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MARCO PAGANO and TULLIO JAPPELLI*

ABSTRACT

We present a model with adverse selection where information sharing between lenders arises endogenously. Lenders' incentives to share information about borrowers are positively related to the mobility and heterogeneity of borrowers, to the size of the credit market, and to advances in information technology; such incentives are instead reduced by the fear of competition from potential entrants. In addition, information sharing increases the volume of lending when adverse selection is so severe that safe borrowers drop out of the market. These predictions are supported by international and historical evidence in the context of the consumer credit market.

A LARGE BODY OF literature on credit markets has shown that asymmetric information may prevent the efficient allocation of lending, leading to credit rationing (e.g., Jaffee and Russell (1976), Stiglitz and Weiss (1981)) or to a wedge between lending and borrowing rates (e.g., King 1986)). In this literature informational asymmetries are taken to be exogenous: lenders fail to observe some relevant characteristic or action of potential borrowers and have no way of learning about it. In some countries, however, lenders can improve their knowledge about new customers by exchanging information with other lenders through information brokers, generally known as "credit bureaus." The latter collect, file, and distribute the information voluntarily supplied by their members, and operate on the principle of reciprocity: lenders who do not provide data are denied access to the bureau's files. In other countries, instead, these institutions do not exist. The literature offers no guide to identify the factors that lead to endogenous communication between lenders. This paper is an attempt to fill the gap.

Information sharing is important for a number of reasons: it may increase the degree of competitiveness within credit markets (Vives (1990)), improve

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efficiency in the allocation of credit, increase volume of lending, and may also have policy implications (e.g., for the issue of debt neutrality, see Yotsuzuka (1987)). Even if we focus on credit markets, the implications of our analysis extend to a variety of situations where an informational asymmetry exists: employers may have an incentive to share records about their former employees, landlords may want to exchange information about tenants, insurance companies about their former customers.

We present a model of the credit market with adverse selection to analyze when information sharing arises endogenously.[1] The model focuses on lending to households, but its insights apply also to lenders' decisions to share information about the creditworthiness of firms. We find that information is more likely to be shared when the mobility of households is high, borrowers are heterogeneous, the underlying credit market is large, and the cost of exchanging information is low. Once some banks agree to share information, there are increasing returns to the scale of information sharing: the credit bureau is a natural monopoly.

We further find that when safe borrowers are priced out of the market because of adverse selection, information sharing leads to an increase in the volume of lending. This creates the potential for two-way causation: an increase in the size of the credit market may generate information sharing, which may in turn lead to more lending activity. Finally we note that membership in a credit bureau entails both benefits and costs: more accurate information about potential borrowers set against the loss of one's informational advantage relative to competitors. Thus, another of the model's predictions is that the incentive to share information is greater when competition is limited by cost or regulatory factors (such as limits to branching).

These predictions are tested on international and historical evidence in the context of the consumer credit market. International comparison shows that the geographical mobility of the population correlates with the amount and quality of information provided by credit bureaus. The amount of information intermediated by credit bureaus is greatest in the United States, Britain, and Japan, which feature relatively high geographical mobility. At the opposite extreme, information sharing is minimal in Belgium, Italy, and Spain, where internal mobility is low. The evidence also reveals a positive correlation between information sharing and the size of the consumer credit market; but this correlation disappears when one controls for geographical mobility. Further, regulatory safeguards for consumer privacy can reduce the amount of information that credit bureaus intermediate, as in France until 1990.

[1] It is uncommon to find models that analyze these issues in relation to financial intermediation (exceptions are Jaynes (1978) and Hellwig (1986)). Many studies have analyzed the oligopolists' incentives to share information about their demand or cost functions. Vives (1990) notes that the results of these studies are highly sensitive to their particular assumptions about "the strategic variables (prices instead of quantities), or the source of uncertainty (demand instead of cost), or the type of uncertainty (common value versus private value)" (p. 413). These results cannot be applied to the analysis of information sharing among lenders, where uncertainty concerns the quality of borrowers rather than the level of demand or costs.

The historical experience of the United States over the last century brings out a similar pattern. Increases in mobility and growth in the market for consumer credit are associated with the rise and spread of credit bureaus. More recently, the activity of credit bureaus has been greatly enhanced by the cost reductions due to the introduction of computerized filing systems. The paper is organized as follows. In Section I we develop the model. Section II presents the international and historical evidence. In Section III we summarize the main results of the paper.

I. The Model

Consider a country with M towns. Each town consists of a continuum of households uniformly distributed on the interval $[0, 1]$ and served by a single bank. Households can borrow to finance their consumption by taking out a loan of size one.[2] They differ in two respects. First, with probability p a household is a "safe" potential borrower repaying with probability q_s, and with probability $1 - p$ it is "risky" and repays with probability q_r, where $q_s > q_r$.[3] Second, tastes differ, in that each household i sets a potentially different subjective value v_i on the loan. The loan's value v_i can be thought of as a reflection of household i's discount rate: more impatient people are more eager to borrow. We assume that v_i is uniformly distributed across households, with support $[0, V]$. Letting the index $i \in [0, 1]$ rank households by decreasing values of v_i, we have

$$v_i = V(1 - i), \tag{1}$$

so that i is the fraction of households who value the loan more than v_i (in fact for $v_i = V, i = 0$).

Each lender faces some turnover in his customer base. In every period a proportion m of the population moves to other towns, and is replaced by an equal fraction of immigrants (m) from other towns. The bank has acquired information on the households that have previously lived in town (the "residents"), so it can distinguish their type. Immigrants, by contrast, are a "black box": the bank knows only that with probability p they are safe and

[2] If instead individuals could borrow from different lenders, each bank would consider the existing debt exposure of a client as valuable private information about the client's repayment probability. This creates a strategic interaction among lenders, that will in general affect their incentives to exchange information, as in the Jaynes (1978) and Hellwig (1986) models of monopolistically competitive insurance markets. Since we rule out borrowing from different lenders, this interaction is absent from our model. However, this does not prevent other forms of strategic interaction affecting the incentives to share information (see Section I.C below).

[3] This assumption is standard in the literature on asymmetric information. The repayment probabilities may differ because the future incomes of borrowers have different variances (due to endowments or technology). This assumption implies that ex post lenders observe the realization of borrowers' incomes, so that the latter cannot lie about their type.

with probability $1 - p$ they are risky.[4] For all classes of households, the reservation values v_i are private information.

