Endogenous Communication Among Lenders and Entrepreneurial Incentives

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If banks have an informational monopoly about their clients, borrowers may curtail their effort level for fear of being exploited via high interest rates in the future. Banks can correct this incentive problem by committing to share private information with other lenders. The fiercer competition triggered by information sharing lowers future interest rates and future profits of banks. But, provided banks retain an initial informational advantage, their current profits are raised by the borrowers' higher effort. This trade-off determines the banks' willingness to share information. Their decision affects credit market competition, interest rates, volume of lending, and social welfare.

One often observes that lenders communicate to each other information about the creditworthiness of their customers. Sometimes this informational exchange is so intense and frequent as to be intermediated by

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information brokers, such as credit bureaus and credit rating agencies. Typically these information brokers gather information about past defaults or delays in payment ("black information") or about the current debt exposure, performance, and riskiness of the borrower ("white information"). These data are mainly provided by banks, finance companies, and suppliers, and are consolidated in a file for each company or individual. This file is later accessed to provide information upon request via a credit report. In most instances, only lenders and suppliers who provide data are allowed to access this consolidated information, albeit at a small fee. The accuracy of the reported information is routinely verified — for instance, by cross-checking lenders' and borrowers' financial and accounting statements — and misreporting is sanctioned by exclusion from further access to the database.

This information exchange concerns companies as well as households. One of the main U.S. rating agencies, Dun & Bradstreet Information Services, collects and delivers information on 32 million companies worldwide, of which 18 million are in the United States, and much of it comes from banks and suppliers. More than 300 banks regularly contribute data on loan and average account size electronically, and thousands more do it by phone or mail. Over 600,000 companies provide payment references with data about delays and defaults by downstream companies. In 1992, Dun & Bradstreet received 3,700,000 banking reports and 207,400,000 payment reports. Also, in the United Kingdom credit reference agencies collect and disseminate vast amounts of data about businesses, mostly reported by finance companies. Credit bureaus provide a similar service for the consumer credit market. In the United States they currently issue some 400 million reports per year about credit seekers, and coverage of the households that have applied for consumer credit is virtually complete. Credit bureaus are also very active in the United Kingdom, Japan, and several other countries [see Pagano and Jappelli (1993)].

Information sharing among banks produces two types of effects. On the one hand, it tends to diminish informational asymmetries between lenders and borrowers, and thus reduces the impact of adverse selection and moral hazard on lending decisions. On the other hand, it stimulates harsher competition between banks, slashing their informational rents. The net effect on banks' profits is ambiguous: the improved performance of entrepreneurs need not translate into higher profits, since the latter may be dissipated by increased competition. Depending on the balance between these factors, banks may have the incentive to pool their private information with competitors or keep their information private. Focusing on this trade-off, one can identify the circumstances in which lenders will share spontaneously their pri-

vate information, as well as the type and precision of the information that they will release to competitors.

Even though we develop the analysis with reference to credit markets, we would like to stress that our story can be seen as an instance of a more general principle — that information sharing, by raising ex post competition among principals, can sharpen agents' incentives, which in some cases can benefit the principals themselves. It is easy to think of other examples. By agreeing to provide references about their former employees, firms can induce them to work harder while they are in the job. Similarly, the U.S. graduate schools' standard practice of writing reference letters for their students in the job market improves the average quality of their research. Other examples can also be found in the housing market and in the insurance market.

We develop the analysis in the context of a two-period model with imperfectly competitive banks and heterogeneous entrepreneurs. The performance of each loan depends both on the intrinsic qualities of the entrepreneur and on his effort choice. In the first period, each bank has better information than its competitors about the characteristics of some entrepreneurs, and can thus extract informational rents from them. However, the very presence of such monopoly power thwarts its borrowers' incentives perform: fearing that the return to their effort will be partly appropriated by their bank via high future interest rates, borrowers will tend to exert a low level of effort and perform badly in the current period.

Banks can correct this incentive problem by committing to share with other lenders their private information about the quality of their customers at the end of the first period. The resulting competitive pressure forces them to forgo opportunistic behavior in the second period. Anticipating this, borrowers step up their initial effort level. This raises banks' profits in the first period, when each bank still retains an informational advantage. But the fiercer competition that intervenes later reduces second-period profits. The ex ante decision to sign an information sharing agreement depends on which effect is expected to prevail. We study how the model parameters impinge on this decision and how its outcome affects the efficiency of the credit market, the volume of lending, and the interest rates charged to entrepreneurs.

To be viable an information sharing agreement must consider that ex post each bank will be tempted to cheat: once a customer has performed well, the inside bank has the incentive to abstain from informing outside competitors (or to misreport its information) and predate on the customer. Thus the agreement must contemplate a system to issue and enforce sanctions against deviant banks. In the context of our model, a simple decentralized reputation system can

prevent such deviant behavior under mild conditions about the banks' discount rate, provided information can be transmitted across generations costlessly: if subsequent customers can learn about the deviation, they will "force" the deviant bank toward the equilibrium with no information sharing.

In practice, one finds that the private enforcement mechanism used in these cases relies on more than a decentralized reputation system: wherever lenders spontaneously agree to share information via credit bureaus, the sanction against opportunistic behavior is subsequent exclusion from the system [Pagano and Jappelli (1993)]. Why in practice do banks need the explicit threat of exclusion from the informational exchange?

In this article, we develop the following explanation. We show that no individual borrower has the incentive to detect past deviations, nor to inform subsequent customers if he has been "squeezed" by his bank. Borrowers are short-lived agents who care only about payoffs in their own lifetime and are thus unwilling to bear the cost of communicating with future generations, even if this cost is small. No individual bank has such an incentive either. Therefore, a decentralized reputation system cannot sustain the information sharing agreement if the transmission of information across generations is costly.[1]

But the effectiveness of the reputation mechanism can be restored by a multilateral institution, such as a credit bureau. The bureau is formed and financed by long-lived banks and is instructed to detect deviants, exclude them from further access to the bureau, and let any customer freely ascertain if its potential lender is still a valid member of the system. So the credit bureau ensures the transmission of information across generations of would-be customers, and thus the viability of the reputation mechanism. We show that, if the costs incurred by the bureau (most importantly, the costs of verifying the information provided by members) are not too large, lenders are willing to finance the bureau in order to be able to lend profitably in the future. The same argument has been proposed to explain other private enforcement mechanisms, such as the system of private judges that sanctioned dishonest merchants in medieval Champagne fairs: "in a large community, [. . .] it would be too costly to keep everyone informed about what transpires in all trading relationships, as a sim-

[1] If a decentralized reputation system can sustain an information sharing agreement among lenders, it can also sustain the lenders' commitment to a sequence of low interest rates, which has the same implications on entrepreneurs' incentives and overall market efficiency as information sharing [see Sharpe (1990)]. But the commitment to low interest rates faces the very same problems of sustainability as an information sharing agreement supported by a decentralized reputation system. (See Section 1.3.)

ple reputation system might require" [Milgrom, North, and Weingast (1990, p. 3); see also Greif, Milgrom, and Weingast (1994)].

This is not the first article to focus on the incentive problems that arise from the exclusive relationship with a bank: Rajan (1992) shows that a company can limit the ex post monopoly power of the inside bank by borrowing from uninformed outside lenders and assigning different priorities to its creditors; in a similar spirit, von Thadden (1992) argues that duplicated monitoring can dominate exclusive monitoring in banking. Also in our model, outside lenders compete with the inside bank, but the effect of competition on entrepreneurial incentives depends on the information that the inside bank optimally precommits to release. As noticed by von Thadden (1992) and Dewatripont and Tirole (1994), the argument that competition can offer protection against the predatory behavior of the inside bank is reminiscent of the "dual sourcing theory" in industrial organization, as developed by Farrell and Gallini (1988) and Shepard (1988). These last two articles analyzed models in which a buyer invests in a specific asset (e.g., a mainframe computer) and a seller chooses, ex post, some variable that affects the value of the asset and is not contractible ex ante (e.g., the quality of service and maintenance). Ex post the seller has an incentive to choose a low quality and, therefore, ex ante the buyer invests little in the asset. Dual sourcing consists of having two or more suppliers, who compete ex post, increasing the equilibrium level of quality and thus raising ex ante efficiency.

The role of information sharing in inducing good behavior by entrepreneurs has also been analyzed in Padilla and Pagano (1996b). The main insight added in that paper is that the incentive effects of information sharing may be greater when banks disclose to each other only data about defaults, rather than more complete information about the credit worthiness of their customers. Another feature of the model in Padilla and Pagano (1996b) is that, due to unrestrained *ex ante* competition, banks always make zero expected profits and the net benefit from information sharing accrues entirely to their customers. Here, instead, we assume imperfect competition, so that banks retain their initial informational rents and internalize part of the incentive effects of information sharing.[2]

[2] Also Pagano and Jappelli (1993) focus on spontaneous information sharing by banks, but in the context of a pure adverse selection model. They show that, by agreeing to share information, each bank earns more profits from customers who happen to "migrate" into its market area, but loses part of its informational rents on its local customer base due to more aggressive outside competition. Also in that model, banks must have some monopoly power (irrespective of their decision to share information) for them to ever want to share information. [See also Van Cayseele, Bouckaert, and Degryse (1994).]

