-type borrowers will be given by $k - sR_2^0$, where R_2^0 is the equilibrium second-period interest rate without information sharing. The low-type borrowers will mimic the high-type by applying for the same amount from each bank where they did not default in the first period. In the absence of additional data, those banks will be unable to distinguish between the two groups of borrowers. What banks can do, however, is to update the probability that their lenders are high-type, conditional on one successful first-period contract:

$$\lambda^0 = \frac{\lambda}{\lambda + (1-\lambda)\left(1 - \frac{R_1}{ma}\right)}.$$

The outcome of the competition among banks in the absence of information sharing is summarized in the following proposition.

Proposition 3.2 *If there is no information sharing, banks will only lend to their successful first-period borrowers. The second-period interest rate is*

$$R_2^0 = \frac{k\lambda^0 + sm\bar{R}}{(m+1)\lambda^0},$$

and the average per-bank second-period profit is equal to

$$\Pi^0 = B_0 \pi^0, \tag{1}$$

where $\pi^0 = \frac{(\lambda_0 k - s\bar{R})^2}{s(\lambda^0(m+1))^2}$ *and* $B_0 = \frac{B}{N}\left(m\left(\lambda + (1-\lambda)\left(1 - \frac{R_1}{a}\right)\right) + \frac{(m-1)}{2}(1-\lambda)\frac{R_1}{a}\right)$.

Proof See Appendix.

[4]We could also consider the case where banks are willing to lend even to "unknown" borrowers. This would lead to a mixed-strategy equilibrium (von Thadden 1998). This case leads to more involved computation, but the basic intuition remains the same.

[5]In order to save on contracting costs, borrowers may also choose randomly just one of the banks. Results are similar in that case.

It can be seen that the banks' profits are decreasing in the number of bank relationships m (which increases competition among banks), increasing in the share of high-type borrowers in the initial pool λ, and decreasing in the interest sensitivity of the demand for loans s.

It may seem intuitive that banks can increase their profits by sharing information on their borrowers. This is because they are able to eliminate more of the low-type borrowers and thus increase the quality of their portfolio. The bright side of information sharing may however hide potential downside risks for the banks, such as increased competition or even the misuse of credit information. We analyze the feasibility, as well as the pros and cons of information sharing in its two main organizational forms: bank consortia and independent credit bureaus.

3.3 Consortium

In a consortium several banks pool the information on their borrowers allowing member banks to learn a firm's credit history even without the benefit of a previous direct relationship. While this will enhance the quality of lending decisions and thus the quality of bank portfolios, information sharing may increase competition among banks since each bank foregoes its informational monopoly. We examine the tradeoff between the two effects of information sharing, and its impact on the size and structure of the credit bureau.

Timing of events in the second period:

1. if banks prefer to share information, a consortium of size $n \leq 2$ is formed;
2. information on credit histories is shared among banks in the consortium;
3. inside and outside banks choose their deposits;
4. banks choose their interest rates conditional on the credit history of each borrower.

Borrowers that have a credit history both inside and outside the consortium can potentially choose to repay (in the case of low-type borrowers) and apply for credit from both groups of banks. We shall be looking at the case where interest rates are relatively low inside the consortium, and therefore borrowers repay and apply for credit inside the consortium if they have had successful inside contracts[6]. Thus some of the borrowers that have had successful contracts with outside banks will not borrow from them in the second period - they will completely "migrate" inside the consortium.

[6]This is arguably the most likely case. As discussed in the Appendix, there may be "fringe cases" where inside banks only serve the types that have had several successful contracts inside the consortium. This form of "cherry-picking" can be obtained for extreme values of the parameters. Apart from making outside banks better off than in the main case we consider, there are no important differences in that case.

We first look at the case where there is no collusion inside the consortium[7]. Inside banks share a common database, and they compete for all inside borrowers, including those that have not had a direct credit relationship with them in the first period.

It is important to note that borrowers inside the consortium will receive different interest rates depending on the number of successful contracts they have had with the inside banks. This is because in equilibrium the banks' "margin" on the funds they have lent must be the same for all borrowers:

$$\lambda^i R^i - \bar{R} = \lambda^j R^j - \bar{R}$$

where i and j denote the number of successful contracts a borrower has inside the consortium, and λ^i and λ^j are the updated probability that a borrower that has repaid i (j) contracts is a high-type borrower.

We can now determine the interest rates and amounts lent to various borrowers.

Proposition 3.3 *Given the size of the consortium n, the inside interest rate for a borrower with one successful contract will be:*

$$R^1 = \frac{\frac{1}{n+1}\sum_{j=1}^{m} B^j + \frac{n}{n+1}\bar{R}s\sum_{j=1}^{m}\frac{1}{\lambda^j}}{s\lambda^1\sum_{j=1}^{m}\frac{1}{\lambda^j}}$$

where B^j is the number of borrowers with j successful contracts inside the consortium. The deposits chosen by an inside bank are

$$D^i = \frac{1}{n+1}\Big(k\sum_{j=1}^{m} B^j - \bar{R}s\sum_{j=1}^{m}\frac{1}{\lambda^j}\Big).$$

The expected profits of an inside bank will be equal to

$$\Pi^{inside} = D^*(\lambda^1 R^1 - \bar{R}) = \frac{1}{(n+1)^2}\frac{1}{s\sum_{j=1}^{m}\frac{1}{\lambda^j}}(k\sum_{j=1}^{m} B^j - \bar{R}s\sum_{j=1}^{m}\frac{1}{\lambda^j})(k\sum_{j=1}^{m} B^j - \bar{R}) \tag{2}$$

Proof See Appendix.

We next determine the optimal size of the consortium. We first look at the most likely case - that in which the consortium grows up to the point where adding another

[7]Collusion inside the consortium will raise inside interest rates. This makes the rationing of inside borrowers more likely. It also implies that an important factor limiting the size of the consortium is the need to avoid opportunistic behavior by individual banks that may be tempted to undercut the other inside banks. We discuss the case of collusive behavior below.

bank would decrease the per-bank profit for the inside banks. That is, the group of inside banks taken as a whole will reject the membership of an additional bank if that leads to a decrease in their individual profits. It can be shown that there is an optimal size of the consortium n that maximizes per-bank profits inside the consortium.

Proposition 3.4 *Under a wide range of parameter values, there exists an optimal consortium size n, $0 < n < N$, where per member profits are maximized.*

Proof See Appendix.

Adding one more bank to the consortium increases both the quantity of information available to the consortium and the competition between banks. When the number of banks in the consortium is small (especially when $n < m$), the positive effect of information is larger than the effect of increased competition. Beyond a certain point, however, this relationship is reversed, and increasing the number of banks in the consortium lowers individual profits.

One important aspect to note here is that it is possible that profits under information sharing can be lower than in the case of "autarky" - even for banks in the consortium. The problem is more likely if N (the total number of banks in the economy) is high. This potential problem can be seen (after some tedious algebra) by comparing equations 1 and 2. The intuition is that inside the consortium banks have better information than in the case of no information sharing (thus in some sense they have lower lending costs) - but at the same time they are competing with n rather than m other banks for each borrower. One can therefore imagine a case where information sharing is not feasible because of the excessive fragmentation of the banking system. This is supported by data in the empirical section.