The interest factor charged is R_s for safe borrowers, R_r for risky borrowers, and R_m for immigrants. The cost of capital to the bank is R. We assume throughout that $R < V$: together with imperfect competition, this allows banks to earn positive expected profits.

A. Banks as Local Monopolies

We posit initially that borrowing from another town's bank is prohibitively expensive. This may be because serving the local market is more costly for "foreign" banks or because of regulatory barriers to intercity branching. Thus, each bank is a local monopolist. In Section I.*C* below, we relax this assumption and introduce competition.

The monopolistic bank can discriminate among three groups: safe residents, risky residents, and newcomers. Among resident households, the marginal safe borrower i_s and the marginal risky borrower i_r are defined respectively by

$$i_s = 1 - q_s R_s/V, \qquad i_r = 1 - q_r R_r/V. \tag{2}$$

For these two households, in fact, the marginal value of the loan equals its interest cost. The expected volume of loans demanded by residents is pi_s for safe borrowers and $(1 - p)i_r$ for risky ones. Immigrants, regardless of type, are charged a common interest factor R_m. Among immigrants, the two marginal borrowers are defined by

$$i_{ms} = 1 - q_s R_m/V, \qquad i_{mr} = 1 - q_r R_m/V, \tag{3}$$

where i_{ms} and i_{mr} denote the marginal safe immigrant and the marginal risky immigrant, respectively. The expected volume of loans demanded by immigrants is pi_{ms} and $(1 - p)i_{mr}$, for the safe and risky types respectively. The bank's expected profits are

$$\begin{aligned} E(\pi) = {} & (1 - m)[\, p(q_s R_s - R)i_s + (1 - p)(q_r R_r - R)i_r \,] \\ & + m[\, p(q_s R_m - R)i_{ms} + (1 - p)(q_r R_m - R)i_{mr} \,]. \end{aligned} \tag{4}$$

Maximizing this expression with respect to R_s and R_r, one finds the interest rates charged to risky and safe borrowers

$$R_s^* = (V + R)/2q_s, \qquad R_r^* = (V + R)/2q_r, \tag{5}$$

where clearly $R_r^* > R_s^*$.

[4] Although this is a static model, it can be viewed as the steady state of an overlapping generations model where people live for two periods. At the start of each period, they borrow and at the end of the same period they either repay or default. Everyone stays in his home town when young, and moves with probability m to a different town when old. The local bank learns young agents' types, so that it knows the creditworthiness of residents when old (but not of immigrants). The model in this paper describes then lending to people in the old generation.

To derive the interest charged to immigrants (R_m), one must take into account the fact that a rise in R_m will shrink the pool of credit applicants. If R_m goes above a certain level, only risky types (among immigrants) will borrow, and the bank will accordingly charge R_r to all newcomers. For some parameter values, the bank has an incentive to do so, because this strategy increases its expected profits by driving safe borrowers out of the market.

We must therefore distinguish between two cases: in Case (a) both types of immigrants borrow, while in Case (b) safe types drop out of the pool of borrowers. We first characterize the two equilibria (Propositions 1 and 2) and then establish the regions of parameter values in which each equilibrium applies (Proposition 3). As we shall see, the main difference between the two cases is that information sharing has different implications for lending activity and for welfare.

Case (a): When safe types stay in the market, the profit-maximizing interest factor is obtained by taking the first order conditions with respect to R_m in equation (4):

$$R^*_{m,a} = \frac{pq_s + (1-p)q_r}{pq_s^2 + (1-p)q_r^2}\,\frac{V+R}{2}, \tag{6}$$

where $R^*_s < R^*_{m,a} < R^*_r$. Substituting equations (5) and (6) in equation (4), one obtains the maximum value of expected profits:

$$E(\pi^*_a) = \frac{1}{V}\left[\left(\frac{V-R}{2}\right)^2 - m(1-\lambda)\left(\frac{V+R}{2}\right)^2\right], \quad \text{where}$$

$$\lambda = \frac{[\,pq_s + (1-p)q_r\,]^2}{pq_s^2 + (1-p)q_r^2}. \tag{7}$$

As is shown in the Appendix, $1-\lambda$ is an index of heterogeneity of the population, since it increases with the distance between the two repayment probabilities ($q_s - q_r$).

PROPOSITION 1: *When safe types stay in the market, higher mobility (m) and heterogeneity of the population (i.e., a mean-preserving spread in q_s and q_r) lower equilibrium expected profits. If the additional condition $pq_s > (1-p)q_r$ holds, an increase in the proportion of safe borrowers (p) raises expected profits.*

This proposition is proved in the Appendix. Mobility and heterogeneity lower profits because they increase the size and the riskiness of the pool of immigrants. A reduction in the proportion of safe borrowers also lowers profits if it worsens the average quality of applicants: the relevant condition is $pq_s > (1-p)q_r$, i.e., the probability of lending to a safe borrower and being repaid is greater than the probability of lending to a risky borrower and being repaid.

Case (b): If, in equilibrium, safe types drop out of the pool of borrowers, the rate of interest charged to immigrants equals that charged to risky residents:

$$R^*_{m,b} = R^*_r = (V + R)/2q_r. \tag{8}$$

The maximum value of profits is found by substituting (5) and (8) into (4), positing $i_{ms} = 0$:

$$E(\pi^*_b) = \frac{1 - mp}{V}\left(\frac{V - R}{2}\right)^2. \tag{9}$$

PROPOSITION 2: *If safe types drop out of the pool of borrowers, higher mobility* (m) *and a higher proportion of safe borrowers* (p) *lower the equilibrium value of expected profits.*

This result follows from equation (9). Mobility lowers profits as in Case (a). Heterogeneity no longer affects profits because in Case (b) the only immigrants who apply for credit are the bad risks. The proportion of safe borrowers p has the opposite effect from Case (a): since the bank only lends to bad risks among immigrants, and high values of p reduce the proportion of bad risks, a high value of p reduces the number of its customers and expected profits.[5]

PROPOSITION 3: $E(\pi^*_a) < E(\pi^*_b)$ i.f.f. $(1 - \lambda/p) > [(V - r)/(V + R)]^2$.

This proposition is obtained by comparing (7) and (9). It determines the parameter regions where Cases (a) and (b) apply. When the condition holds, we have Case (b): safe borrowers drop out. As shown in the Appendix, this can happen either because the interest factor $R^*_{m,a}$ is too high to attract any safe borrower ($q_s R^*_{m,a} > V$), or because the bank *chooses* to charge the higher interest factor R^*_r even though at $R^*_{m,a}$ safe borrowers are willing to borrow ($q_s R^*_{m,a} < V$).