The article proceeds as follows. In Section 1 we present the basic model, where two types of entrepreneurs — high- and low-ability — can borrow to finance a project of a fixed size: we show that, if low-ability entrepreneurs invariably choose negative-NPV projects, information sharing is required for the credit market to operate at all. We also analyze the conditions to prevent cheating by the banks who participate in the information sharing agreement, and compare the sustainability (and thus the actual efficiency properties) of information sharing agreements vis-à-vis that of commitments to low interest rates. In Section 2 we generalize the model in various directions. Relaxing some of the assumptions of the basic model, we find — more realistically — that banks can operate also if they fail to share information, and study in which circumstances one would expect them to communicate and how this affects the size of the credit market and the rates charged to borrowers. Section 3 concludes the article.

1. The Basic Model

1.1 Description

We consider a two-period model of the credit market with risk-neutral borrowers and banks, where only one-period loan contracts are available.[3] Our economy is composed of many (strictly speaking, $N \geq 3$) "towns," each of which hosts a single bank and a continuum $[0, 1]$ of entrepreneurs. The local bank has superior information on local entrepreneurs, while it must incur a cost to learn about borrowers located in other towns.[4] Apart from this, competition among banks is unrestrained. Competition ensures that no bank will acquire costly information about lenders located in other towns: all the resulting rents would be dissipated to the benefit of entrepreneurs.

Entrepreneurs differ as to their ability to identify profitable projects. They fall in two classes: high- (H) and low-ability (L) types, whose respective proportions in the population are γ and $1-\gamma$ for $\gamma \in (0, 1)$. High-ability entrepreneurs choose projects which, if successful, yield

[3] In this model, by the time the loan contract is signed, the effort choice is sunk (see below), so that in the absence of repeated interaction long-term contracts cannot be used by the bank to precommit to anything other than the time-consistent policy. So the assumption of one-period contracts is not restrictive: the sequence of one-period contracts derived below coincides with the optimal *time-consistent* two-period contract. Otherwise, if the bank could precommit, it could always do better by offering *nonlinear* long-term contracts. (We thank Ian Jewitt for pointing this out to us.)

[4] Hannan (1991) presents evidence that U.S. firms mainly borrow from local lenders because of prohibitive informational and transactional costs. Petersen and Rajan (1995) also report that in their sample "over half the firms are within 2 miles of their primary institution. 90% of the firms are within 15 miles of their primary institution."

R^* units of output per period and, if unsuccessful, yield nothing. The probability of success, $p \in [0, \hat{p}]$, depends on their level of effort, which is nonobservable noncontractible, by assumption. (We define $\hat{p}$ as the first-best full information effort level, that is, the level of effort that would be chosen by high-ability entrepreneurs when banks charge actuarially fair interest rates.) Effort is chosen once and for all prior to any borrowing.[5] Since the probability of success p is monotonic in effort, we shall consider it as the borrowers' choice variable. Low-ability entrepreneurs, instead, are not creditworthy: whatever the rate at which they get credit, they choose projects with no return and are insolvent.

Each investment project requires one unit of capital, that entrepreneurs must always borrow entirely from one of the competing banks (entrepreneurs have zero initial wealth available for investment, and the project's output cannot be stored, so it does not generate additional collateral for subsequent operations). We assume that each individual investment project is run as a private limited liability company[6] and that the entrepreneur cannot be disqualified after default, so that (1) once the project matures the company is liquidated, (2) if the project fails to produce positive returns, the entrepreneur cannot be held liable for the losses incurred, so that his future investment projects are free from any floating charge, and (3) the failure of the current project has no bearing on the entrepreneur's legal capacity to promote new investment projects.[7] Furthermore, we assume that the profitability of any investment project is observable and contractible by the current lender, but not observable by any other outside lender. This last assumption implies that if the project succeeds the entrepreneur must repay the loan, and that if the entrepreneur defaults the event is only observed by his current lender.

If the high-ability entrepreneur i gets no credit, his expected utility is zero. If, instead, he gets credit and chooses a success probability

[5] Relevant examples may be the effort spent on hiring a good manager or on laying out a good business plan. These choices must be made *prior* to raising any external finance. But our main results would extend to a more general model, where some effort is also exerted after the loan contract is signed. In this case the bank and the customer would want to sign a two-period contract to correct the incentives of the borrower. This contract would solve the incentive problem for the portion of the effort to be exerted after the contract is signed, but our model would still apply for the portion of the effort that is sunk when the contract is signed.

[6] This is a simplifying assumption that makes our algebra simpler. We relax this assumption at the end of Section 1.2 to consider the case of entrepreneurs' unlimited liability, showing that our main results are robust to alternative bankruptcy rules.

[7] In most countries company managers are disqualified only if the company becomes insolvent because of fraud, negligence, or in general, if the conduct of the entrepreneur as a manager of the company makes him unfit to be concerned in the management of a company (see, for instance, the U.K. Company Directors Disqualification Act 1986). None of these reasons applies to our high-ability but unlucky entrepreneurs.

$p(i)$, his total discounted utility is equal to

$$U_H(p(i)) = p(i)\left[\left(R^* - R_{b1}\right) + \beta\left(R^* - E(R_{b2})\right)\right] - V(p(i)), \qquad (1)$$

where R_{b1} is the period 1 gross interest rate charged by bank b; $E(R_{b2})$ is the expected period 2 gross interest rate charged by bank b; $\beta \in (0, 1)$ is the discount factor; and finally, $V(p(i))$ is the total disutility of effort exerted to achieve $p(i)$. $V(\cdot)$ is increasing and convex ($\infty > V' \geq 0$ and $V'' > 0$), and $V(0) = V'(0) = 0$. Entrepreneurs rationally anticipate future interest rates, but assume that they cannot affect them, that is, behave as price takers. Notice that no high-quality entrepreneur will demand credit at rates strictly exceeding R^* (but since his effort is sunk, he is willing to borrow and run his project even if the bank charges him the rate R^*). Low-ability entrepreneurs derive no monetary payoff from borrowing, because their projects yield no return with certainty, and for the same reason they spend no effort on their project. But since they are assumed to derive positive, although arbitrarily small, utility from "being in business," they still participate in the credit market.[8]

In each period, lenders raise capital at a cost $\overline{R}$ and compete in interest rates given their respective information sets. At the beginning of the first period, each bank can costlessly distinguish between high- and low-ability entrepreneurs located in its town. It also knows the average ex ante probability of success, p, of the local high-ability entrepreneurs. Thus it has an informational advantage over its rivals with respect to these entrepreneurs. More precisely, we assume that

$$\gamma \widehat{p} R^* < \overline{R} < \widehat{p} R^*, \qquad (2)$$

which implies that in the absence of information sharing the local bank enjoys monopoly power in its own town in both periods, and that there are effort levels for which such a power is indeed profitable.[9] Define $\underline{p} > 0$ such that $\underline{p} R^* \equiv \overline{R}$, that is, as the minimum effort level by high-ability types that allows the bank to break even. Then Equation (2) ensures that, for all $p \in [\underline{p}, \widehat{p}]$, lending to high-ability entrepreneurs is a profitable activity.

[8] Notice that, with some slight changes, the model can be reinterpreted as referring to consumer credit rather than to business lending. More precisely, it can apply to the credit extended by a retailer for the purchase of a consumer durable, which is repossessed by the retailer in case of default. R^* can be thought of as the flow utility from the services of the durable and p as the effort that the consumer must undertake to avoid default, for instance by working overtime.

[9] We shall discuss the implications of relaxing this assumption in Sections 2.1 and 2.2.

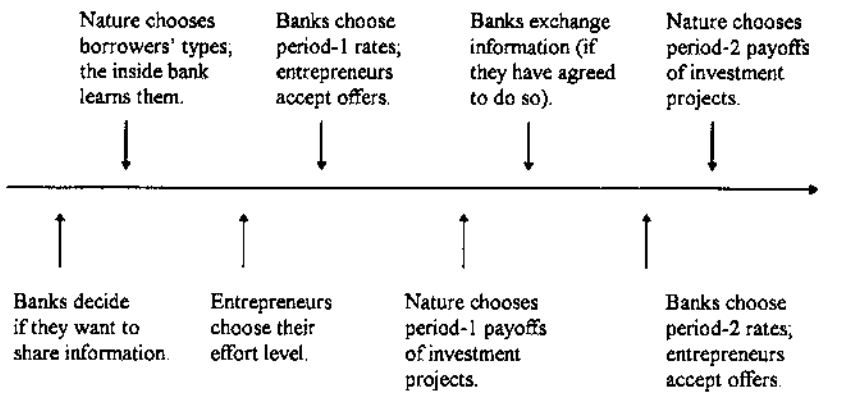

Figure 1
Timing of actions in the model

Since effort is assumed to be noncontractible, then interest rates cannot be conditioned on the individual borrower's probability of repayment $p(i)$, albeit they will obviously depend on the ex ante average probability of repayment, p. In period 2, bank b sets R_{b2} so as to maximize its current profits, Π_{b2}. In period 1, it chooses R_{b1} to maximize its total discounted expected profits, $\Pi_b = \Pi_{b1} + \beta\Pi_{b2}$, where Π_{b2} is evaluated at the equilibrium period 2 rates. This reflects the inability of banks to precommit to a given path of interest rates. The rates posted by each bank are public knowledge, but the rival bank cannot observe to whom they are offered. The sequence of events described above is summarized by the time line in Figure 1.