3.3.1 Outside banks

The banks that are not included in the consortium only have information about their own first-period borrowers. Thus they will only lend to the borrowers that have had a lending relationship with the bank and that decide to stay with the bank. Given the lower interest rates within the consortium, however, those of the original borrowers that have had banking relationships with the banks in the consortium will prefer to apply for loans from inside banks.

Outside banks decide on the optimal amount of funds for lending based on the anticipated demand from successful borrowers. They then compete in interest rates.

The good type borrowers that have had contracts outside the consortium will have m banks competing for each of them. They can borrow from any of these banks, and are unable to go to other banks. The outside banks understand this and set their interest rates accordingly. In equilibrium, the interest rates will be the same for the m banks.

The demand of high type borrowers will depend on the interest rate they are offered by the outside bank with which they have had a lending relationship. For simplicity, we assume that the high type borrowers decide to borrow from each of the banks that give them the same interest rate. Hence the demand for loans from each bank will be $\frac{1}{m}(k - sR_2)$. [8]

Low-type borrowers do not repay anything in the second period, but they still derive private benefits from being in business. Those of them that have had at least one "success story" with a bank can - and will - apply for loans. In order to get credit, low type borrowers will have to mimic the demand of the high type borrowers: they will get $\frac{1}{m}(k - sR_2)$ from each of the banks where they did not default in the first period.

Proposition 3.5 *Outside banks will lend to their first-period borrowers that have fully repaid their share of the loans. The outside interest rate will be*

$$R_2^{out} = \frac{k\lambda^0 + sm\bar{R}}{(m+1)\lambda^0}, \tag{3}$$

i.e., is equal to the case without information sharing.

As it may be expected, the interest rate will be increasing in the cost of funding $\bar{R}$, and decreasing in the price sensitivity of loans s and proportion of high-type borrowers λ.

The total deposits for each bank, as well as its expected profits will depend on the number of successful first-period contracts.

Proposition 3.6 *When $n < N - m$, he average profit of an outside bank is*

$$\Pi^{out} = \frac{N^{tot}}{N-n}\pi^{out}$$

where

$$N^{tot} = \frac{B}{N}\Big(\lambda + (1-\lambda)\Big(1 - \frac{R_1}{ma}\Big)\Big)(N - n - m + 1)\Big(\frac{m(m-1)}{2}\frac{R_1}{ma - R_1} + \frac{(a-R_1)m^2}{am - R_1}\Big)$$

and $\pi^{out} = \frac{(\lambda_0 k - s\bar{R})^2}{s(\lambda^0(m+1))^2}$ is the average number of successful first-period borrowers of an outside bank that apply for loans. Moreover, Π^{out} is decreasing in n.

When $n \geq N - m$ outside bank profits are 0.

As the number of banks in the consortium increases (the number of outside banks decreases), the proportion of borrowers that is lost to the inside banks gets larger, and this hurts the outside banks.

[8] One can also think that each of the high type borrowers choose to borrow from one of these banks - the results would be similar.

3.3.2 Collusion

It is easy to think that the banks in the consortium have the opportunity to collude and set interest rates above their competitive levels. The repeated interaction between inside banks can make collusion sustainable, since the rents from co-operation overwhelm the short-term gains from undercutting the other banks.

Proposition 3.7 *1. The highest interest rate that banks in the consortium can charge for a borrower with i successful contracts within the consortium is* $R^i_{coll} = \frac{1}{2s\lambda_i}(s\bar{R} + k\lambda_i)$.

2. Collusion between inside banks will be sustainable as long as the number of banks in the consortium is not too high.

Proof See Appendix.

Banks in the consortium can take advantage of their privileged information about their borrowers and charge them high interest rates - as long as those interest rates do not exceed the level offered by outside banks. In theory, the highest point is the monopoly interest rate ($\frac{k}{2s}$). Comparing this interest rate with the outside interest rate from equation 3, we can see while in theory it is possible that this monopoly rate should be below the outside interest rate, in most cases it will be higher. Thus it seems reasonable to think that inside banks will be limited by the level of interest rates offered by outside banks - a form of limit pricing.

As in any form of collusion, inside banks are faced with the issue of potential deviations by individual banks. A member of the consortium may be tempted to increase its loanable funds above the levels implied by the collusive interest rate. This will bring it a considerable share of the inside credit market. Since the gains from this one-time deviation are increasing in the number of banks in the consortium, as shown in the Appendix, the potential for opportunistic behavior will limit the number of banks in the consortium[9].

3.3.3 Virtues and weaknesses of bank consortia

Summing up, we can say that in most cases information sharing will be profitable for the banks involved - unless the banking system is very fragmented. If N (and therefore n) are very high, competing with more banks may overwhelm the effect of better information.

Moreover, the size of the consortium will be limited in many cases. If there is no collusion inside the consortium, the effects of increased competition will be more important than the effects of information beyond a certain point, and per-bank profits will decrease. Side payments are also not feasible if there are many banks inside

[9]The "punishment" we consider for shirking banks is exclusion from the consortium once from the following period.

the consortium, since the decrease of inside bank profits becomes too large to be compensated by an outside bank. If there is collusion inside the consortium, there is one additional limit on the number of inside banks. This limit stems from the fact that deviation by inside banks becomes more attractive as n increases.

3.4 The independent credit bureau

Independent credit agencies collect information from banks, assemble the available information for each borrower and give the resulting credit reports to potential lenders. It is important to note that the ones who "generate" the credit information are the banks, and that the independent credit bureau needs their cooperation in order to become viable. Banks may not be always willing to share their information with the outside credit bureau, however. On the one hand, becoming a member of the credit bureau provides banks with better information about potential borrowers. On the other hand, it also exposes them to at least two threats: that of increased competition from other "inside" banks and that of the credit bureau misusing information. We deal with each of these threats in turn.

3.4.1 Credit report prices and poaching

The independent bureaus charge a combination of fixed fee from members and report price $c \geq 0$ for each report request. We first discuss the effect of the report on competition given full coverage (we will later on see that fixed fees will not impact the ex-post competition). Banks will get the most comprehensive credit reports possible based on the first-period performance of each borrower. They will only lend to those borrowers that have not defaulted on any first-period contracts. The updated share of high-type borrowers in this subset is given by the following equation:

$$\lambda^m = \frac{\lambda}{\lambda + (1-\lambda)\left(1 - \frac{R_1}{a}\right)}.$$

Timing of the game for the second period is given by

1. The independent bureau announces fixed fee F for participation and report price c
2. banks decide whether or not to join
3. information on credit histories is collected and shared to banks upon request
4. inside and outside banks choose their deposits;
5. banks choose their interest rates conditional on the credit history of each borrower.

Proposition 3.8 *If banks purchase credit reports for both their existing successful borrowers and new borrowers, all banks will compete for "all" borrowers, the equilibrium interest rate will be given by*

$$R_2^{low} = \frac{k\lambda^m + (\bar{R}+c)s}{s\lambda^m(N+1)},$$

and the amount of deposits per bank will be

$$D_j^{low} = \frac{B(k\lambda^m - (\bar{R}+c)s)}{\lambda^m(N+1)}.$$

The profits per bank will be

$$\Pi^{low} = \frac{B(\lambda + (1-\lambda)(1-\frac{R_1}{a})}{s}\frac{(k\lambda^m - s(\bar{R}+c)^2}{(\lambda^m)^2(N+1)^2} - \frac{B}{N}(1-\lambda)\frac{R_1}{a}c. \tag{4}$$

Proof See Appendix.