It can be shown that in Case (b) the volume of lending is lower than in Case (a).[6] This is because in Case (b) the adverse selection problem is more severe. Proposition 3 indicates under which conditions this occurs. Other things equal, safe borrowers are more likely to be priced out of the market if: (1) the pool of immigrants is very heterogeneous ($1 - \lambda$ is high); (2) the fraction of safe borrowers (p) is low; (3) the reservation value is low relative to the cost of capital ($V - R$ is small), so that safe borrowers prefer not to borrow rather than to pay high interest to the bank.

B. Information Sharing

The next step is to allow for the possibility of information sharing. Suppose that all or some of the banks in the country agree to set up a credit bureau.

[5] In both Cases (a) and (b), profits are increasing in V, and decreasing in R. An increase in V implies that the average reservation value of loans increases, so that the demand for loans shifts outward. On the other hand, if the cost of capital R rises, the markup falls.

[6] To show this, compare the expressions for i^a_m and i^b_m in the Appendix (Proof of Proposition 4).

The bureau merges the information provided by all banks into a single database, which the members of the system can access for information about the quality of their credit applicants. Typically, setting up such a system entails a fixed cost (purchase of equipment, filing systems, etc.), which we denote by K.

Assume for simplicity that each member of the bureau contributes equally towards this cost, that all towns are identical, and that all banks agree to participate. Then the cost of the bureau for each participant is K/M. In return all lenders operate with full information. Expected profits are then given by

$$E(\pi_f^*) = \frac{1}{V}\left(\frac{V-R}{2}\right)^2 - \frac{K}{M}, \tag{10}$$

where the subscript f stands for "full information." The credit bureau will operate if it leads to an increase in expected profits, after netting out the costs of setting up the bureau. The proposition below shows the conditions under which information is shared in Case (a) and Case (b).

PROPOSITION 4: (*i*) *Information sharing increases profits if, respectively*

$$\textit{in Case (a)}: \quad E(\pi_f^*) - E(\pi_a^*) = \frac{m(1-\lambda)}{V}\left(\frac{V+R}{2}\right)^2 - \frac{K}{M} > 0, \tag{11a}$$

$$\textit{in Case (b)}: \quad E(\pi_f^*) - E(\pi_b^*) = \frac{mp}{V}\left(\frac{V-R}{2}\right)^2 - \frac{K}{M} > 0. \tag{11b}$$

(ii) Information sharing increases lending volume in Case (a) and reduces it in Case (b).

The proposition is proved in the Appendix. The first term in (11a) and (11b) represents the profits that banks obtain from the reduction in the risk of lending: when information is shared, default rates fall in both cases.[7] Credit bureaus are more advantageous the greater the demand for loans (captured by V), the higher the geographical mobility (m), the lower the cost of operating the system (K) and the greater the number of participants (M). In Case (a), where both types of immigrants borrow, the heterogeneity of borrowers ($1 - \lambda$) raises the net benefit from the creation of a credit bureau: the gain from eliminating the asymmetry of information between borrowers and banks increases with the uncertainty about the quality of applicants.[8]

[7] Denoting by d_a, d_b, and d_f the default rates of migrants in Case (a), in Case (b), and under full information respectively, it can be shown that

$$d_a - d_f = [(1-\lambda)/(2-\lambda)][\,pq_s + (1-p)q_r\,] > 0, \quad \text{and} \quad d_b - d_f = p(q_s - q_r) > 0.$$

[8] The parameter p may have different effects in the two cases. In Case (a), a higher p reduces the gain from sharing if and only if it increases heterogeneity (the relevant condition is $pq_s > (1-p)q_r$, which implies $\partial\lambda/\partial p > 0$). In Case (b), instead, an increase in p will always increase the gain from information sharing, since it implies that the proportion of safe borrowers that can be drawn into the market when the bureau is established is larger.

The main difference between the two cases is the effect of information sharing on the volume of lending, which expands in Case (b) and contracts in Case (a). In Case (b), information sharing makes credit accessible to immigrants that would otherwise have been priced out of the market—with the rates charged to other borrowers remaining unchanged. As we know from Proposition 3, Case (b) arises when the pool of applicants is heterogeneous and of poor quality, and when the desire to borrow is low relative to the cost of credit, i.e., when, in the absence of information sharing, the credit market is thin. In this case, communication between lenders is a Pareto improvement: profits increase, safe borrowers benefit, and risky borrowers are indifferent.

In Case (a), on the contrary, information sharing reduces the volume of loans, because it has two effects: it enables the monopolist to practice price discrimination, and it eliminates uncertainty about borrowers' types. With no uncertainty and linear demand, price discrimination does not affect the optimal quantity for a monopolist (Tirole (1988)): the increase in the quantity purchased by one group of customers is matched by the reduction in the demand by other customers. But in our uncertain environment, the introduction of price discrimination coincides with the elimination of uncertainty about types, so that the increase in lending to safe borrowers does not fully compensate for the reduction in lending to the risky, and total lending falls.[9]

So far we have assumed that all M banks cooperate in the institution of the credit bureau. Now consider the case when only M' banks ($M' < M$) agree to pool their information, possibly because they are better managed than the remaining $M - M'$. For ease of handling we take the symmetric case, where all towns are identical and the migrants from each town distribute themselves equally among all the other towns, so that each town receives m/M percent of them.

The gain from this partial information sharing is a fraction M'/M of what it would be if all lenders joined. If costs are equally shared by the M' banks, the cost per participant is K/M'. Thus, in Case (a), the net benefit per participant increases with the number of participants M':

$$\frac{M'}{M}\frac{m(1-\lambda)}{V}\left(\frac{V+R}{2}\right)^2 - \frac{K}{M'}. \tag{12}$$

Setting (12) equal to zero yields the minimum number of banks for the system to be profitable:

$$M^* = \frac{2}{V+R}\sqrt{\frac{KMV}{m(1-\lambda)}}. \tag{13}$$

A similar expression for M^* can be obtained for Case (b).

[9] In Case (a) the change in welfare, defined as the sum of consumer surplus and profits, is $(1-\lambda)\{R^2 - [(V-R)/2]^2\}/2V$, and is positive if and only if $V < 3R$. In contrast to Case (b), welfare does not always increase, because profits rise but consumer surplus falls.