In Section 1.2 we analyze the model under two different scenarios. First, we assume that banks do not communicate any information about their borrowers. Second, we analyze the case in which they share information about the entrepreneurs' ability *and* can commit to report it honestly. (The case in which they cannot commit to honest reporting is analyzed in Section 1.3.)

In each case, we look for the subgame perfect equilibria (SPE) of the model, that is, a vector $\{p, (R_{b1}, R_{b2}), \forall b\}$ such that

1. Each high-ability entrepreneur i chooses $p(i)$ to maximize his expected utility, correctly anticipating the interest rates R_{bt} for $t = 1, 2$ and all b, and taking as given the effort choices of the other entrepreneurs in his town. Since high-ability entrepreneurs are all identical, we have that, in equilibrium, $p(i) = p$ for all i.

2. Banks maximize their profits given the average ex ante probability of success p, so that the interest rates (R_{b1}, R_{b2}), $\forall b$, constitute a subgame perfect equilibrium for the banking competition subgame.

1.2 The main result

Suppose for the moment that the entrepreneurs' average effort level, p, is exogenously given. In the absence of communication among banks, our previous assumptions imply that each bank can extract all surplus from the entrepreneurs at its location. Therefore, if $p \geq \underline{p}$, high-ability entrepreneurs are charged the reservation rate R^*, whereas low-ability entrepreneurs are denied access to credit. Otherwise, if $p < \underline{p}$, both classes of entrepreneurs are left without credit. The total discounted profits of each bank in the absence of communication are thus equal to

$$\Pi^{ns}(p) = \begin{cases} (1+\beta)\gamma(pR^* - \overline{R}) & \text{if } p \geq \underline{p}, \\ 0 & \text{otherwise.} \end{cases} \tag{3}$$

By sharing information on the types of local entrepreneurs in period 2, banks give away their informational rents and so forgo all monopoly profits in this period. In fact, rate-setting competition among fully informed banks in period 2 leads to actuarially fair interest rates for high-quality entrepreneurs, that is, $R_2^{is} = \overline{R}/p$, and no credit to low-ability entrepreneurs if $p \geq \underline{p}$. As before, credit is refused to everybody if $p < \underline{p}$. Therefore, period 2 profits are equal to zero for all banks. But in period 1 banks retain their informational advantage in their respective towns, so that they can extract all the surplus from high-ability entrepreneurs by lending to them at a rate R^*, and simultaneously refuse credit to low-ability entrepreneurs if $p \geq \underline{p}$. The total discounted profits of each bank under information sharing are equal to

$$\Pi^{is}(p) = \begin{cases} \gamma(pR^* - \overline{R}) & \text{if } p \geq \underline{p}, \\ 0 & \text{otherwise,} \end{cases} \tag{4}$$

so that

$$\Pi^{is}(p) \leq \Pi^{ns}(p) \text{ for all } p. \tag{5}$$

Therefore, if effort levels were exogenous banks would have no incentive to communicate their borrowers' types, as this would only have the effect of fostering competition in period 2. But of course effort levels are endogenously chosen. When banks do not communicate, high-quality entrepreneurs know that, if they are given credit, their bank will appropriate the entire surplus of the project ex post. So they choose to exert zero effort ex ante: in equilibrium, $p^{ns} = 0$. This implies that in the absence of communication among banks the credit market *collapses*, since banks have to close down or else incur losses. This need not happen under information sharing. In this case, there may be multiple SPE for our model: there is always an equilib-

rium involving zero effort and market collapse, but there may be other equilibria involving positive effort levels that strictly Pareto dominate the zero effort equilibrium. The intuition behind this multiplicity is clear: if the average borrower chooses a low p^{is}, the interest rate will be high, so that each individual borrower is induced to choose a low effort level, and p^{is} will be low in a symmetric equilibrium (and vice versa if the average borrower chooses a high p^{is}). Hence, in those cases where multiple equilibria do exist, the credit market will be active under information sharing provided entrepreneurs can coordinate on an equilibrium with positive effort. This indicates that information sharing is a necessary but not sufficient condition for an active credit market: in a depressed economy where entrepreneurs are expected to slack, setting up an information sharing system among banks will not per se induce lending. These results are formally stated in the following lemma and proposition (proofs are in Appendix A).

Lemma 1. *Under information sharing, the repayment probability optimally chosen by a high-ability entrepreneur is no lower than under no information sharing, that is,* $p^{is} \geq p^{ns} = 0$. *Furthermore, there are functional forms for the total disutility of effort* $V(\cdot)$, *such that there is at least an SPE (which is not Pareto dominated) with* $p^{is} > \underline{p} > p^{ns} = 0$.

From Lemma 1 and Equations (3), (4), and (5), we can directly establish our main result:

Proposition 1. *Under information sharing, equilibrium profits are no lower than under no information sharing, that is,* $\Pi^{is}(p^{is}) \geq \Pi^{ns}(p^{ns}) = 0$. *Furthermore, there are functional forms for the total disutility of effort* $V(\cdot)$, *such that there is at least an SPE (which is not Pareto dominated) with* $\Pi^{is}(p^{is}) > 0 = \Pi^{ns}(p^{ns})$.

In conclusion, in this simple model communication among lenders is a necessary condition for the existence of an active credit market. In the absence of communication, lending is always unprofitable; in its presence, lending can become profitable. If it does, the welfare level of borrowers rises so that information sharing brings about a strict Pareto improvement. This result is independent of the precise bankruptcy rules described in Section 1.1, which put a limit on the entrepreneurs' liability in case of default. Consider what happens if entrepreneurs have *unlimited liability* (though, as before, are not disqualified from business in case of failure). This means that, if the period 1 project fails, the unpaid debt and interest is carried over to period 2, and this liability is senior relative to period 2 interest. Under a condition analogous to Equation (2), which ensures that without information sharing the inside bank enjoys local monopoly power in both periods, we can show that (1) in the absence of communi-

cation the credit market collapses, since in equilibrium high-ability entrepreneurs optimally choose to exert no effort; (2) under information sharing, lending can be profitable: high-ability entrepreneurs exert positive effort in any non-Pareto dominated SPE, irrespectively of whether they can avoid past liabilities by switching banks or not. These results are shown in Appendix B.

1.3 Sustainability of the information sharing agreement

While in this basic model information sharing is needed for the viability of the credit market, the information sharing agreement itself will not be viable if it does not contemplate sanctions against deviant banks. In fact, once its customers have performed well, each bank has the incentive to renege on its commitment to honestly reveal its private information to outside competitors so that it can predate on its customers. Obviously, if customers anticipate this behavior, they do not exert any effort in the first place. Thus one must make sure that the punishment for deviant banks exceeds the temptation to deviate. This requires that the game described in the previous section be repeated over time. We assume that infinite-lived banks face overlapping generations of two-period-lived customers (where each generation is identical to the single generation in the original model): at each date, in the equilibrium with information sharing, they lend monopolistically to young customers in their market area and compete with other banks for old customers. Banks' payoffs are now determined as the discounted sum of their periodic profits. The timing of events is as described in Figure 1 with the additional assumption that the effort choices of any newborn generation are sunk by the time banks post their rates for young and old customers, respectively.

1.3.1 Game 1. Informationally isolated generations. Our first model represents the situation of entrepreneurs who only know the lending rates offered to them: in particular, when young, they cannot observe the interest rates charged on old customers nor communicate with previous and/or future generations of entrepreneurs any information regarding the behavior of their banks. In this game, it is immediate that

Proposition 2. *No Nash equilibrium of game 1 can support the information sharing outcome* $\{p^{is}, (R^*, \overline{R}/p^{is}),\ \forall\ h\}$.

In other words, no reputation mechanism based only on sanctions from those who are cheated can sustain the most efficient information sharing equilibrium. As emphasized by Greif, Milgrom, and Weingast (1994), Nash equilibrium is the relevant concept to use here, since we just want to show that even with the most inclusive of noncoopera-

tive equilibrium concepts, there is no way to sustain the information sharing agreement.

1.3.2 Game 2. Informationally linked generations: a decentralized communication mechanism. Suppose now that entrepreneurs learn about the interest rates charged to previous generations, because, in any period, old customers can credibly and costlessly communicate their experiences and those of their predecessors to young customers in the same market area. That is, we assume that young entrepreneurs always know whether a bank behaved dishonestly with any preceding generation.

Proposition 3. *There is an SPE for game 2 in which information sharing is sustainable over time if and only if* $\beta > 0.62$.

Thus, under mild restrictions on the discount factor, a simple reputational mechanism ensures that banks do not cheat. But this requires that the old customers "squeezed" by the local bank can credibly and costlessly communicate their experiences to younger customers in the same market area. Moreover, it requires that the would-be customers of the local bank in each generation inform those in the subsequent generation that the bank misbehaved in the past, so that the latter's bad reputation lingers on. But none of these agents has any incentive to pass on this information: entrepreneurs who were "squeezed" have nothing to gain from doing so, and they strictly lose if documenting the fact involves a cost. The same holds for subsequent generations of would-be customers. Nor does any individual bank have such an incentive since (1) detecting a deviation at a location different from its own amounts to learning the true types of the entrepreneurs at that location, which involves a cost, and (2) there is no direct gain to benefit from, since competition with the local bank will dissipate all rents to the benefit of the local entrepreneurs.