As c becomes very small, the per-bank profits approach $\Pi^{low} = \frac{B}{s}\frac{(k\lambda^m - s\bar{R})^2}{(\lambda^m)^2(N+1)^2}$. Comparing these profits with the profits without information sharing, one can see that a high proportion of good borrowers (the higher λ) increases profits, while increased competition (N rather than m banks compete for each borrower) reduces them. There may be a fair amount of customer "poaching" among banks, and banks may be rationally afraid of losing their first-period "investment" in acquiring information. As a result, profits are not unambiguously higher with information sharing, and banks may not always be willing to join the credit bureau. This prediction of the model is in agreement with survey findings that document the banks' misgivings about independent credit agencies and the difficulty of establishing such an institution.

Proposition 3.9 *It is always optimal for banks to ask for credit reports for the borrowers that have already had a successful banking relationship with them in the first period. The interest rate in this case will be*

$$R_2^{high} = \frac{k\lambda^m + sm(\bar{R}+c)}{(m+1)s\lambda^m},$$

while expected per-bank profits will be

$$\Pi^{high} = \frac{B}{N}\Big(\lambda + (1-\lambda)\Big(1-\frac{R_1}{a}\Big)\Big)\frac{(k\lambda^m - s(\bar{R}+c))^2}{\lambda^m s(m+1)^2} - \frac{B}{N}(1-\lambda)\frac{R_1}{ma}c. \tag{5}$$

Proof See Appendix.

Thus, banks profits are higher when they ask for credit reports about borrowers that have already had a success story with them. The equilibrium involves no poaching

of unknown borrowers. The intuition behind this result is that banks will not find it worthwhile to bear the additional cost of getting reports for new borrowers because the probability of getting a favorable credit report for "unknown" borrowers is lower when compared to the probability of a favorable report for borrowers that have already repaid a loan with the bank (λ compared to $\frac{\lambda}{\lambda+(1-\lambda)(1-\frac{R_1}{ma})}$). Hence the expected returns from sending "random" requests to the credit bureau are lower than the cost of the report As a result of the lack of "poaching", first, losses from unused reports are lower, and, second, competition will be milder and profits (net of unused report costs) higher[10].

3.4.2 Monopolistic case

We first discuss the case when the monopolistic credit bureau is available. The bureau charges a combination of fixed fee $F \geq 0$ from members and report price $c \geq 0$ for each report request.

The monopolist's maximization problem is thus given by

$$\begin{aligned} \max \quad & \Pi_M = nF \\ s.t. \quad & \Pi(n) \geq \Pi^{out}(n), \\ & \Pi(n) \geq \Pi^{ns}, \\ & nF \geq 0. \end{aligned}$$

where $\Pi^{out}(n)$ is outside bank profit when consortium size is n, Π^{ns} is per bank profit when there is no information sharing.

Proposition 3.10 *If independent credit agencies are possible, then full coverage obtains.*

Proof See Appendix.

3.4.3 The competitive case

Under this scenario we allow the bureau to charge a fixed fee for membership, as well a report price for each credit report once a borrower approaches the lender. We show, that while the bureau's profits are zero in this case, information sharing banks secure the same profits and coverage under both ownership structures.

This can be seen from the comparison of the two maximization problems.

The competitive credit bureau maximizes banks' profits to attract banks to its services. The independent credit bureau's maximization problem is given by

[10] One can also think of banks using per-report pricing within the consortium in order to reduce competition and keep the favorable side of information sharing. However, in that case, since banks are also the owners of the consortium, the cost of reports will return to the banks and the mechanism will not prevent poaching.

$$\begin{aligned} \max \quad & \Pi(n) = \Pi inside - F && (6)\\ s.t. \quad & \Pi(n) \geq \Pi^{out}(n), && (7)\\ & \Pi(n) \geq \Pi^{ns}, && (8)\\ & nF + \sum_{j=1}^{m} B^j c \geq 0. && (9) \end{aligned}$$

where

$$\Pi^{inside} = D^*(\lambda^1 R^1 - \bar{R} - c) = \frac{1}{(n+1)^2} \frac{1}{s\sum_{j=1}^{m} \frac{1}{\lambda^j}} (k\sum_{j=1}^{m} B^j - (\bar{R}+c)s\sum_{j=1}^{m} \frac{1}{\lambda^j})(k\sum_{j=1}^{m} B^j - (\bar{R}+c)) \quad (10)$$

When banks own the bureau, they solve

$$\begin{aligned} \max \quad & \Pi(n) = \Pi^{inside}\\ s.t. \quad & \Pi(n) \geq \Pi^{out}(n),\\ & \Pi(n) \geq \Pi^{ns}, \end{aligned}$$

where

$$\Pi^{inside} = D^*(\lambda^1 R^1 - \bar{R} - (c_c - \frac{1}{n} c_c)) \quad (11)$$

where c_c is the per report cost established by the consortium. As the bank purchases an additional credit repot, $1/n$ share of the price gets back to the purchasing bank. Moreover, the cash generated by report purchases by the rest of the banks, $(n-1)\sum_{j=1}^{m} B^j c_c$, is shared among all members.

Proposition 3.11 *When independent bureaus compete for banks to provide information sharing services, the size and coverage of the credit bureau is invariant to the ownership structure of the bureau. The independent credit bureau has 0 profits, while banks have the same interest rate and (positive) profits.*

Proof. See Appendix

3.4.4 Regulation and coverage

In the previous subsection we saw that coverage may in fact be the same when a competitive independent bureau industry exists. However, credit report prices are higher under the bank ownership case. Interestingly many countries face price caps on credit report prices. Under a binding price cap it can be shown that banks may in fact prefer independent bureaus as they can achieve higher profits and coverage.

Proposition 3.12 *The consortium's report price is positive and higher than the one established by the independent bureau.*

$$c_c = \frac{n}{n-1}c \tag{12}$$

Proof. See Appendix

The intuition for this result is that when bank own the bureau they care less about higher credit report prices. This is because at the purchase of a given report a proportional share of the price paid is back in the bank's cash flow as it is the shareholder of the overall profit. As a result, in the simplest case when the price is binding for the consortium but not for the independent bureau, i.e., $c < c_r < \frac{n}{n-1}c$, only constrained maximization is available for bank-owned consortia, which will yield lower profits than the otherwise unconstrained price with independent bureau. Moreover, banks may prefer to reduce the size of the consortium further, yielding lower coverage.

3.4.5 Collusion of independent bureaus

As discussed earlier in the paper, evidence of survey of bank managers suggests that a potential problem of collusion is present in case of outside ownership: the bureau may decide to collude with one of the banks and provide it the information on the borrowers of other banks. The bank can then undercut its competitors for one period and share the proceeds with the agency. If banks anticipate this can happen, they will decide to stay out and the credit bureau will not be feasible.

If the independent agency can collude with individual banks (institutions are weak), then this type of credit bureau will not occur.

We test the statement in the empirical section: in countries with weak institutions, it is much less likely that independent bureaus occur due to the threat of collusion.