Equation (13) highlights the possibility that only a subset—conceivably, a small one—of the banks may agree to institute a credit bureau. However, as equation (12) shows, once M^* banks have agreed to participate, there is a tendency for the system to encompass the whole of the market: as $M' > M^*$, nonmembers derive a net benefit from joining and incumbents have an incentive to let outsiders join. Note that this result does not depend on the assumption of fixed costs. The net benefit per member increases with M' even if costs are proportional to the number of members (e.g., $K = kM'$, where k is a constant): the extension of the system's coverage itself enhances its effectiveness. In this sense, the credit bureau is a natural monopoly.

C. Competition and the Gains from Information Sharing

So far it has been assumed that regulation or prohibitively high costs prevent banks from extending loans to citizens of other towns. This assumption precludes all competition between banks. A more realistic assumption is that credit markets are contestable. When this feature is included in the model, it becomes clear that in deciding whether to join a credit bureau lenders must take an additional effect into account, besides those already examined.

When a bank supplies information about its own customers to a competitor, in effect it is helping the latter to compete more aggressively. Monopoly profits will thus be reduced. This effect reduces the expected gain from information sharing and may deter banks from sharing information. To illustrate the interaction between market contestability and information sharing, we introduce competition via assumptions that require minimal changes in the model's structure:

1. Banks can extend credit to households living in neighboring towns at an additional cost c that reflects their lower efficiency in competing outside their market area or the presence of regulatory barriers.[10] Effectively, the cost of capital for potential entrants is $R + c$. The cost of extending credit to residents of "distant" towns stays instead prohibitive, as in the monopoly case.
2. Immigrants move to distant towns, so that their former lender is unable to retain them as customers (no bank has national coverage). It follows that immigrants are still a "black box" for the local bank as well as for any potential entrant.
3. Outside competitors can sort out migrants from residents. Their only informational disadvantage relative to the local bank is that they are unable to sort out safe from risky borrowers *among residents.*
4. The order of moves by the players is the following. First, the local bank announces a menu of interest rates, one for each group of borrowers (R_s,

[10] Alternatively, the parameter c may reflect the cost of switching from the local lender to an outside competitor. Ausubel (1991) reports evidence for the United States pointing to the existence of substantial switching costs in the credit card industry (pp. 68, 69).

R_r and R_m in Case (a): R_s and R_r in Case (b)). These rates maximize expected profits, taking into account the entrant's best response. Second, the entrant announces the interest rate(s) that maximize his profits, conditional on the rates offered by the local bank in the first stage. Third, each borrower chooses a lender. To break ties between the players, borrowers are assumed to always prefer the local bank when they are offered the same interest rate by the two banks.

5. In the absence of information sharing, an entrant can compete only for risky borrowers, who are willing to pay an interest rate high enough to cover the entrant's addition cost c. Thus the only contestable segment of the market is that formed by borrowers who pay the highest rate: risky residents in Case (a), and both risky residents and risky immigrants in Case (b).[11] In all other market segments the local lender remains a monopolist. For brevity we concentrate on this situation only. Even when outside banks can compete in all market segments, the basic insight of this section is still valid: information sharing calls for more aggressive competition.

C.1. Case (a)

As just explained, the entrant's cost disadvantage c is assumed to be low enough that the market for risky borrowers is contestable, but high enough that other segments of the local market are not. Thus c lies within an interval $(\underline{c}, \bar{c})$. The upper bound $\bar{c}$ is found by equating to zero the entrant's profits from lending to risky borrowers at the monopolistic rate R_r^*: if $c < \bar{c}$, these profits are positive, and the entrant has an incentive to undercut the incumbent in this market segment (if $c > \bar{c}$, one reverts to the local monopoly case of I.A). The lower bound $\underline{c}$ is computed by setting to zero the profits that the entrant can obtain by lending to immigrants at the same rate as the monopolistic incumbent ($R_{m,a}^*$). If $c > \underline{c}$, the entrant has no incentive to compete away these customers from the incumbent. The relevant condition is

$$\frac{\left[\frac{V-R}{2}\right]^2 - (1-\lambda)\left[\frac{V+R}{2}\right]^2}{V - \lambda\left[\frac{V+R}{2}\right]} \equiv \underline{c} < c < \bar{c} \equiv \frac{V-R}{2}. \tag{14}$$

The expression for $\underline{c}$ can be shown to be the profit per customer that the local bank obtains by lending to immigrants at the monopolistic rate $R_{m,a}^*$: the left-hand side inequality says that this potential profit is wiped out by the entrant's cost disadvantage per customer, c. Similarly, the expression for $\bar{c}$ is the profit per customer that the incumbent earns by lending to risky residents at the monopolistic rate R_r^*: the right-hand side inequality states

[11] Recall that in Case (b) immigrants are charged the same rate as risky residents, while safe types drop out of the pool of immigrant borrowers.

that this potential profit exceeds the entrant's cost disadvantage per customer, c. The interval defined by (14) is nonempty.

The game has a unique Nash equilibrium, where the local bank sets $R_s = R_s^*$; $R_m = R_{m,a}^*$; $R_r = (R + c)/q_r$, and entry does not occur (see Pagano and Jappelli (1991), pp. 16 and 17, for a proof).

The value of equilibrium expected profits when information is not shared is then

$$E(\pi_a^*) = \frac{1}{V}\left\{[(1-m)(1-p)c(V-R-c)] + \left[(1-m)p\left(\frac{V-R}{2}\right)^2\right] + m\left[\left(\frac{V-R}{2}\right)^2 - (1-\lambda)\left(\frac{V+R}{2}\right)^2\right]\right\}. \tag{15}$$

The first term in square brackets is the profit on risky loans to residents, and it is lower than under monopoly. The other two terms in square brackets are the profits on safe loans to residents and to (all) immigrants respectively, and are unchanged from the case of monopoly.

If the local bank agrees to share information with all other lenders it learns how to distinguish between risky and safe borrowers among immigrants, but it loses its informational advantage concerning residents, for now outside competitors can sort out safe and risky borrowers just as well as the local bank. So all market segments become contestable. To prevent entry, the local bank will charge the limit prices $(R + c)/q_s$ and $(R + c)/q_r$ on safe and risky borrowers respectively. Again, this is the unique Nash equilibrium for the game. At this equilibrium the local bank can make positive expected profits only because it retains the cost advantage c:

$$E(\pi_f^*) = c(V - R - c)/V - K/M. \tag{16}$$

The change in expected profits associated with information sharing is then

$$E(\pi_f^*) - E(\pi_a^*) = \frac{1}{V}\left\{m(1-\lambda)\left(\frac{V+R}{2}\right)^2 - [m + p(1-m)]\left(\frac{V-R}{2} - c\right)^2\right\} - \frac{K}{M}. \tag{17}$$

The first term in braces is the gain from information sharing that accrues to the bank under monopoly (equation 11a). The second term—absent when the bank acted as a local monopoly—is the loss due to the increased competition associated with information sharing. While this increase in competition reduces profits, it increases the volume of loans if the parameter c is low enough. Under monopoly this effect is absent in Case (a): lending increases only in Case (b).[12]

[12] See footnote 16 in Pagano and Jappelli (1991).