In summary, if communication across generations involves any cost, entrepreneurs — being short-lived and self-interested — will not inform future generations of their experiences and the decentralized reputation system will collapse. The problem is similar to that analyzed in Allen (1984), Klein and Leffler (1981), and Shapiro (1983). These authors show that, in markets for experience goods, firms cannot credibly commit to offer high quality unless they can earn nonnegligible rents from honest behavior and there is perfect communication among buyers so that cheating firms lose all their future sales. It is this last requirement that, according to our previous reasoning, is unlikely to hold in practice.

1.3.3 Game 3. Informationally linked generations: credit bureaus. The problems just discussed explain why in practice information sharing agreements among lenders require an institution like a credit bureau to be viable. The credit bureau must be designed to enforce compliance by individual banks: it must detect and credibly sanction any deviation by excluding the deviant bank from further access to the bureau, and it must inform current and future generations of entrepreneurs about any such deviation.

Suppose that at t_0, N banks choose to form a credit bureau. The credit bureau is an independent legal entity, which acts as a principal with respect to the member banks at $t \geq t_0$ and whose statutes are designed at t_0. We assume that creating and organizing a credit bureau involves a fixed start-up cost $K > 0$, which is equally shared among the bureau's members at t_0. Its statutes instruct the personnel of the credit bureau to collect information about entrepreneurs' types from their local banks, verify it, and make it available to all the members of the bureau, and only to them. We assume that the credit bureau can perfectly monitor, albeit at a cost, all reports provided by its members.[10] Once failure to report or misreporting is detected, these statutes mandate the bureau exclude the deviant bank from the common database. The statutes of the bureau also include a clause forbidding the readmission in the bureau of past deviators.[11] At any point in time, the bureau publicizes the list of its current members as well as the list of previous members who deviated in the past. So entrepreneurs at any location can always freely ascertain whether their potential lenders are still valid members of the bureau or if they misbehaved in the past.

On top of its fraction of the start-up fixed cost K, each member of the credit bureau must pay a membership fee $c \geq 0$ in each period $t \geq t_0$ to cover the costs incurred by the bureau to handle the files of the member bank's customers and to verify the information contained in them. A bank qualifies for membership only if it pays the fee c in each period.

[10] There are many ways in which banks can verify the information provided by their members. Misleading information may eventually emerge if the borrower goes bankrupt or may be simply revealed by word of mouth. In practice, credit bureaus cross-check the information they obtain from lenders with that provided by suppliers, by the debtors themselves, as well as from public sources, such as courts, public registers, accounting statements, etc. Our results are qualitatively unaffected if misreporting is not detected with probability one. Basically this would reduce the parameter region in which the credit bureau is sustainable, just like an increase in the cost of verifying the truthfulness of the members' reports.

[11] In the absence of such a clause, the deviator could bribe the remaining members of the bureau to admit it back into the bureau and delete its name from the bureau's black list. Hence, the exclusion threat would not be renegotiation-proof, which would destroy the credibility of the credit bureau.

Proposition 4. *For any $c \in [0, c^*]$, where $0 < c^* < \infty$, there exists a real number $\underline{\beta}(c) \in [0, 1]$, strictly increasing in c, such that there is an SPE for game 3 for which information sharing is sustainable over time if and only if $\beta > \underline{\beta}(c) \geq 0.62$.*

Intuitively, for the credit bureau to be viable its costs of verifying reported information must not be too large, that is, its fees c must be below the critical level c^*. Within that range its viability will depend on the discount factor of banks. An expensive credit bureau (a high c) is viable only if banks are sufficiently farsighted (a high β).

Two important remarks are in order. First, if (β, c) satisfy Proposition 4, there is a range of values of K, $0 < K < N(\gamma(p^{ts}R^* - \bar{R}) - c)/(1 - \beta))$, for which every bank will pay its share of the fixed costs, K/N, at t_0 and remain a faithful member of the bureau at $t \geq t_0$. That is, the credit bureau is viable: at t_0 every bank finds it privately optimal to join the credit bureau. Second, the multilateral arrangement analyzed here is less efficient than the decentralized reputation system in game 2 whenever the latter is also viable: if information can be costlessly transmitted across generations, for all $c > 0$ and discount factors $\beta \in (0.62, \underline{\beta}(c))$ the information exchange is viable in game 2 and not in game 3. But if borrowers of different generations are informationally isolated, the information exchange cannot be sustained without a mechanism such as a credit bureau.

The creation of such a multilateral institution entails a commitment at the *collective* level. In a situation where banks and borrowers at different locations, as well as borrowers of different generations, are informationally isolated, misbehavior can still be detected, publicized, and punished by a collective institution that acts as a third party vis-à-vis any of its members and their customers. The same argument has been offered by Greif, Milgrom, and Weingast (1994) and Milgrom, North, and Weingast (1990) to explain the successful performance of other private collective enforcement mechanisms, such as the private judicial system of medieval trade fairs or the merchant guilds that "emerged during the late medieval period to allow rulers of trade centers to commit to the security of alien merchants." Milgrom and Roberts (1992, pp. 266–269) provide a number of examples that support the theory, which lies at the heart of this subsection, that private multilateral institutions, such as credit bureaus, can help enhance the efficiency of a reputation system.

1.4 Information sharing versus alternative precommitment devices

One may wonder if to solve our incentive problem banks really need to sign an information sharing agreement. Why cannot banks pre-

commit at the individual level to a sequence of interest rates via a *decentralized reputational mechanism*, solving the incentive problem even in the absence of information sharing? Under the informational assumptions of game 2 in the previous section, banks could indeed credibly precommit to a sequence of rates $(R^*, \overline{R}/p^{is})$ offered to high-ability entrepreneurs only, which would induce the latter to exert a positive effort level p^{is}, leading to the very same equilibrium outcome that prevails under information sharing. This outcome could be achieved in a simpler bilateral setting, in which each local bank only deals with the current and future generations of entrepreneurs at its location (without interacting with rival banks based at other locations). But the sustainability of commitments to a sequence of interest rates via a decentralized reputation mechanism is exposed to the same objections raised in the discussion of game 2. The point is, as before, that the reputational mechanism fails to operate if the detection and the collective memory of deviant behavior is imperfect.[12]

If reputation is an inadequate mechanism, however, one may ask why a *multilateral* institution such as a credit bureau is a better precommitment device than a contracting arrangement at the *individual* bank's level, for instance by hiring an external auditor to monitor and publicly certify its credit policy. The answer is that a multilateral institution is likely to be both cheaper and more credible than a bank-level contract with an auditor. First, a credit bureau is likely to entail lower resource costs, its fixed outlays being spread over many participating banks. Second, it should have better incentives to police and sanction deviations than an auditor, since by serving many banks it would be less easily captured by any individual lender.

Finally, one may wonder if banks at different locations could entrust the task to enforce their precommitments to some *other multilateral institution*, for instance a trade association, rather than to a credit bureau. Though in principle equivalent, in practice this solution would run into greater problems than a credit bureau. Detecting deviations would require collecting information about the pricing strategies of individual banks, which is strictly forbidden by the antitrust laws of most developed countries.[13]

[12] Sharpe (1990) was the first to propose the simple solution of precommitment to a sequence of interest rates in a banking model related to ours. In his model, entrepreneurial incentives are not a problem, but still inefficiencies in the credit market may arise because of distortions in the borrowers' optimal investment choices due to ex post monopoly power. However, Sharpe himself emphasized that the effectiveness of a decentralized reputation mechanism "depends upon the bank's valuation of future transactions and *the existence of informal mechanisms for transmitting information about a bank's behavior*." [Sharpe (1990, p. 1084); italics added by the authors.]

[13] Information agreements involving communication to competitors about details of a company's pricing policy, price lists, discount structures, and the dates when prices would be increased are not lawful under, for instance, Article 85 of the Treaty of Rome (which regulates anticompeti-

2. Extending the Basic Model

Proposition 1 shows that, under simple assumptions on the returns to entrepreneurs' projects and on the elasticity of the demand for credit, banks strictly prefer to share information about the quality of their borrowers. Indeed, in the absence of such informational exchange, the credit market fails to operate. In this section we show that when some of these assumptions are relaxed, the credit market can operate even without information sharing. Banks can also operate when they choose not to communicate, but in some cases their expected profits are higher if they do communicate. The focus thus shifts to the parameters that determine the profitability of information sharing and to the effects of information sharing on default rates, interest rates, and lending volume. This enables us to draw several empirical predictions from the model.

We consider three extensions. First, we relax the assumption that, absent information sharing, the inside bank has an unchecked monopoly over its customers and can therefore wholly expropriate the surplus produced by them. Despite the inside bank's informational advantage, outside banks may in fact exert some pressure on its pricing policy. Second, we analyze what happens if there are more than two classes of potential borrowers, by introducing a third class of "medium-type" entrepreneurs, whose projects are less profitable than those of high-ability entrepreneurs but nevertheless are "creditworthy," in the sense that they have positive net present value if financed at the actuarially fair interest rate. Third, we relax the assumption that the size of the investment projects is fixed and construct an example featuring an elastic demand for loans at the individual level.

One extension that we abstain from modeling explicitly is the endogenous production of information by banks. All the versions of the model analyzed here assume that initially each bank has private information about the ability of the local entrepreneurs. In each case, one could instead assume that the bank must produce such information at a cost, thus adding a period 0 decision about information production. Then it is easy to see that whenever information sharing is shown to increase the bank's expected profits, the bank would be more willing to produce the information in the first place: communication among banks, rather than depressing the incentives to produce private information, can stimulate its production.