4 Empirical Results

As shown in Table 1, our model predicts that bank consortia will be associated with low bank concentration and will be relatively unaffected by the quality of institutions. They will also be generally preferred by banks because they can provide higher profits.

Table 1: Bank concentration, institutions and information sharing

		Bank concentration	
		High	Low
Institutions	Strong	Consortium	Independent
	Weak	Consortium	-

Table 2: Correlations between the main variables of the model

Correlation	Consortium	Independent	Institutions	Fragmentation
Consortium	1.000			
Independent	-0.829	1.000		
Institutions	0.259	-0.307	1.000	
Fragmentation	-0.284	0.299	-0.093	1.000

Independent agencies will require better institutions. Another fundamental prediction of our model is that coverage will be significantly higher in the case of independent agencies.

We test the empirical implications of the model in this section. The data we use comes from the following sources:

- the data concerning credit bureau coverage, creditor rights, and contract enforcement is taken from Doing Business;
- the data on credit bureau ownership come from the IFC
- the data concerning the share of private credit in GDP and the structure of bank ownership come from the World Bank databases.

In total, our largest sample covers 125 countries. 30 of these countries have bank consortia, while 41 countries have independent credit bureaus.

We first look at the relationship between the existence and type of credit bureaus and the two variables that should influence them based on our model: the fragmentation of the banking system and the quality of institutions.

Table 2 presents the correlations between the indicators for consortia and independent credit bureaus. The correlations confirm the idea that consortia are associated with less fragmented banking systems, while independent agencies are more likely in countries with good institutions.

Table 3 regresses the occurrence of consortia on fragmentation, institutional quality and other controls. We can see that:

Table 3: Dependent variable: existence of consortium

Fragmentation	**-0.037**	**-0.499**
	(0.268)	(0.017)
Weak Institutions	0.0830	**1.329**
	(0.101)	(0.076)
Foreign		**-6.971**
		(0.006)
Private credit/GDP		**2.100**
		(0.087)
Creditor rights		**-0.987**
		(0.012)
State ownership		-2.451
		(0.165)
Public register		-0.961
		(0.202)
Pseudo-R^2	0.09	0.32
No of observations	125	125

- consortia are more likely if the banking system is more concentrated and institutions are weaker;
- the existence of consortia is negatively correlated with foreign bank ownership (perhaps co-ordination between banks is more difficult in that case), and with good creditor rights (there may be a substitution effect between the two institutional features). State ownership and the existence of public registers are insignificant.

While the sign for the relationship between the existence of bank consortia and the fragmentation of the baking system is the "right one", there is no significance in the sample that uses all countries - including those that do not have a credit bureau. The main explanation for that may be that in our model we only consider symmetric banks. In real life, however, most banking systems are quite asymmetric: a small number of very large banks co-exist with many small banks. The result of this asymmetry is that large banks with many borrowers may be very unwilling to share information with the small banks. In terms of our model in Sections 3.2 and 3.3, large banks have high profits under no information sharing and are unwilling to become "similar" to small banks by joining the consortium.

Table 4 looks at the factors leading to the existence of independent agencies. We can see that independent credit bureaus are a feature of countries with good institutions and fragmented banking systems. In the next table we compare these results: indeed, strong institutions are more important for independent bureaus.

Table 4: Dependent variable: existence of independent bureau

Fragmentation	**0.673**	**0.610**
	(0.000)	(0.012)
Weak Institutions	**-0.152**	**-1.986**
	(0.011)	(0.019)
Foreign		1.058
		(0.508)
Private credit/GDP		-1.590
		(0.216)
Creditor rights		0.548
		(0.162)
State ownership		-0.814
		(0.689)
Public register		0.851
		(0.292)
Pseudo-R^2	0.16	0.34
No of observations	125	125

Table 5: Dependent variable: existence of consortium/ independent credit bureau

Dependent variable	Consortium		Independent bureau	
Fragmentation	**-0.037**	**-0.499**	**0.673**	**0.610**
	(0.268)	(0.017)	(0.000)	(0.012)
Weak Institutions	0.0830	**1.329**	**-0.152**	**-1.986**
	(0.101)	(0.076)	(0.011)	(0.019)
Foreign		**-6.971**		1.058
		(0.006)		(0.508)
Private credit/GDP		**2.100**		-1.590
		(0.087)		(0.216)
Creditor rights		**-0.987**		0.548
		(0.012)		(0.162)
State ownership		-2.451		-0.814
		(0.165)		(0.689)
Public register		-0.961		0.851
		(0.202)		(0.292)
Pseudo-R^2	0.09	0.32	0.16	0.34
No of observations	125	125	125	125

Table 6: The regressions use just the sample of countries that have credit bureaus. The dependent variable is equal to 1 if a country has a consortium and 0 if the country has an independent credit bureau.

Fragmentation	**-0.397**	**-0.785**
	(0.028)	(0.016)
Weak Institutions	**0.942**	**1.701**
	(0.040)	(0.058)
Foreign		**-7.821**
		(0.021)
Private credit/GDP		1.972
		(0.294)
Creditor rights		-0.731
		(0.143)
State ownership		-1.161
		(0.701)
Public register		-0.988
		(0.351)
Pseudo-R^2	0.09	0.48
No of observations	71	71

Table 6 shows the results for the smaller sample of countries that have credit bureaus. We can see that, if a credit bureau is feasible, concentrated banking systems will favor bank consortia over independent credit bureaus. Results concerning the quality of institutions are similar for this smaller sample. A large share of foreign banks seems to be strongly associated with independent agencies.

We now turn to the relationship between the type of credit bureau and the proportion of borrowers covered by the lenders participating in the bureau. Our model shows that there are several factors that can limit the number of banks participating in a consortium, while an independent agency will be more likely to accept additional lenders - and thus generate higher coverage.

Table 7 presents the results about the relative coverage of the two types of credit bureaus. The raw data say that the average coverage of a consortium is 26%, while the average coverage of independent agencies is 48%. Regression results confirm this difference: the proportion of borrowers included in information sharing arrangements is higher for independent agencies, whethere additional controls are added or not. There also seems to be a residual effect of fragmentation, as well as a substitution effect between public and private credit sharing arrangements.

Table 7: Dependent variable: share of borrowers covered by credit bureau

Ownership: Consortium	**-22.050**	**-22.663**
	(0.006)	(0.013)
Fragmentation		**4.496**
		(0.042)
Institutions		4.144
		(0.567)
Private credit/GDP		**27.493**
		(0.015)
Creditor rights		-3.873
		(0.303)
Public register		-0.553
		(0.088)
Adj. R^2	0.10	0.31
No of observations	71	71

5 Conclusions

Looking at alternative arrangements to share credit information, we have shown that bank consortia are associated with lower coverage, and that they work better in concentrated banking systems. Independent credit agencies provide higher coverage, but they require good institutions.

A bank consortium will generally be more profitable for its member banks than an independent credit bureau. If the banking system is extremely fragmented, however, banks may still choose not to share information even in a consortium structure.

We show that a bank consortium will usually not involve all banks in the economy. If there is no collusion between banks inside the credit bureau, adding one more bank to an already large credit bureau will decrease per-bank profits. This is because an additional bank brings both better information and more competition to the consortium, and beyond a certain point the positive effect of the former is smaller than the negative impact of the latter. Moreover, if one considers the possibility of side payments by outside banks, one can show that beyond a certain size of the consortium an outside bank will be unable to acquire membership in the information-sharing arrangement.