C.2. Case (b)

Here the marginal group includes all risky borrowers—residents and immigrants alike. For brevity, we analyze only the case in which the interest factor $R^*_{m,a}$ is too high to attract any safe borrower, i.e., $q_s R^*_{m,a} > V$. The condition implied by assumption (5) reduces to

$$0 \equiv \underline{c} < c < \bar{c} \equiv \frac{V - R}{2}. \tag{18}$$

The only change relative to condition (14) is that now the lower bound for c is zero: even if outside competitors are not burdened by a cost disadvantage, they are unable to compete safe borrowers away from the local bank. Their informational disadvantage is sufficient to prevent entry in this market segment.[13]

The unique Nash equilibrium is now $R_s = R^*_s$, $R_m = R_r = (R + c)/q_r$, with no entry. The resulting expression for expected profits in the absence of information sharing is

$$E(\pi^*_b) = \frac{1}{V}\left\{(1 - p)c(V - R - c) + (1 - m)p\left(\frac{V - R}{2}\right)^2\right\}. \tag{19}$$

Subtracting expression (19) from (16), we find that the net gain from information sharing is

$$E(\pi^*_f) - E(\pi^*_b) = \frac{1}{V}\left\{mp\left(\frac{V - R}{2}\right)^2 - p\left(\frac{V - R}{2} - c\right)^2\right\} - \frac{K}{M}. \tag{20}$$

As in Case (a), the expression can be broken down into two parts: the expected gain under monopoly (the first term in braces, identical to (11b)) and the loss that the bank incurs by revealing its privileged information to its competitors (the second term).

From (17) and (20), it appears that in both cases the loss that the bank incurs by disclosing its information decreases with its cost advantage c. When the local bank agrees to share information, a lower c reduces the profits it extracts from all market segments.When it refuses to share information, a lower c reduces only the profits extracted from risky borrowers. So the bank's incentive to share information falls with c.

Considering that the cost differential c is an index of barriers to entry, contestability reduces the gain from information sharing, and may even turn

[13] To attract safe borrowers, the entrant would have to offer a rate below R^*_s. By (5), $R^*_s < V/q_s$, so that the entrant's offer should be lower than V/q_s. But at this rate he would make losses, as shown in Figure A1: to the left of V/q_s, the relevant profit function (the thick line) is below zero.

it into a loss.[14] In this case, information sharing will not occur because it triggers unwanted competitive forces. But if lenders choose to share information, the resulting increase in competition is likely to increase lending activity. Recall that under local monopoly information sharing leads to an expansion in lending only in Case (b), due to the elimination of the adverse selection problem. When credit markets are contestable, it may lead to an increase in lending also in Case (a).

II. The Evidence

The foregoing theoretical framework has a number of empirical implications. First, the extent to which lenders share information on customers' creditworthiness should correlate positively with mobility, whereas its predicted correlation with the size of the consumer credit market is ambiguous. Second, once some lenders have agreed to pool their information in a credit bureau, there will be a tendency for others to join, leading to comprehensive coverage of the population of would-be borrowers: the credit bureaus are natural monopolies. Third, information sharing may be deterred by fear of competition. Finally, any technical innovation that reduces the costs of filing, organizing, and distributing information should foster information exchange.

In order to compare these theoretical predictions with the evidence, we have collected data on the extent of information sharing in the consumer credit market, the degree of geographical mobility, and the size of the consumer credit market in 14 countries belonging to the Organization for Economic Cooperation and Development (OECD).[15] The evidence on credit bureaus is gathered from direct interviews and questionnaires sent to credit bureaus and their associations. In the second part of this section, the validity of the model's predictions is assessed on the basis of the long historical record of the United States, where credit bureaus appeared as early as the end of the 19th century.

A. International Comparative Evidence

In all countries where lenders (banks, finance companies, or retailers) share information, the operation of credit bureaus has common features, the main ones being the principle of reciprocity and the related sanctions. A

[14] For instance, information sharing will definitely lower profits if $c = 0$: in this case, under full information, competition reduces expected profits to zero on all loans, and in addition each bank would have to pay the fixed cost K/M to share information. In fact, in Case (b), with $c = 0$ information sharing is unprofitable even if it is costless ($K = 0$): expression (20) is negative with $c = K = 0$. This is to be contrasted with the local monopoly case, where information sharing is always profitable if it is costless: expression (11b) is positive if $K = 0$.

[15] In principle, the appropriate variable is the mobility of customers between lenders, rather than between geographic locations. In the model the two concepts coincide, whereas in reality they may be only imperfectly correlated. Thus geographic mobility should be taken only as a proxy for the customer turnover faced by lenders in different countries.

lender is entitled to access only the type of information that he is willing to contribute to the bureau. The main distinction here is between "black" (or negative) information, concerning only defaults, and "white" (or positive) information, i.e., data about the credit history and the current debt exposure of all customers. In all cases, failure to comply with the rules (for instance, by providing late or inaccurate information) is sanctioned by the denial of further access.

Even if the operation of credit bureaus is basically standard around the world, there are enormous differences in the amount and type of information shared. Table I gives the key indicators of the credit-reporting activity in the consumer credit market of 14 OECD countries. The data exclude all credit reports associated with the purchase of houses. The number of consumer credit reports in millions (column 1) is a gauge of the quantity of information exchanged by lenders. To compare information sharing across countries, we also report the number of reports per capita (column 2) and per 10,000 dollars of consumption expenditure (column 3). Column 4 provides an indicator of the quality of the information pooled by lenders. Information sharing systems also differ in the length of time they have existed (column 5): whereas in the United States and Sweden credit bureaus have operated for almost a century, they were not introduced until 1987 in Belgium, and until 1990 in France, Italy, and Spain.

On the basis of Table I, the countries surveyed divide into two groups. In the first group of countries, information sharing is widespread. In the United States, Japan, and Britain, the number of credit reports per person is highest, lenders exchange black as well as white information, and credit bureaus have been active for at least thirty years. The responses to the questionnaires also indicate that in these countries credit bureaus possess information on the entire population of credit seekers. Credit bureaus operate also in Finland, the Netherlands, Australia, Germany, and Sweden, but on a smaller scale. In Australia and Finland reports are available on any credit seeker, but the bureaus provide black information only.