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tive agreements within the European Union), the U.K. Restrictive Trade Practices Act 1976, and section 1 of the U.S. Sherman Act 1890. On the contrary, information agreements as to descriptions of persons to whom goods are to be supplied are not prohibited unless they plainly distort competition. [See Singleton (1992) for further discussion.]

2.1 Limited informational monopoly by the inside bank

In Section 1.2 the inside bank was assumed to have such a large informational advantage that, absent information sharing, it was a complete monopolist. Outside banks would make losses in lending to the local bank's clients, even if the safe clients exerted the first-best level of effort $\widehat{p}$, since the return on successful projects R^* would not cover the break-even pooling rate of uninformed banks: $R^* < \overline{R}/\gamma\widehat{p}$. Here we instead consider what happens when, absent information sharing, outside competition "bites" in the local bank's customer pool. This requires the return to successful projects to exceed the break-even pooling rate offered by uninformed banks: $R^* > \overline{R}/\gamma p_0 \equiv R_0$, where p_0 is the effort of high-ability entrepreneurs consistent with the break-even rate R_0.[14]

Consider first what happens if banks do not share information. Neglecting corner solutions, the optimal effort level of a high-ability entrepreneur i who borrows from bank b is given by the first-order condition

$$\left(R^* - R_{b1}\right) + \beta\left(R^* - E(R_{b2})\right) = V'(p(i)). \tag{6}$$

By symmetry the equilibrium effort choice is obtained by setting $p(i) = p$ for all i. The lowest rate that outside competitors can offer to the local customers in either period is the break-even rate

$$R_0 = \frac{\overline{R}}{\gamma p_0}, \tag{7}$$

where p_0 is the effort level corresponding to the break-even rate, that is, solves

$$(1+\beta)\left(R^* - \frac{\overline{R}}{\gamma p_0}\right) = V'(p_0). \tag{8}$$

There can be several positive values of p_0 (and corresponding values of R_0) that solve this equation, but for the purpose of our argument it suffices that there is at least one such value of p_0. Clearly this requires our initial assumption that $R^* > R_0$: the effort level is positive if a surplus is left to the entrepreneurs.

We now turn to determine the equilibrium of this game. To ensure the existence of a pure-strategy equilibrium, we assume that the two banks move sequentially: first, the inside bank offers its menu of rates to local entrepreneurs, then the outside competitors make their bid (while the results about equilibrium interest rates do not depend on

[14] This is a more stringent condition than $\gamma\widehat{p}R^* > \overline{R}$, since the level of effort elicited by the break-even rate R_0 will generally be less than the first-best, full-information level of effort: $p_0 \leq \widehat{p}$.

the order of moves, no pure-strategy equilibrium exists with simultaneous moves). We also assume that, if offered the same rate by the inside bank and its competitors, entrepreneurs borrow from the inside bank.

The optimal policy for the inside bank is to offer the rate R_0 to the high-ability entrepreneurs in both periods and refuse lending to the low-ability ones. To avoid losing money, competitors can at most match this offer and will attract no customers. But their potential competition erodes the informational monopoly of the inside bank, forcing it to leave a fraction of the surplus to the entrepreneurs. As a result, even without information sharing, entrepreneurial effort is positive: $p^{ns} = p_0$ and the credit market does not collapse — or to be more precise, there is at least one SPE in which this is true.

Consider now what happens if in period 2 banks share their information. The period 2 equilibrium interest rate offered to high-quality entrepreneurs will then be their actuarially fair rate $\overline{R}/p^{is}$: period 2 informational rents will be wiped out. In period 1, when the inside bank still has superior information, its optimal policy is to offer the rate $\overline{R}/\gamma p^{is}$ to the high-ability entrepreneurs — which cannot be undercut by outside competitors — and refuse lending to the low-ability ones. The equilibrium effort level will be given by

$$\left(R^* - \frac{\overline{R}}{\gamma p^{is}}\right) + \beta\left(R^* - \frac{\overline{R}}{p^{is}}\right) = V'(p^{is}). \tag{9}$$

Information sharing raises the equilibrium effort level, because it leaves a larger surplus to the entrepreneur. To see this, note that when evaluated at $p^{is} = p^{ns} = p_0$ the function on the left-hand side of Equation (9) exceeds that on the left-hand side of Equation (8). But the right-hand side of both equations, $V'(p)$, is increasing in p. So it must be $p^{is} > p^{ns} = p_0$.

Will information sharing also raise the profits of the inside bank b? In this case, it will not. The difference between its profits in the two regimes is

$$\Pi_b^{is} - \Pi_b^{ns} = -\beta(1-\gamma)\overline{R} < 0.$$

In this case the loss of the period 2 informational rents is not compensated by greater profits in period 1, because the fall in the pooling rate charged to high-ability entrepreneurs, $\overline{R}/\gamma p$, fully offsets the effect of their increased effort level. The entrepreneurs appropriate all the increase in surplus, also in the first period. So the inside bank will not want to share its information if, absent information sharing, it already experiences limit pricing competition by outside banks.

To summarize, the results in this section and in Section 1.2, taken together, show that in an economy with two types of potential borrowers, information sharing is privately profitable only if there is no limit pricing competition for the better type. Only in that case, inside banks can effectively appropriate some of the rents resulting from the extra effort exerted by entrepreneurs when information is shared. But this extreme result only holds if there are two types of entrepreneurs. With more than two types, we can have cases in which the inside bank wants to share information *and* still the credit market would not collapse without information sharing.

2.2 More than two types of entrepreneurs

The results of the model are considerably richer if one introduces an additional type of entrepreneur in addition to the two already present in the basic model. The new type of entrepreneur features a medium level of entrepreneurial ability, and their type is indexed by M. In fact, the payoff to their projects is $\widetilde{R} < R^*$, that is, less than that obtained by H types. However, they are creditworthy, in the sense that the expected return of their projects exceeds the cost of capital $\overline{R}$ rather than being zero as for L types.

In this more general setting, one can show that [see Padilla and Pagano (1996a)]:

1. Credit markets can function in the absence of information sharing, as in Section 2.1 and in contrast with Section 1. This occurs when inside banks face limit competition for M-type and H-type entrepreneurs. In this case, creditworthy entrepreneurs enjoy some surplus, and hence exert positive effort, even when information is not shared.

2. There are parameter configurations for which information sharing is privately profitable, although not needed to avoid market collapse. If inside banks face limit pricing competition for the two creditworthy market segments, but outside banks cannot distinguish between M-type and H-type entrepreneurs, then inside banks still retain some monopoly power over H-type entrepreneurs. Hence, in contrast to Section 2.1, the impact of higher effort by H-type entrepreneurs on the inside bank's period 1 profits is not fully offset by the fall in the period 1 interest rate charged on them. If the increase in period 1 profits is sufficiently large, information sharing becomes privately profitable.

3. When information is not shared, credit is expensive and may be affordable only for top-notch borrowers, whereas if information is shared, interest rates are on average lower and loans may be extended to lower-grade borrowers.

4. The time profile of interest rates extended to individual entrepreneurs is flat if information is not shared and declines over time if it is shared.

Moreover, one obtains some predictions that specifically pertain to the cases where information sharing produces an expansion in credit market participation: in these cases, information sharing is more likely the greater the profitability of the projects of the potential borrowers (as measured against the benchmark of the banks' cost of capital), the lower the discount factor of banks, and the higher that of entrepreneurs (in a slightly more general version of the model where these two factors are allowed to differ).

Finally, the welfare implications are the same as in the basic model: in all the instances in which information sharing is profitable for banks, it is also welfare increasing for borrowers. This is true whether information sharing draws new borrowers into the market or merely reduces the interest rates faced by existing borrowers.

2.3 Elastic individual demand for credit

In this section we revert to the initial assumption that there are only two types of entrepreneurs — high- and low-ability ones — but extend the model in a different direction: we assume that the scale of investment projects is endogenous and therefore that the demand for loans by each entrepreneur is elastic with respect to the interest rate. Note that if the demand for loans is elastic, the inside bank's ability to appropriate the surplus produced by its customers is reduced: as borrowers can scale down the project in response to higher interest rates, the monopolistic bank will have less scope for "squeezing" its clientele. Since the incentive problem is less severe, one would expect that information sharing will be less needed. Indeed, there are instances in which banks will optimally refrain from communicating. Nevertheless, we show below that in this case the rationale for information sharing can survive: there are values of the parameters for which banks want to communicate their private information.