Banks inside the consortium will most likely interact repeatedly, and this raises the issue of collusion between its members. In this particular case, one additional limit on the size of the consortium is given by the potential for deviation by individual banks. As the size of the consortium increases, each member bank's share of the "inside market" for credit decreases. As a result, the benefit from one-period opportunistic behavior (i.e. from undercutting the mass of competitors for one period) increases. Therefore, if banks want to collude, they will have to choose a size of the consortium that is low enough to avoid single-bank deviation.

Independent agencies will be less likely to limit entry. This is because the main source of their profits is the sale of credit reports, and the number of reports is directly related to the number of banks included in the information-sharing arrangement. The higher coverage seems to be a virtue of this particular type of arrangement. We show however that independent agencies are only feasible if competition between member banks is not too high and if institutional arrangements prevent opportunistic behavior by the agency itself.

Our empirical results largely confirm the predictions of our model. Independent credit agencies provide significantly higher coverage. They are also associated with more fragmented banking systems, and with better institutions.

While largely focusing on the positive aspect, our paper also has normative implications. It points to the potential role of public registers in countries with ineffective contracting institutions.

References

[1] Djankov S., McLiesh C., Shleifer A. "Private Credit in 129 Countries", NBER Working Paper No. W11078, 2006

[2] International Finance Corporation, "Credit Bureau Knowledge Guide", World Bank Group, 2006.

[3] Jappelli T., Pagano M., "Information Sharing in Credit Markets: The European Experience", WP no 35, 1999

[4] Jappelli T., Pagano M., "Information Sharing in Credit Markets: A Survey", WP no 36, 2000

[5] Jappelli T., Pagano M, "Information Sharing in Credit Markets", The Journal of Finance, 1993.

[6] Jappelli T., Pagano M.,"Information Sharing, Lending and Defaults: Cross Country Evidence", Journal of Banking and Finance, 2002.

[7] Kallber J., Udell G., "The Value of Private Sector Business Credit Information Sharing: The US Case", Journal of Banking and Finance, 2003

[8] Jose A. Scheinkman, David M. Kreps - "Quantity Pre-Commitment and Bertrand Competition Yield Cournot Outcomes", Bell Journal of Economics, 1983

[9] Love M., Mylenko N.. "Credit Reporting and Financial Constraints", World Bank WP 3142, 2003.

[10] McIntosh C., Wydick B., "Competition and Microfinance", WP, University of California at San Diego and University of San Francisco, 2004a.

[11] Miller M., "Credit Reporting Systems and the International Economy", MIT Press, 2003.

[12] Negrin J., "Credit Information Sharing Mechanisms in Mexico: Evaluation, Perspectives and Effects on Firms' Access to Bank Credit", Stanford University WP No 114, 2001.

[13] Padilla J., Pagano M, "Endogeneous Communication Among Lenders and Entrepreneurial Incentives", The Review of Financial Studies, 1997.

[14] Padilla J., Pagano M,"Sharing Default Information as a Borrower discipline Device, European Economic Review", 2000.

[15] Panetta F., Schivardi F., Shum M.,"Do Mergers Improve Information? Evidence from the Loan Market", WP, Stanford University.

[16] Stiglitz J., Weiss A.,"Credit Rationing in Markets with Imperfect Information", American Economic Review, 1981

[17] Vercammen J.,"Credit Bureau Policy and Sustainable Reputation Effects in Credit Markets", Economica, 1995.

Appendix A

To visualize the interaction between banks and borrowers, one can think of the N banks and B potential borrowers (with $N \gg B$) as uniformly distributed on a circle as illustrated in the figure. Each borrower has signed m contracts in the first period, starting from a given bank and going clockwise along the circle ($m = AC'$). The initial quality of borrowers is assumed to be similar at each "bank point" on the circle in the first period. We also assume that banks "do not know" where they are on the circle - they know only whether they are inside or outside the consortium in the second period (green arrow BC'). This is because we want to maintain the simplicity of the geometric illustration (which avoids overly complicated and unnecessary combinatorics), while avoiding the artificial effects generated for instance by a bank's location "on the edges" of the credit bureau[11].

While we use a geometric illustration, we are not building a location model - there are no "transportation costs" in our model. Adding transportation costs may be useful in terms of modeling borrowers' preferences for various banks - preferences that are unrelated to the pure price-based lending relationship and that may be important in real life. This addition would also complicate computations and make results less transparent. The model can still obviously be extended in that direction, however.

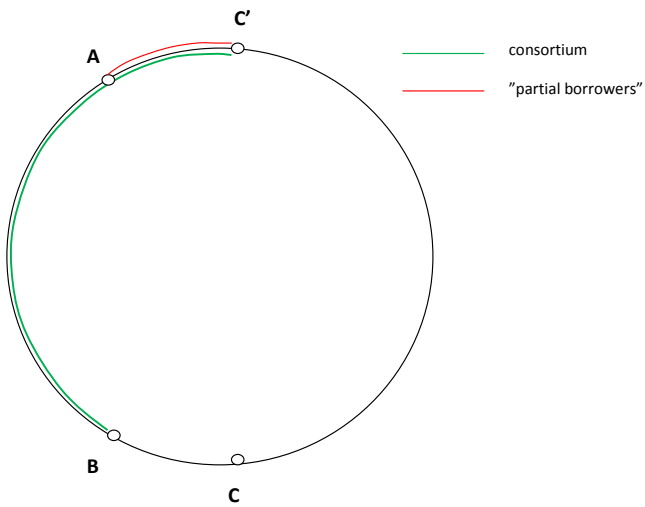

Figure 1: Geographic representation: N banks (and B borrowers) are uniformly distributed along the circle. Borrowers sign contract with $m = BC = AC'$ banks.

The circle in Figure 1 represents the whole economy (N banks located uniformly in N districts, across the whole circle), while segment BC' is the consortium, the size of

[11]The main intuition of our model would be preserved in more complicated setups.

which is to be determined For simplicity, we assume that each borrower signs contracts with the banks located clockwise up to distance m from the borrower's location. On our circle, this will lead to the existence of four distinct segments:

- borrowers who have all their contract in the consortium - these are borrowers on segment BA. Inside banks therefore have the best "possible" information on those borrowers, and will be able to select just those borrowers that have repaid the full amount.
- borrowers who have "partial" contact with the consortium - these are borrowers on segment AC'(segment 1), and CB (segment 3). These borrowers have a credit history both inside and outside the consortium. They can repay both inside and outside (the high types will pay both in all cases). They can also receive credit from either group of banks.
- borrowers that have had no contracts inside the consortium (segment CC'). These borrowers can only get credit from outside banks.

The number of creditworthy borrowers of in each group is equal to all high type borrowers on each segment, plus those lucky low-type borrowers, who have succeeded on all their contracts in the consortium. To calculate the number of borrowers in each category, note that the length of segment (2) is $n - m + 1$, and borrowers there need to have m success for second period credit. The length of segment 1 and 3 is $m - 1$ each, and borrowers need to have from 1 up to $m - 1$ success depending on their exact location.