In a second group of countries, information sharing is not practiced at all or is in its infancy. In Belgium, a 1987 law obliged lenders to provide information on defaults to a public agency managed by the central bank and to request a report on every application for credit. In France a similar scheme has just been set up, implementing a law passed in October 1989. These compulsory schemes contrast with the spontaneous nature of information sharing in all other countries. In Italy and Spain, credit bureaus did not exist until 1990, and are just starting to operate on a very limited scale. In Greece, no such experiment is under way.

Columns 6 and 7 display estimates of *residential* and *long-range mobility*, respectively. The first is a measure of the frequency with which the typical household changes residence in a year, irrespective of the distance travelled. The second is the frequency of moves between communities with average population of 1 million, such as cities or regions. Column 8 displays total *consumer credit* as a percentage of private consumption in 1985 to 1987.

By international standards the group of countries where credit bureaus are most active also exhibits high mobility and deep consumer credit markets. The countries where there is very little information sharing or none at all are characterized by scanty mobility and thin markets. In fact, the correlation between the number of credit reports (scaled by consumer spending) and long-range mobility is 0.77.[16] Its correlation with the size of the consumer credit market is positive but rather small—only 0.11. This is confirmed by the following regression:

$$\begin{aligned}\text{Number of credit reports} = & \underset{(-0.69)}{-0.14} + \underset{(3.19)}{0.06}\ \text{residential mobility} \\ & \underset{(-1.23)}{-0.01}\ \text{consumer credit},\ \bar{R}^2 = 0.41,\end{aligned}$$

where credit reports and consumer credit are both scaled by consumption, and t-statistics are reported in parentheses (the data are those of Table I, excluding Greece). This regression is merely intended to summarize the partial correlations between information sharing and the other two variables, since according to the model consumer credit is an endogenous variable. The regression explains a large proportion of the international differences in information sharing, and is consistent with the main prediction of the model. The coefficient of mobility is positive and significantly different from zero; the insignificant coefficient of consumer credit does not contradict the model. We obtain a similar pattern of results by replacing residential with long-range mobility (here Germany is also dropped for lack of data on mobility):

$$\begin{aligned}\text{Number of credit reports} = & \underset{(-0.36)}{-0.06} + \underset{(3.58)}{0.21}\ \text{long range mobility} \\ & + \underset{(0.15)}{0.01}\ \text{consumer credit},\ \bar{R}^2 = 0.50.\end{aligned}$$

The results are qualitatively unaffected if credit reports are scaled by population.

The largest negative residual in the regressions refers to France. In fact, this is a country where mobility is relatively high (in the same range of the Netherlands and the United Kingdom) but there was no information sharing until 1990. The reason is that in France *regulations* protecting consumer privacy thwart private incentives to share information about households. The person investigated must be notified in advance of requests to access a credit file, and no report can be issued without his or her consent. The French provisions are stricter than those of other countries, even though the activity

[16] One possible objection is that the correlation between mobility and credit reports is spurious, because in some countries when people move and purchase a house, a credit report is often requested by their lender. But this objection does not apply to our data, which refer to the consumer credit market only, and excludes credit reports associated with housing loans.

Table I

Information Sharing, Mobility, and Consumer Credit in 14 OECD Countries

The number of credit reports refers to 1989 for the United States, the United Kingdom, Germany, France, Italy, and Spain, to 1988 for Japan, and to 1990 for all other countries. The term "black" indicates that only default information is shared; "white" indicates that lenders also share data on credit history and debt exposure of borrowers. Residential mobility is the household's probability of changing residence in a year. Long-range mobility measures the probability of moving in a year across communities with average population of 1 million inhabitants. The figures for consumer credit are averages of 1985–87 values (1987 for the United Kingdom, 1989 for Australia, 1985–86 for Sweden); see Pagano and Jappelli (1991, Appendix B) for sources and definitions. Private consumption is drawn from the OECD National Accounts.

	Number of Credit Reports[a]					Mobility Rate[d]		Consumer Credit (Percent of Private Consumption)
Country	Level (Millions) (1)	Per Capita (2)	Per $10,000 of Consumption (3)	Type of Information[b] (4)	Period Started[c] (5)	Residential (6)	Long Range (7)	(8)
United States	400	1.62	1.08	black + white	1890s	18.40	5.52	22.8
United Kingdom	60	1.05	1.08	black + white	1960s	11.93	2.91	14.0
Japan	110	0.89	0.67	black + white	1960s	12.78	3.47	16.5
Finland	3.5	0.70	0.52	black	n.a.	11.92	1.31	30.5
Netherlands	7.5	0.50	0.52	black + white	1960s	10.20	1.75	5.1
Australia	5.8	0.34	0.33	black	1930s	15.62	2.65	22.1
West Germany	18	0.29	0.26	black + white	1920s	10.00	n.a.	15.4
Sweden	2.2	0.26	0.20	black + white	1890s	13.30	1.91	36.8
Belgium	1.3	0.13	0.12	black	1987	4.53	0.70	9.7
Norway	0.5	0.12	0.10	black	n.a.	10.67	1.05	42.7
France	0	0	0	black	1990	10.31	2.48	6.0
Italy	0	0	0	—	1990	3.69	0.90	2.7
Spain	0	0	0	—	1990	1.47	0.33	7.6
Greece	0	0	0	—	—	n.a.	n.a.	0.3

Table I—*Continued*

n.a., not available.

[a]The United Kingdom figure is a lower bound, based on data supplied by the two largest credit reference agencies.

[b]In Japan, the affiliates of the three major credit bureaus exchange white information; in turn, these three bureaus exchange only black information through a network. In the United Kingdom, finance companies and local banks share black and white information, but exchange only black information with national banks. In Germany 12,000 lenders exchange white information and 2,000 lenders share only black information. In Finland privacy protection laws prevent the collection of white information.

[c]In Belgium and France, since 1987 and 1990 respectively, all the defaulted consumer loans must be reported to a consumer credit register managed by the Central Bank. In Italy and Spain private credit bureaus started operating in 1990. In both countries a public credit reporting system also exists: banks must report to a credit register managed by the Central Bank all defaults above 80 million lire and above 4 million pesetas respectively, but very few personal loans exceed these limits.