To illustrate these points, consider the following example where the only production technology available to high-ability entrepreneurs features decreasing returns to scale, the future is undiscounted ($\beta = 1$), and the total disutility of effort is given by $V(p) = bp^2/2 - dp$, where $b > 2d > 0$ (otherwise effort is always positively valued). Let us denote the number of units of capital invested by l and assume that the average product per unit invested is given by $f(l) = l^{-1/2}$, so that total output $F(l) = f(l)l$ is a concave and isoelastic function of l.[15] Then

[15] Consider the more general case where the average product per unit invested is $f(l) = l^{-1/\varepsilon}$, $\varepsilon > 1$

the optimal scale of an investment project undertaken at time t (once effort is sunk), given the interest rate R_t, is $l(R_t) = 1/4R_t^2$, and the associated return per unit (or average product) is $R_t^* = 2R_t > R_t \ \forall t$. Hence, the total discounted utility for a high-ability entrepreneur who chooses an effort level $p(i)$ is

$$U_H(p(i)) = p(i)\left[(R_{b1}l(R_{bi})) + (E(R_{b2})l(E(R_{b2})))\right] - bp(i)^2/2 + dp(i), \tag{10}$$

and, given the ex ante average probability of success p, the profits of bank b are

$$\Pi_b(p) = \gamma\left[(pR_{b1} - \overline{R})l(R_{b1}) + (pR_{b2} - \overline{R})l(R_{b2})\right]. \tag{11}$$

Assuming that a condition analogous to Equation (2) holds, so that without information sharing banks have full monopoly power over the entrepreneurs at their respective locations, one can show that (1) when banks do not communicate the characteristics of their local clientele to rivals, p^{ns} is equal to 1 if $b < \frac{1}{4\overline{R}} + d$ and equal to $4\overline{R}d/(4\overline{R}b - 1)$ if $b > \frac{1}{4\overline{R}} + d$; $R_1^{ns} = R_2^{ns} = 2\overline{R}/p^{ns}$; (2) when banks inform their rivals, p^{is} is equal to 1 if $b < \frac{3}{8\overline{R}} + d$ and equal to $8\overline{R}d/(8\overline{R}b - 3)$ if $b > \frac{3}{8\overline{R}} + d$; $R_1^{is} = 2\overline{R}/p^{is}$, $R_2^{is} = \overline{R}/p^{is}$. So in equilibrium, $p^{is} \geq p^{ns}$, and they are both positive since $V'(0) = -d < 0$. Thus information sharing leads to lower interest rates and to an increased demand for loans.

From (1) and (2), it follows that

1. For relatively low values of the marginal disutility of effort (low b and/or high d), effort is set at the maximum level in both regimes: if $b < \frac{1}{4\overline{R}} + d$, then $p^{is} = p^{ns} = 1$. In this case, banks' profits are greater if information is not shared because information sharing dissipates informational rents without any countervailing effect on entrepreneurial effort: if $b < \frac{1}{4\overline{R}} + d$, then $\Pi^{ns}(1) > \Pi^{is}(1)$.

2. For intermediate values of the marginal disutility of effort, information sharing raises effort and banks' profits: if $\frac{1}{4\overline{R}} + d < b < \frac{1}{2\overline{R}}$, then $p^{ns} < p^{is} \leq 1$ and $\Pi^{ns}(p^{ns}) < \Pi^{is}(p^{is})$.

3. Finally, for relatively large values of the marginal disutility of effort, information sharing raises effort but fails to raise banks' profits. This is because the increase in first-period profits stemming from

and the total disutility of effort is given by $V(p) = Ap^{\alpha}$, where $A > 0$ and $\alpha > 1$. In this more general case, existence of an interior solution requires $\alpha > \varepsilon$. In this section, instead, we have assumed $\alpha = \varepsilon = 2$ to keep the algebra tractable, but in exchange we had to introduce a linear term $-dp$ in function $V(.)$ to ensure existence (which introduces an additional, albeit minor, departure from the assumptions of the basic model in Section 1.1.).

increased effort does not outweigh the loss of informational rents in the second period: if $\max\{\frac{3}{8\bar{R}} + d, \frac{1}{2\bar{R}}\} < b$, then $p^{ns} < p^{is} < 1$ and $\Pi^{ns}(p^{ns}) > \Pi^{is}(p^{is})$.

3. Conclusions

When banks have an informational monopoly about their borrowers, the latter's incentives can be thwarted by the fear that the return to their effort will be partly appropriated by their banks via high future interest rates. Banks can correct this incentive problem by committing to share with other lenders their private information about the quality of their customers. The resulting competitive pressure forces them to forgo opportunistic behavior in the future and encourages borrowers to perform better. As a result, information sharing among banks has two opposite effects on their profits: the borrowers' higher effort levels raise current profits (when each bank retains an informational advantage), but the fiercer competition triggered by information sharing lowers future profits. The trade-off between these two effects determines the banks' choice to sign an information sharing agreement.

At the outset of this article we focused on a setting in which this trade-off is carried to the extreme, since without communication among banks lending cannot even get off the ground: lacking the competition induced by information sharing, the inside banks' informational monopoly destroys all entrepreneurial incentives. Clearly in this case information sharing is profitable and socially efficient. Moreover, we show that it can be sustained as the equilibrium of a repeated game between long-lived banks and short-lived borrowers, provided banks have a sufficiently low discount rate and the costs of verifying private information are not too large. In this context we also formally explain why information sharing agreements are easier to sustain ex post than precommitment to low interest rates, even if they both have the same efficiency properties ex ante.

We then extend the model and show that in general the trade-off is less stark than in the basic model: the credit market can operate even if banks do not agree to communicate, and there are instances in which banks will indeed refrain from communicating. We also find that if they share information, interest rates and default rates are lower on average, and interest rates decrease over the course of the relationship between each client and his bank. In addition, the volume of lending may increase: when we drop the assumption of only two types of borrowers and introduce a class of medium-quality entrepreneurs, we find that information sharing may expand the customer base; similarly, when we extend the model to the case of elastic individual

demands for credit, we find that information sharing tends to increase the demand for loans. But in both these extensions the welfare implications of information sharing are the same as in the basic model: whenever banks choose to communicate, they bring about a Pareto improvement, since they raise the customers' welfare along with their own profits.

Finally, an interesting direction for further research is to investigate when banks will prefer to restrain their informational exchange to a subset of the relevant variables — for instance, providing only "coarse" information about the quality of their customers or exchanging only data about their past defaults rather than about their quality. In a related model, Padilla and Pagano (1996b) show that partial information sharing can have stronger effects on entrepreneurial incentives than full disclosure. It remains to be shown if, in a model like that examined in this article, partial information sharing can be more profitable for banks than complete information sharing, which may explain why lenders often confine their informational exchange to "black lists" of insolvent borrowers.

Appendix A: Proofs

Proof of Lemma 1. Under information sharing, the total discounted utility of a high-ability entrepreneur i, with a probability of success $p(i) \in [0, 1]$, denoted by $U_H(p(i) \mid p^{is})$, is equal to $p(i)\beta(R^* - \overline{R}/p^{is}) - V(p(i))$ if $p^{is} \geq \underline{p}$ (where p^{is} is the ex ante average repayment probability for high-ability entrepreneurs under information sharing), and is equal to 0 if $p^{is} < \underline{p}$. Hence, (1) if $p^{is} > \underline{p}$ and $\beta(R^* - \overline{R}/p^{is}) \geq V'(1)$, then $p(i) = 1$, provided that $U_H(1 \mid p^{is}) > U_H(0 \mid p^{is}) = 0$, otherwise $p(i) = 0$; and (2) if $p^{is} \geq \underline{p}$ and $0 = V'(0) < \beta(R^* - \overline{R}/p^{is}) < V'(1)$, then there exists a unique interior optimal choice $p(i) \in (0, 1)$ such that $\beta(R^* - \overline{R}/p^{is}) = V'(p(i))$, provided that $U_H(p(i) \mid p^{is}) > U_H(0 \mid p^{is}) = 0$, otherwise $p(i) = 0$. (Note that in both cases, (1) and (2), uniqueness of the optimal choice $p(i)$ follows from the global concavity of $U_H(p(i) \mid p^{is})$ in the relevant subspace.)

From (1) and (2) above and since in equilibrium $p(i) = p^{is}$ $\forall i$, $R_1^{is} = R^*$, and $R_2^{is} = \overline{R}/p^{is}$, it is immediate that there may be multiple SPE for our game, which can be exhaustively characterized according to p^{is} as follows:

I. $p^{is} = 0$ is always an equilibrium for our game.

II. $p^{is} = 1$ provided that $\beta(R^* - \overline{R}) \geq \max\{V'(1), V(1)\}$.

III. $p^{is} \in (0, 1) \mid \beta(R^* - \overline{R}/p^{is}) = V'(p^{is}) > 0$. (There may be several values of $p \in (0, 1)$ satisfying these conditions, which further increases the number of possible SPEs for our game.)

Equilibria of type II and type III both strictly Pareto dominate the type I equilibrium, which thus can only originate as a result of a coordination failure. Furthermore, if an equilibrium of type II exists, then there also exists an equilibrium of type III.

To show the second part of this lemma, it is enough to find one such functional form for $V(\cdot)$. Take, for instance, $V(p) = Ap^2/2$, where $0 < A < \beta(R^* - \overline{R})$. Then, (i) $\beta(R^* - \overline{R}) > V'(1) > V(1)$ and (ii) if p^{is} solves $\beta(R^* - \overline{R}/p^{is}) = V'(p^{is}) = Ap^{is}$, then $p^{is} > \underline{p}$ and $U_H(p^{is} \mid p^{is}) > U_H(0 \mid p^{is}) = 0$ (since in equilibrium $U_H(p \mid p) = pV'(p) - V(p)$ and our functional form for $V(\cdot)$ is such that $V'(p)p > V(p)$). Hence, we have *three* SPE for our game:

I. $p^{is} = 0$ and the credit market collapses.

II. $p^{is} = 1$, $R_1^{is} = R^*$, $R_2^{is} = \overline{R}$.

III. $p^{is} = \frac{1}{2A}(\beta R^* - \sqrt{\beta^2 R^2 - 4\beta A\overline{R}})$, $R_1^{is} = R^*$, $R_2^{is} = \overline{R}/p^{is}$.