Hence the total number of creditworthy borrowers inside the consortium will be obtained by adding

- the number of borrowers that have only had contracts inside the consortium and have fully repaid their loan:

$$B^m = (n - m + 1)\frac{B}{N}\Big[\lambda + (1 - \lambda)\Big(1 - \frac{R_1}{a}\Big)\Big]$$

- the number of borrowers that have had i $(1 \leq i \leq m - 1)$ contracts in the consortium, and have repaid them. This includes equal numbers of borrowers from segment 2 and 3 (we will refer to borrowers with i successful contracts as i type borrowers):

$$B^i = \frac{2B}{N}\Big[\lambda + (1 - \lambda)\Big(1 - \frac{iR_1}{ma}\Big)\Big]$$

.

Appendix B
Proof of Proposition 3.1

In the first period, borrowers can go to any bank and apply for loans. Banks cannot distinguish between potential borrowers. Hence all banks compete for all borrowers.

Banks will choose the deposits they need for the first period, and then they will compete in prices (loan interest rates) to attract borrowers.

Given binding deposit constraints[12], the interest rate will satisfy the following equation:

$$B(k - sR_1) = \sum_{i=1}^{N} D_i$$

In choosing deposits, the maximization problem of each bank will be:

$$\text{Max} D_i \Big(\lambda_1 R_1 - \bar{R} \Big)$$

Hence, in a symmetric equilibrium, each bank will choose total deposits equal to

$$D^i = \frac{1}{\lambda(N+1)} \Big(\lambda k B - B \bar{R} s \Big)$$

The equilibrium interest rate for borrowers that have had a success story within the consortium is equal to

$$R_1 = \frac{k\lambda - Ns\bar{R}}{s\lambda(N+1)}.$$

The profits of each bank will be given by

$$\Pi_1 = \frac{B}{s\lambda} \frac{(\lambda k - \bar{R})^2}{(N+1)^2}.$$

Proof of Proposition 3.2

In the second period, borrowers cannot move freely among banks. They can only get funding from banks where they have not defaulted - m banks in the case of high-type borrowers. Thus m banks compete for each high-type borrower. Banks will choose the deposits they need and then compete in interest rates in order to attract borrowers.

Given binding deposit constraints, the equilibrium interest rate is given by

[12]The deposit constraints will be binding in equilibrium.

$$k - sR_2^0 = \sum_{j=1}^{m} D_j^0;$$
$$R_2^0 = \frac{k - \sum_{j=1}^{m} D_j^0}{s}.$$

In choosing their deposits, banks solve the following maximization problem:

$$\text{Max}_{D_j^0} D_j^0(\lambda^0 R_2^0 - \bar{R})$$

where λ^0 is the updated proportion of high-type borrowers conditional on observing a successful repayment:

$$\lambda^0 = \frac{\lambda}{\lambda + (1-\lambda)\Big(1 - \frac{R_1}{ma}\Big)}$$

The first-order condition of the maximization problem is:

$$\lambda^0 \frac{k - D_j^0 - \sum_{j=1}^{m} D_j^0}{s} = \bar{R}$$

hence optimal deposits per successful borrower are:

$$D_j^0 = \frac{\lambda^0 k - s\bar{R}}{\lambda(m+1)}.$$

Plugging in he expression for optimal deposits we get the second-period interest rate without information sharing:

$$R_2^0 = \frac{k}{s}\frac{1}{m+1} + \frac{m\bar{R}}{(m+1)\lambda^0}.$$

The expected second-period profits per successful first-period contract are:

$$\pi^0 = \frac{(\lambda_0 k - s\bar{R})^2}{s(\lambda^0(m+1))^2}.$$

The average per-bank profit will be the product between the average number of successful contracts and the expected profit per borrower: $\Pi^0 = B_0\pi^0$, where

$$B_0 = \frac{B}{N}\Big(m\Big(\lambda + (1-\lambda)\Big(1 - \frac{R_1}{a}\Big)\Big) + \sum_{i=1}^{m-1} i(1-\lambda)\frac{R_1}{ma}\Big).$$

Proof of Proposition 3.3 and 3.4

We will use the "geographic" representation of our economy in order to get a simple picture of the interaction between banks and borrowers. The N banks and B borrowers are uniformly distributed on a circle. The segment BC' is the consortium, the size of which is to be determined. For simplicity, we assume that each borrower signs contracts with the banks located clockwise up to distance m from the borrower's location.

Thus, borrowers are divided into two general categories:

1. borrowers who have all their contract in the consortium - these are borrowers on segment BA (segment 2);
2. borrowers who have "partial" contact with the consortium - these are borrowers on segment AC'(segment 1), and CB (segment 3). In both categories, L-type borrowers can default in the consortium, and thus not get a credit in the second period.

Low-type borrowers that have a credit history both inside and outside the credit bureau can choose where to repay or default ("strategic repayment"). We consider the case where 1. interest rates inside the consortium are low and 2. borrowers with a partial history inside the consortium are not "rationed" by the inside banks. This means that borrowers that have had contracts with members of the consortium will prefer to repay within the consortium, and that they will ask for/receive credit *only* from banks within the consortium[13].

The number of creditworthy borrowers in each group is equal to all high type borrowers on each segment, plus those lucky low-type borrowers, who have succeed on all their contracts in the consortium. To calculate the number of borrowers in each category, note that the length of segment (2) is $n - m + 1$, and borrowers there need to have m success for second period credit. The length of segments 1 and 3 is $m - 1$ each.

Creditworthy borrowers:

- For category (1) this includes borrowers with m successful contracts in the consortium, includes: $(n - m + 1)\frac{B}{N}\lambda$ high type borrowers and

$$B^m = (n - m + 1)\frac{B}{N}\Big[\lambda + (1 - \lambda)\Big(1 - \frac{R_1}{a}\Big)\Big];$$

For category (2), with i $(1 \leq i \leq m - 1)$ successful contracts in the consortium, this

[13]One may wonder why low-type borrowers care about the interest rates, given that they will not repay anything with probability 1 (given our simplifying assumption). In our model, a lower interest rate means a higher demand for loans from the high-type borrowers. Since low-type borrowers mimic the high-type borrowers, they will ask for/ receive a similar amount. Moreover, it is quite likely that the private benefits from "being in business" are increasing in the amount of funding they can get.

includes equal number of borrowers from segment 2 and 3 (we will refer to borrowers with i success contract as i type borrowers):

$$B^i = \frac{2B}{N}\Big[\lambda + (1-\lambda)\Big(1 - \frac{iR_1}{ma}\Big)\Big].$$

Banks have already had lending relationships with some of the borrowers in the first period, and they have observed their success or failure (default). In the second period:

- the number of banks in the consortium, n, is chosen;
- information on first-period credit histories is exchanged among inside lenders;
- banks choose the quantity to lend;
- interest rates are determined.

We are looking for an equilibrium where

1. The consortium size is bigger than the number of banks borrowers have contracted with ($n > m$);
2. All other borrowers (that is, borrowers with 1 or more success histories and no default) are served in the consortium.

This is equivalent to saying that a) the equilibrium interest rate for borrowers with at least a contract in the consortium is below that set by outside banks, and b) banks will have enough capacity to lend to all these borrowers.