[d]Mobility rates computed from census data are not comparable between countries because they count people who move between administrative areas of different sizes. To overcome this problem, following Courgeau (1973), we estimate distance decay functions for mobility rates across areas of different size by fitting the relationship $p_i = a \log (P_o/P_i)$, where p_i is the probability of moving across areas of average population P_i, and P_o is the total population of the country. In the table we report the fitted values of p_i for $P_i = 4$ and $P_i = 1{,}000{,}000$. The data for the United States, the United Kingdom, Japan, Finland, the Netherlands, Sweden, Belgium, and France refer to 1971 and are drawn from Long (1989), Tables 8.1 and 8.5. Residential mobility in Australia is also drawn from Long (1989); other data for Australia are from *Labour Statistics*, Australian Bureau of Statistics, 1986, Tables 1.6 and 1.7, and refer to 1986. The figure for Germany is drawn from J. O'Loughlin and G. Glebe, Intraurban migration in West German cities, *Geographical Review* 74, 1984, p. 4. Data for Italy refer to 1984, and are drawn from *Statistiche Demografiche*, 34, Part 2, 1987, Table 1.6, p. 19. Data for Spain refer to 1982, and are from the *Anuario de Estadistica*, 1983, Table 3.1, and from S. Bentolila and J. Dolado, Mismatch and internal migration in Spain, 1962–1986, Banco de España, Documento de Trabajo no. 9006, 1990.

of credit bureaus is regulated almost everywhere so as to prevent excessive infringement of privacy and civil liberties.

In all countries, at most a few large credit bureaus dominate the market: in 1990, three giant bureaus were operating in the United States, three in Japan, and four in the United Kingdom; in Australia, Germany, Sweden, and the Netherlands the market is dominated by a single credit bureau. This high degree of concentration is a relatively new feature of the industry: historically, credit bureaus were born to serve local business communities, and accordingly they tended to be numerous and relatively small (in the 1950s there were 1,700 credit bureaus in the United States and 30 in Australia, and in the 1970s there were at least 30 in Japan). The emergence of a few dominant bureaus with nationwide coverage has stemmed from rapid and extensive mergers and acquisitions of smaller bureaus, especially in the 1970s and 1980s. We interpret this tendency as confirmation that information sharing is indeed, as shown in Section I, a *natural monopoly*.

Another of the model's predictions is that information sharing makes *competition* tougher by depriving lenders of the monopoly power attached to exclusive customer information. Fear of competition may inhibit or limit information sharing.[17] But if lenders are well protected by barriers to entry, they should be more willing to share information. Some evidence supports this theoretical prediction. In the United States, branching regulations have traditionally limited competition among banks in different states, an entry barrier that may help explain why credit bureaus arose so early and lenders began sharing both black and white information as far back as the 1920s.[18] In Britain, by contrast, banks are free to compete nationwide, and have refused a 1989 proposal from finance companies to share white information on a reciprocal basis. As a result, finance companies share only black information with banks (though sharing white information as well among themselves). Conceivably, this is because with their nationwide presence British banks feel more exposed to competition than finance companies, whose customer bases are more concentrated geographically. Similarly in Italy, where banks compete nationwide, the initiative to create the first credit bureau in 1990 was taken by local lending institutions, with national banks joining only later.

[17] This tradeoff was already stressed in a 1940 National Bureau of Economic Research report: "... a complete interchange of information [between lenders] is greatly to be desired. Under such conditions the costs of investigation and the risks of lending would be reduced substantially. The possession of credit information, however, is sometimes viewed by individual lenders and by groups as an important asset, not to be shared with competitors... Consequently, the growth of an adequate interchange of credit information between personal finance companies has been inhibited, though such interchange has been developed to a certain degree" (Young (1940), p. 160).

[18] In principle, limits to interstate branching do not prevent lending to households in other states. Banks can lend out of state provided they do not collect deposits out of their state. Since the cheapest way to acquire information on households' solvency is by monitoring their asset position, in practice this inhibits informed lending to households in other states.

B. Evidence from the History of the United States

The beginnings of information sharing in the United States are closely connected with the high mobility of households and the development of consumer credit. Before 1870 lending to households was limited, and the role of the family and of small communities in the provision of credit was predominant. An organized consumer credit market appeared following the Civil War and the dramatic socioeconomic changes after 1870. In the words of Nugent (1939),

> The Civil War... marked for many communities the beginning of the breakdown in the social cohesiveness that made mutual assistance beneficial... [Immigrants] were transplanted from intimate communities, where they had enjoyed the security of partial self-sufficiency and the protection of family and neighborhood facilities for mutual assistance, to impersonal cities, where... their nearest neighbors were usually anonymous (pp. 65, 66).

Mass urbanization led to informational asymmetries in the relationship between lenders and immigrant loan applicants. As a result, banks changed their lending policies:

> Liberal credit policies could readily be maintained in small and stable communities, where the financial worth, earning capacity, family history, and personal qualities of applicants were matters of common knowledge. In metropolitan cities, on the other hand, the difficulty of appraising credit worth on any basis other than the ownership of readily negotiable collateral led to the denial of credit to classes of consumers whose credit needs were supplied by banks in intimate communities (p. 82).

The low quality of public information, coupled with the interest in financing the consumption of immigrants with scanty assets, engendered the need to organize the exchange of information about households. At the end of the century few credit bureaus operated, and those that did collected almost exclusively information on defaults from public records and credit pay habits, specializing in a certain local area (typically, a county) and serving the local community only.[19] But the high geographical mobility of households created the need for organized interbureau reporting. In 1906 six credit bureaus agreed to cooperate in the exchange of information and founded the National Association of Mercantile Agencies (NAMA)—forerunner of the still active Associated Credit Bureau of America, Inc. (ACB), founded in 1937: the aim was to exchange data about consumers moving from one town to another,

[19] The first information brokers, associated with the massive European immigration to industrial cities of the Northeast in the late 19th century, were probably the "customer peddlers." These were English-speaking members of the immigrant group who established relations with the newly arrived, and acted as intermediaries between the credit stores and the borrowers. "The intimacy of the relationship between the peddler and his customers... generally compelled scrupulous honesty and fair dealing" (Nugent (1939), p. 68).

and to act as a clearing house for the payment of interbureau credit reports (Phelps (1949)).

In the 20th century, there have been three spurts of growth in information sharing: in the 1920s, in the 1950s, and in the 1980s. The 1920s witnessed a credit bureau explosion, the membership of NAMA soaring from 88 in 1916 to 267 in 1924 and 800 in 1927; at the same time the information exchanged was upgraded, with lenders beginning to supply the local bureaus with white as well as black information.