These three cases are illustrated in Figure 2, where for simplicity we set $A = 1$, so that the marginal disutility of effort $V'(p) = p$.

If, instead, $\beta(R^* - \overline{R}) < A$, then there cannot be an equilibrium involving $p^{is} = 1$. Whether there is an equilibrium with $p^{is} > 0$ or not depends on the sign of $(A - \widetilde{A})$, where $\widetilde{A} = \beta R^2 - 4\overline{R}$. If $A < \widetilde{A}$, then there are two SPE of type III with p_1^{is}, $p_2^{is} \in (\underline{p}, 1)$ (see Figure 3a); if $A = \widetilde{A}$, then there is a unique type III SPE with $p^{is} \in (\underline{p}, 1)$ (see Figure 3b); and, lastly, if $A > \widetilde{A}$, then there is no SPE involving $p^{is} > 0$ (see Figure 3c). An equilibrium of type I with $p^{is} = 0$ always exists.

In conclusion, this example shows that there are functional forms for $V(\cdot)$ such that there exists at least an SPE involving $p^{is} > \underline{p} > p^{ns} = 0$ and active credit markets. The same proof goes through if $V(\cdot)$ is any power function $V(p) = Ap^{\alpha}$, with $\alpha > 1$ and $A > 0$ not too large (i.e., $A < \beta(R^* - R)/\alpha$). ■

Proof of Proposition 2. Suppose that there was such an equilibrium, and consider the payoff to a bank that deviates from the equilibrium strategy at the end of the first period by refusing to release information on its old customers to other banks and charging the predatory rate R^* on their loans, but then reverts to the equilibrium strategy. The gains from deviating are equal to the additional profits that the bank earns on its old customers: $\gamma(p^{is}R^* - \overline{R}) > 0$. The informational assumptions of the model imply that the play of future generations is unaffected. So the bank's total payoff from deviating in the first period and then adhering to the purported equilibrium is equal to $\gamma(p^{is}R^* - \overline{R}) > 0$. Thus, the specified behavior is not consistent with Nash equilibrium. ■

Proof of Proposition 3. Consider the following strategies:

1. At time t, each bank reports honestly to its competitors, and

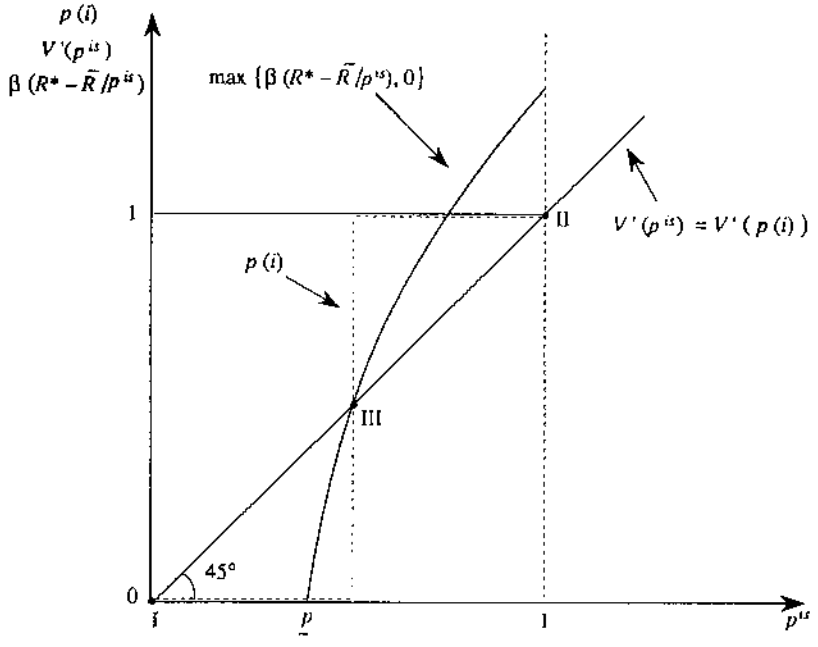

Figure 2
Example with three equilibria
The figure shows the choice of the probability of repayment by the individual borrower i, $p(i)$, as a function of the ex ante average probability of repayment in the regime with information sharing, p^{is}, in the basic model. The dotted line depicts individual i's best-reply function in his choice of $p(i)$. The solid 45-degree line shows the locus in which $p(i) = p^{is}$ and therefore it corresponds to the condition that the marginal disutility of effort of individual i, $V'(p(i))$, equals that of the average borrower, p^{is}. Subgame perfect equilibria correspond to points where the best-reply function and the 45-degree line intersect. In the figure, three equilibria arise: equilibrium I, which corresponds to a zero probability of repayment; equilibrium II, where repayment is certain; and equilibrium III, where the probability of repayment takes an intermediate value. In equilibrium III, borrower i is at an interior maximum in his choice of $p(i)$: in that point his marginal return from effort, shown as the curved locus $\max\{\beta(R^* - \overline{R}/p^{is}), 0\}$, equals his marginal disutility of effort, $V'(p(i))$. In the other two equilibria, the borrower is at a corner solution.

lends to the current old at its location at rate $\overline{R}/p^{is}$ and to the local entrepreneurs born at t at rate R^*, if and only if it has done so in all past periods. Otherwise it misreports the types of its current customers, lends at the monopoly rate R^* to the old local entrepreneurs of generation $t-1$ and to the entrepreneurs of generation t in both periods of their life, and does not lend to any generation born after t.

2. Each entrepreneur born at t borrows from the local bank in both periods of his life and chooses a positive effort level $p^{is} > 0$ if and only if he has no knowledge of dishonest behavior by the bank. Otherwise he sets effort to zero and does not borrow.

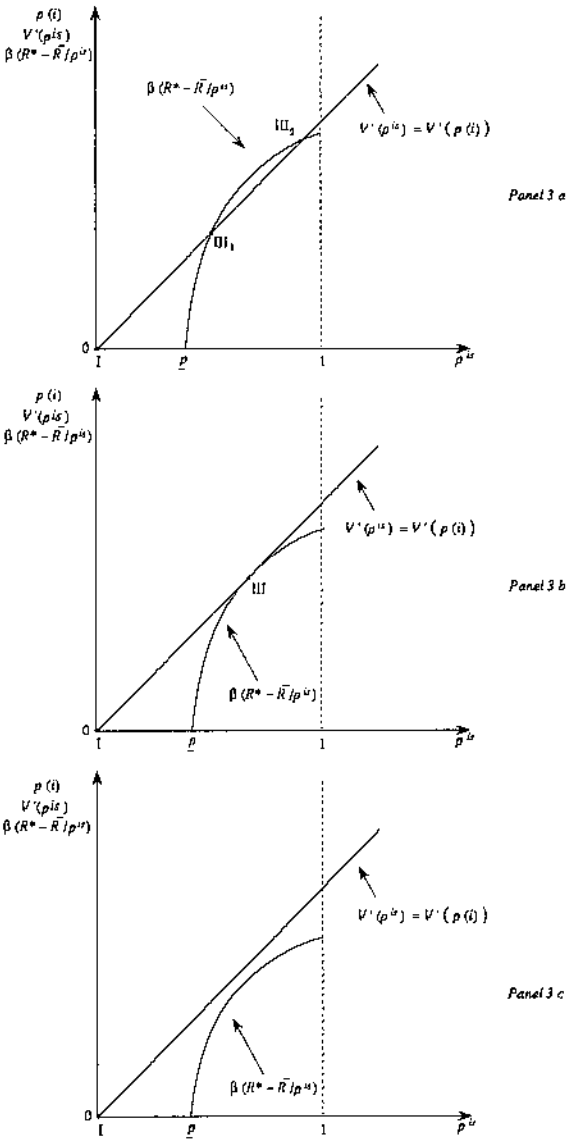

Figure 3
Other potential equilibria configurations
This figure shows that the basic model illustrated in Figure 2 can generate other equilibria configurations, under alternative parameter values. The interpretation of the curves in this figure is the same as in Figure 2. Panel 3a shows the situation in which there is an equilibrium where the probability of repayment is zero (point I) and two equilibria where it is positive but below unity (points III_1 and III_2). Panel 3b illustrates the case in which there are only two equilibria, one where the probability of repayment is zero (point I) and one where it is positive but below unity (point III). Finally, panel 3c depicts the case in which the only equilibrium is that corresponding to zero probability of repayment and credit market collapse (point I).

The entrepreneurs' strategies are optimal because each of them cares only about payoffs in his own lifetime and thus is willing to exert positive effort if and only if the bank is expected to share its information honestly. If the bank ever refuses to report or misreports the true types of the local entrepreneurs, then local borrowers will choose to exert no effort in all subsequent generations (except for the generation whose effort is sunk when the bank deviates). Hence, the best pricing strategy of a deviant bank is to charge R^* to the current old at t, set (R^*, R^*) to the local entrepreneurs born at t, and then stop lending. The short-run gains from such deviation are equal to the profits made on the current old, $\gamma(p^{is}R^* - \overline{R})$, plus the extra profits to be made from the current young in the second period of their lives, $\beta\gamma(p^{is}R^* - \overline{R})$. The long-run cost incurred after a deviation is equal to the forgone profits on all generations born after the deviation, $\beta\gamma(p^{is}R^* - \overline{R})/(1-\beta)$. Hence, the strategies (1) and (2) constitute an SPE for game 2, and information sharing is sustained in equilibrium if and only if $\beta - (1-\beta^2) > 0$, that is, iff $\beta > \underline{\beta} \simeq 0.62$. ■

Proof of Proposition 4. Consider the following strategies:

1. At time t, each bank reports honestly to the credit bureau and pays its membership fee c, and lends to the current old at its location at rate $\overline{R}/p^{is}$ and to the local entrepreneurs born at t at rate R^*, if and only if it has done so in all past periods. Otherwise it fails to report to the bureau and saves the membership fee c, lends to old entrepreneurs at rate R^*, lends also to the local entrepreneurs of generation t during the two periods of their life charging them the monopoly rate R^* in both periods, and stops lending to any generation born after t.