More formally, the above equilibrium condition means inside banks should make the same profits on funds lent to any type:

$$\lambda^i R^i - \bar{R} = \lambda^j R^j - \bar{R}$$

thus

$$R^i = \frac{\lambda^1}{\lambda^i} R^1$$

for any $1 \leq i \leq m$.

If the equality did not hold, banks would always be able to increase their profits by shifting their funds to the more profitable type.

The interest rate for type i can therefore be expressed as a function of the interest rate for the borrowers that have had only one contract inside the consortium:

$$R^i = \frac{\lambda^1}{\lambda^i} R^1$$

for any $1 \leq i \leq m$.

Each inside bank i chooses D_i so as to solve the following maximization problem:

$$\text{Max}D_i\Big(\lambda_1 R^1 - \bar{R}\Big)$$

s.t

$$\sum_{j=1}^{m} B^j(k - sR^j) = \sum_{l=1}^{n} D_l$$

Interest rates will be determined from the constraint, and therefore will be given by

$$R^1 = \frac{k\sum_{j=1}^{m} B^j - \sum_{l=1}^{n} D_l}{s\lambda^1 \sum_{j=1}^{m} \frac{1}{\lambda^j}}$$

Thus the maximization problem reduces to

$$\text{Max}D_i\Big(\frac{k\sum_{j=1}^{m} B^j - \sum_{l=1}^{n} D_l}{s\sum_{j=1}^{m} \frac{1}{\lambda^j}} - \bar{R}\Big)$$

In a symmetric equilibrium, each bank will choose total deposits equal to

$$D^i = \frac{1}{n+1}\Big(k\sum_{j=1}^{m} B^j - \bar{R}s\sum_{j=1}^{m} \frac{1}{\lambda^j}\Big)$$

The equilibrium interest rate for borrowers that have had a success story within the consortium is equal to

$$R^1 = \frac{\frac{1}{n+1}\sum_{j=1}^{m} B^j + \frac{n}{n+1}\bar{R}s\sum_{j=1}^{m} \frac{1}{\lambda^j}}{s\lambda^1 \sum_{j=1}^{m} \frac{1}{\lambda^j}}$$

The profit margin for the funds lent by the inside banks is equal to

$$\lambda^1 R^1 - \bar{R} = \frac{1}{n+1}\frac{k\sum_{j=1}^{m} B^j - \bar{R}}{s\sum_{j=1}^{m} \frac{1}{\lambda^j}}$$

Expected profits per bank:

$$D^*(\lambda^1 R^1 - \bar{R}) = \frac{1}{(n+1)^2}\frac{1}{s\sum_{j=1}^m \frac{1}{\lambda^j}}(k\sum_{j=1}^m B^j - \bar{R}s\sum_{j=1}^m \frac{1}{\lambda^j})(k\sum_{j=1}^m B^j - \bar{R})$$

$$\begin{aligned}\sum_{j=1}^m B^j &= (n-m+1)\frac{B}{N}\Big(\lambda + (1-\lambda)\Big(1-\frac{R_1}{a}\Big)\Big) + \frac{2B}{N}\sum_{j=1}^{m-1}\Big(\lambda + (1-\lambda)\Big(1-\frac{R_1 i}{ma}\Big)\Big) \\ &= (n+m-1)\frac{B}{N}\Big(\lambda + (1-\lambda)\Big(1-\frac{R_1}{a}\Big)\Big) + \frac{B}{N}(1-\lambda)(m-1)\end{aligned}$$

Denote $c \equiv kB/N\Big(\lambda + (1-\lambda)\big(1-\frac{R_1}{a}\big)\Big)$, $b' \equiv \frac{(m-1)kB/N\Big(\lambda+(1-\lambda)\Big(1-\frac{R_1}{a}\Big)+(1-\lambda)\Big)}{c}$and note that $k\sum_{j=1}^m B^j = c(n+b')n$. Now denote $b \equiv b'-1$, and $n+1 \equiv n$, and note that our per member profit maximization will be equivalent to maximizing (after ignoring constant $\frac{1}{s\sum_{j=1}^m \frac{1}{\lambda^j}}$)

$$\frac{1}{n'^2}\Big(n' + b - \frac{\overline{R}}{c}s\sum_{j=1}^m \frac{1}{\lambda^j}\Big)\Big(n' + b - \frac{\overline{R}}{c}\Big)$$

Rewriting it as

$$\frac{1}{n'^2}\Big(n' - \big(\frac{\overline{R}}{c}s\sum_{j=1}^m \frac{1}{\lambda^j} - b\big)\Big)\Big(n' + b - \frac{\overline{R}}{c}\Big)$$

Further denoting $\frac{\overline{R}}{c}s\sum_{j=1}^m \frac{1}{\lambda^j} - b \equiv d$, and $b - \frac{\overline{R}}{c} \equiv e$, we simplify our objective function to

$$\frac{1}{n'^2}(n'-d)(n'+e)$$

Now we can find optimal n' from FOC

$$\big(2n' + (e-d)\big)n'^2 - \big(n'^2 + (e-d)n\text{"} - de\big)2n' = 0$$

Thus,

$$n' = \frac{2de}{e-d}$$

Proof of Propositions 3.5 and 3.6

The proof is very similar to that of 3.2
Given binding deposit constraints, the equilibrium interest rate is given by

$$k - sR_2^0 = \sum_{j=1}^{m} D_j^0;$$
$$R_2^0 = \frac{k - \sum_{j=1}^{m} D_j^0}{s}.$$

In choosing their deposits, banks solve the following maximization problem:

$$\text{Max}_{D_j^0} D_j^0(\lambda^0 R_2^0 - \bar{R})$$

where λ^0 is the updated proportion of high-type borrowers conditional on observing a successful repayment:

$$\lambda^0 = \frac{\lambda}{\lambda + (1-\lambda)\left(1 - \frac{R_1}{ma}\right)}$$

The first-order condition of the maximization problem is:

$$\lambda^0 \frac{k - D_j^0 - \sum_{j=1}^{m} D_j^0}{s} = \bar{R}$$

hence optimal deposits per successful borrower are:

$$D_j^0 = \frac{\lambda^0 k - s\bar{R}}{\lambda(m+1)}.$$

Plugging in he expression for optimal deposits we get the second-period interest rate without information sharing:

$$R_2^{out} = \frac{k}{s}\frac{1}{m+1} + \frac{m\bar{R}}{(m+1)\lambda^0}.$$

The expected second-period profits per successful first-period contract are:

$$\pi^{out} = \frac{(\lambda_0 k - s\bar{R})^2}{s(\lambda^0(m+1))^2}.$$

The total number of successful contracts of outside banks is equal to

$$N^{tot} = \frac{B}{N}\Big(\lambda + (1-\lambda)\Big(1 - \frac{R_1}{ma}\Big)\Big)(N-n-m+1)\Big(\frac{m(m-1)}{2}\frac{R_1}{ma-R_1} + \frac{(a-R_1)m^2}{am-R_1}\Big)$$

yielding the result in proposition 3.6. Note now, that

$$sign\Big(\frac{\partial \Pi^{out}}{\partial n}\Big) = sign\Big(\frac{\partial (N-n-m+1)/N-n}{\partial n}\Big) = sign\Big(\frac{-m+1}{(N-n)^2}\Big).$$

Thus, $\frac{\partial \Pi^{out}}{\partial n} < 0$.