2. Each entrepreneur born at t borrows from the local bank in both periods of his life and chooses a positive effort level $p^{is} > 0$ if and only if he has no knowledge of dishonest behavior by the bank. Otherwise he sets effort to zero and does not borrow.

As in Proposition 3, the entrepreneurs' strategies are optimal given the strategies of banks. Hence we just need to consider the optimality of the banks' strategies and, in particular, their incentives to deviate, taking the entrepreneurs' strategies as given. Since membership is costly and misreporting is always detected, a deviant bank at t will save c and will not report to the credit bureau. Given that the statutes of the bureau make exclusion upon deviation automatic and readmission impossible, the threat of excluding the deviant bank from the exchange of information is credible unless a member, or a group of members, of the existing bureau quits it and forms a new bureau together with the deviator. However, the deviator has no incentive to create a new bureau. Strategy (2) implies that a deviating bank is not

trusted by any future generation of entrepreneurs, who are informed of his misbehavior by the existing bureau. Hence its local customers would choose to exert no effort and the deviator would not raise any rents from lending to them. Moreover, no bank subscribing to the existing credit bureau has an incentive to create a new bureau with the deviator. First, the deviator's information has no marginal value for the remaining $N-1$ banks, who can still reap the benefits of information sharing by exchanging it among themselves (and, due to competition, would make no profits from the information of the deviant bank). Second, creating a new bureau involves an additional fixed cost $K > 0$.

Hence, as in Proposition 3, the best pricing strategy of a deviant bank is to charge R^* to the current old at t, set (R^*, R^*) to the local entrepreneurs born at t, and then stop lending. The gains from this deviation are equal to the extra profits made on the current old, $\gamma(p^{ts}R^* - \overline{R})$, plus the discounted profits to be made from the current young when old, $\beta\gamma(p^{ts}R^* - \overline{R})$, *plus* the savings of all current and future membership fees, $c/(1-\beta)$. The long-run cost incurred after a deviation equals $\beta\gamma(p^{ts}R^* - \overline{R})/(1-\beta)$, as in Proposition 3. Therefore strategies (1) and (2) constitute an SPE for game 3 and, thus, information sharing will be sustained as an equilibrium outcome of this game if and only if

$$\chi(\beta, c) = \gamma(p^{ts}R^* - \overline{R})(\beta - (1-\beta^2)) - c \geq 0.$$

Note that $\chi(\beta, c)$ is a continuous function, strictly decreasing in c and strictly increasing in β. Let c^* be such that $\chi(1, c^*) = 0$ (i.e., $c^* = \gamma(p^{ts}R^* - \overline{R}) \in (0, \infty)$). For all $0 \leq c \leq c^*$, (1) there exists a value of β, $\underline{\beta}(c) \in [0, 1]$, such that $\chi(\underline{\beta}(c), c) = 0$ (since for all $0 \leq c \leq c^*$, $\chi(0, c) < 0$ and $\chi(1, c) > 0$); (2) for all $\beta \geq \underline{\beta}(c)$, $\chi(\beta, c) \geq 0$; and (3) $\underline{\beta}(0) \simeq 0.62$. ■

Appendix B: Unlimited Liability

In this appendix we extend our model to analyze the case of unlimited liability, formally proving the results stated at the end of Section 1.2. We distinguish two alternative scenarios, depending on whether failed entrepreneurs can elude past liabilities by switching banks or not. A failed entrepreneur can elude his unpaid debts by switching banks if the profitability of his project can only be observed by the current lender and cannot be verified by a third party, such as a court. We shall refer to this scenario as case 1. If instead a third party can verify the profitability of the current project at the request of a previous unpaid creditor, then switching banks does not eliminate the consequence of past defaults. We shall refer to this scenario as case 2.

Suppose that $\gamma(\hat{p}R^* + \hat{p}(1-\hat{p})R^*) < \overline{R} < \hat{p}R^*$, so that in the absence of information sharing, in both cases the local bank enjoys monopoly power at its own town in both periods and there are effort levels for which such a monopoly power is profitable.

Case 1. Consider first the total discounted utility for a high-ability entrepreneur who chooses a success probability $p(i)$ and borrows from the inside lender I in both periods. This is equal to

$$U_H(p(i)) = p(i)[(R^* - R_{I1}) + \beta[R^* - p(i)E(R_{I2}^{nd}) - (1-p(i))\min(E(R_{I2}^{d}) + R_{I1}, R^*)]\} - V(p(i)), \quad (12)$$

where R_{I1} represents the period 1 rate charged by I, R_{I2}^{nd} is the period 2 rate charged on borrowers who repaid their period 1 loans [which occurs with probability $p(i)$], and R_{I2}^{d} is the period 2 rate charged on entrepreneurs who defaulted in period 1 [which occurs with probability $(1-p(i))$]. If, instead, he borrows from the outside competitor O in period 2 at a rate R_{O2}, his utility is

$$U_H(p(i)) = p(i)\left[\left(R^* - R_{I1}\right) + \beta\left(R^* - E(R_{O2})\right)\right] - V(p(i)). \quad (13)$$

Under no information sharing, the inside bank's second-period profits are equal to $\gamma[p(pR_{I2}^{nd} + (1-p)\min(R_{I2}^{d} + R_{I1}, R^*)) - \overline{R}]$ and, thus, it sets R_{I2}^{d} such that $R_{I2}^{d} + R_{I1} = R^*$ for those borrowers that defaulted in period 1 and $R_{I2}^{nd} = R^*$ for those who repaid the period 1 loan. Consequently, the inside bank's second-period profits are $\gamma(pR^* - \overline{R})$. In period 1, the inside bank sets R_{I1} to maximize its total discounted profits $\gamma[(pR_{b1} - \overline{R}) + \beta(pR^* - \overline{R})]$, implying that $R_{I1} = R^*$. Given these rates, $U_H(p(i)) = -V(p(i))$ for all $p(i)$ and, therefore, $p(i) = p^{ns} = 0\ \forall i$.

Under information sharing, the inside bank competes with all outside lenders. The former's period 2 profits are given above while the latter's are equal to $\gamma(pR_{O2} - \overline{R})$. Bertrand competition ensures that $R_{I2}^{nd} = R_{I2}^{d} + R_{I1} = R_{O2} = \overline{R}/p$ so that period 2 profits are zero. Hence outside competition effectively prevents the inside lender from recovering unpaid period 1 interest rates. In period 1, the inside bank sets R_{I1} to maximize its total discounted profits $\gamma[pR_{b1} - \overline{R}]$ so that $R_{I1} = R^*$. Given these rates, $U_H(p(i)) = p(i)[\beta(R^* - \overline{R}/p)] - V(p(i))$ so that $p(i) = p^{is}\ \forall i$ as characterized in Lemma 1. Hence, the level of effort, banks' profits, and borrowers' utility are exactly the same as those obtained under the assumption of limited liability.

Case 2. In this case, the total discounted utility for a high-ability entrepreneur who chooses a success probability $p(i)$ is given by Equation (12) if he borrows from the inside lender in both periods. If, instead, the entrepreneur borrows from the outside competitor O in

period 2, his utility is equal to

$$U_H(p(i)) = p(i)[(R^* - R_{I1}) + \beta\{R^* - p(i)E(R_{O2}) - (1 - p(i))\min(E(R_{O2}) + R_{I1}, R^*)\}] - V(p(i)). \quad (14)$$

The analysis is identical to case 1 for the no information sharing regime. Under information sharing, however, the analysis is now slightly different. Now an entrepreneur can no longer elude his previous debts by switching banks, so that $R_{I2}^{nd} = R_{I2}^{d} = R_{O2} = \overline{R}/p$. Hence period 2 profits are simply equal to the interest payments that are recovered from defaulting entrepreneurs: $\gamma(1-p)p\max(R_{I1}, R^* - \overline{R}/p)$. In period 1, R_{I1} maximizes its total discounted profits $\gamma[(pR_{I1} - \overline{R}) + \beta(1 - p)p\max(R_{I1}, R^* - \overline{R}/p)]$ so that $R_{I1} = R^*$. Given these rates, $U_H(p(i)) = p(i)[\beta(p(i)R^* - \overline{R}/p)] - V(p(i))$. Following the same steps as in the proof of Lemma 1, we can show that there are functional forms of $V(\cdot)$ for which there exists a (Pareto nondominated) SPE such that $p^{is} > p^{ns}$, and hence, $\Pi^{is}(p^{is}) > \Pi^{ns}(p^{ns}) = 0$. Note that in this case p^{is} does not coincide with that derived in Lemma 1 because there are additional incentive effects due to the unlimited liability: a negative effect, since the entrepreneur appropriates a smaller share of the investment's expected proceeds, and a positive "disciplinary" effect, since unlimited liability makes default more costly for the entrepreneur.

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