Proof of Proposition 3.7

1. The highest possible interest rate is the monopoly interest rate, which maximizes the profits banks can extract from each borrower. For a borrower with i successful contracts within the consortium, the monopoly interest rate will solve the following maximization problem:

$$\text{Max}(k - sR^i)(\lambda^i R^i - \bar{R}).$$

Hence the highest collusive interest rate for group i borrowers will be $R^i_{coll} = \frac{1}{2s\lambda_i}(s\bar{R} + k\lambda_i)$.

2. An individual bank will deviate by choosing an amount of loanable funds in excess of that implied by collusion. The equilibrium interest rate for borrowers with one successful contract will be given by:

$$R^1 = \frac{k\sum_{j=1}^m B^j - \sum_{l=1,l\neq i}^n D_l - D_i}{s\lambda^1 \sum_{j=1}^m \frac{1}{\lambda^j}}.$$

The shirking bank maximizes

$$\text{Max} D_i\Big(\frac{k\sum_{j=1}^m B^j - \sum_{l=1,l\neq i}^n D_l - D_i}{s\sum_{j=1}^m \frac{1}{\lambda^j}} - \bar{R}\Big)$$

It is easy to check that the profits generated by solving this maximization problem are increasing in n. At the same time, increasing n decreases the per-bank collusive profits. Hence shirking becomes possible if n is too high.

An alternative way to define deviation assumes that the other inside banks will keep their interest rates unchanged when one of the banks in the consortium shirks. This means that the deviating bank will capture the whole market for one period.

Since the ratio between profits from shirking and the individual profits under collusion is increasing in the number of the banks in the consortium (an individual bank is $\frac{1}{n}$ of the inside market), shirking becomes more attractive as the size of the consortium increases.

Proof of Proposition 3.8

With very low credit report prices, banks will find it worthwhile to ask for reports even for borrowers that have not had a bank relationship with them in the first period.

Given binding deposit constraints, the interest rate will be given by

$$B'(k - sR^{low}) = \sum_{i=1}^{N} D_i,$$
$$R^{low} = \frac{Bk - \sum_{i=1}^{N} D_i}{Bs}.$$

where $B' = B(\lambda + (1-\lambda)(1-\frac{R_1}{a})$ The optimal per-bank deposits will solve the following maximization problem:

$$\text{Max} D_j \Big(\lambda^m R^{low} - \bar{R} - c \Big).$$

The first-order condition is

$$\bar{R} + c = \frac{B'k - \sum_{i=1}^{N} D_i - D_j}{B's}.$$

Hence the equilibrium interest rate is

$$R^{low} = \frac{k\lambda^m + s(\bar{R} + c)}{s\lambda^m(N+1)}.$$

The expected profits for each bank are

$$\Pi^{low} = \frac{B'}{s} \frac{(k\lambda^m - (\bar{R} + c))^2}{(\lambda^m)^2(N+1)^2} - \frac{B}{N}(1-\lambda)\frac{R_1}{a}c \tag{13}$$

where the last term represents cost of per member unused reports, the number of which is $\frac{B-B'}{N} = \frac{B}{N}(1-\lambda)\frac{R_1}{a}$.

Proof of Proposition 3.9

If capacity constraints hold, then m banks compete for Bm/N borrowers choosing interest rate for each borrower and deposits d by

$$\sum_{j=1}^{m} d_j = \frac{Bm}{N}(k - sR)$$

Let's denote

$$\sum_{j=1}^{m} D_j = k - sR$$

$$R = \frac{k - \sum_{j=1}^{m} D_j}{s}$$

Banks will choose their deposits so as to maximize their profits:

$$\text{Max} D_i[\lambda^m R(\sum_{j=1}^{m} D_j) - \bar{R} - c]$$

$$\text{Max} D_i\Big[\lambda^m \frac{k - \sum_{j=1}^{m} D_j}{s} - \bar{R} - c\Big]$$

The first-order condition is:

$$\lambda^m \frac{k - \sum_{j=1}^{m} D_j}{s} - \bar{R} - c - \frac{\lambda^m}{s} D_i = 0$$

In a symmetric equilibrium, the quantity chosen by each bank for one of its own successful/ confirmed borrowers will be:

$$D_i = \frac{k\lambda^m - (\bar{R} + c)s}{(m+1)\lambda^m}$$

The equilibrium interest rate will be:

$$R = \frac{k\lambda^m + s(\bar{R} + c)}{s\lambda^m(m+1)}.$$

The profits per successful borrower are

$$\pi = \frac{(k\lambda^m - (\bar{R}+c))^2}{s(\lambda^m)^2(m+1)^2}.$$

The ex ante expected total profits are

$$\Pi^{tot} = \frac{Bm}{N}\Big(\lambda + \Big(1-\lambda\Big(1-\frac{R_1}{a}\Big)\Big)\Big)\frac{(k\lambda^m - (\bar{R}+c))^2}{s(\lambda^m)^2(m+1)^2} - \frac{B}{N}(1-\lambda)\frac{R_1}{ma}c \qquad (14)$$

Comparing profits and the previous two equilibria (13 and 14) one can see that poaching is never optimal

Proof of Proposition 3.10

We show the following is an equilibrium:
1.Bureau offers: $F = \Pi^{high} - \epsilon = \frac{B}{N}\Big(\lambda + (1-\lambda)\Big(1-\frac{R_1}{a}\Big)\Big)\frac{(k\lambda^m - s(\bar{R}+c))^2}{\lambda^m s(m+1)^2} - \frac{B}{N}(1-\lambda)\frac{R_1}{ma}c - \epsilon$ and c per report for those who contribute to the report while prohibitively costly for those who do not. 2.All banks join the bureau. Given the bureau's strategy deviation by any bank yields 0 profits, while in bureau they earn ϵ.

For any c and F and deviating to selling reports at c to non-contributing banks increases competition (for any size of the bureau), reduces bank profits from Π^{high} to $\Pi^{inside} = D^*(\lambda^1 R^1 - \bar{R} - c) = \frac{1}{(n+1)^2}\frac{1}{s\sum_{j=1}^m \frac{1}{\lambda^j}}(k\sum_{j=1}^m B^j - (\bar{R}+c)s\sum_{j=1}^m \frac{1}{\lambda^j})(k\sum_{j=1}^m B^j - (\bar{R}+c))$ which can directly be seen from the proof of proposition 3.3. This hits participation constraint, else the bureau has to reduce the fee. For any F and c and any n it is always optimal to reduce c and increase F in a way that participation constraints binds (up to an ϵ). deviating to offering membership to fewer banks reduces profits from NF to nF for $n \geq N - m$ and also decreases F to $F = \Pi^{high} - \Pi^{out}$ when $n < N - m$ and decrease number of reports purchased.

Proof of Proposition 3.11 and 3.12

It can be easily seen that the bureau's participation constraint is binding. If not, then the bureau can increase bank's profits by either decreasing c or F. Substituting for F from the binding participation constraint and comparing 10 and 11, it can be immediately seen that a member bank's objective function is the same except that $\frac{n-1}{n}c_c$ stand for c. Thus, $c_c = \frac{n}{n-1}c$ and that in equilibrium banks have the same profits under the two ownership structures.