In the 1950s, the number of credit bureaus rose further—ACB membership rose from 1,453 in 1948 to 1,700 in 1955. The number of credit reports reached 60 million in 1960, as coverage of the consumer credit market became virtually total (in 1954 credit bureaus could already report on anyone in the United States, with 70 million consumers on file). The range of the information also widened (including data about the liabilities and employment of household members, law suits, family history, etc.), and interbureau reporting expanded tremendously. The third spurt of growth in information sharing started in the mid 1970s: the number of consumer credit reports grew fourfold, from 100 million in 1970 to 400 million in 1989.

Figure 1 shows that of these three waves (marked by the shaded areas), the first two are associated with an increase in households' mobility and in the volume of consumer credit. As an indicator of household mobility, we plot the percentage of the U.S. population not living in the state of birth in census years (Long, 1989, Table 2.1), which rose from 20.6 percent in 1900 to 23.5 in 1930, and from 25.6 percent in 1950 to 27.3 in 1960. Consumer credit as a percentage of gross national product (GNP) saw buoyant growth in the 1920s and in the 1950s.

The third wave of growth in information sharing is probably related to the dramatic technological changes due to the introduction of computers in the 1970s and 1980s. Not only did computerization lower costs and further stimulate the exchange of information among lenders; the new technology eliminated the spatial segmentation that had previously limited competition among local credit bureaus. Creditors started to centralize their databases and no longer felt obliged to provide their information to the credit bureau in their local trade area. This deprived many local bureaus of the information earlier furnished by the local branches of the creditors' offices, to the advantage of the credit bureaus in the large cities. This advantage was compounded by more aggressive marketing by the larger, computerized bureaus. From a network of local monopolies, credit bureaus began to evolve into a nationwide oligopoly.

Despite a deliberate effort by the ACB to help the smaller credit bureaus survive (by mandating parity of access to creditors' files with the larger, automated bureaus), the powerful tendency to concentration has prevailed. The 1970s and 1980s have witnessed an unprecedented wave of closures, mergers, and acquisitions, with the disappearance of over 900 independent bureaus and the eventual emergence of three giant industry leaders. In terms of our model, while reducing the costs of information sharing, computeriza-

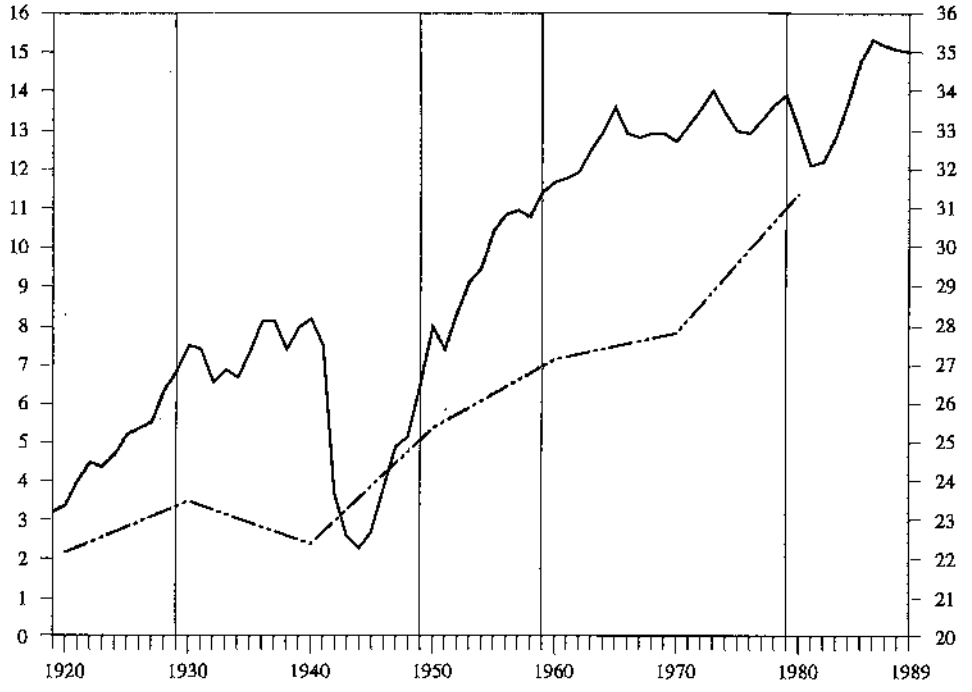

Figure 1. Information sharing, consumer credit, and household mobility in the United States (1919 to 1989). The figure reports consumer credit as a percentage of GNP (*solid line and left-hand scale*) and the percentage of the population not living in the state of birth (an indicator of household mobility) (*broken line and right-hand scale*). The *shaded areas* mark periods of rapid growth in the activity of credit bureaus. For 1919 to 1949, consumer credit data are drawn from the *Survey of Current Business* (1972), Series X, 393–409, and for 1950 to 1989 from the *Economic Report of the President* (1990). For GNP, data up to 1929 are drawn from N. S. Balke and R. J. Gordon, The estimation of prewar gross national product: Methodology and new evidence, *Journal of Political Economy* 97, 1989, pp. 38–92; after 1929, we rely on the *Economic Report of the President* (various years). Data on mobility are drawn from Long (1989), Table 2.1.

tion has eliminated the original geographic segmentation in the operation of credit bureaus, and this has fully brought out the natural monopoly inherent in information sharing.

III. Conclusions

Lenders can overcome informational asymmetries by exchanging private information about potential borrowers. This exchange varies considerably by country and over time. For instance, in the United States, the United Kingdom, and Japan, information sharing in the consumer credit market takes place on a vast scale, while in other countries it is absent or embryonic. In this respect, there are two important questions that the literature has failed to address. First, why do lenders share information in certain instances

but not in others? Second, does the agreement to share information foster the expansion of credit markets? This paper offers a theoretical framework for approaching these issues, and some evidence to assess its relevance.

The incentive to create credit bureaus is greatest, it is argued, where each lender is confronted by large numbers of customers on which it has no previous information, e.g., where borrowers are very mobile. The size of the credit market also increases the incentives to share information. On the other hand, the model indicates that sharing information does not always increase lending activity. Credit bureaus increase lending only if, in the absence of information sharing, safe borrowers would be priced out of the market by adverse selection. Finally, the model sheds light on several other features of credit bureaus: information sharing is a natural monopoly, it is discouraged by the fear of competition from potential entrants and fostered by cost-reducing innovations in information processing technology. These predictions are consistent with international and historical evidence in the context of the consumer credit market.

Appendix

Proof of Proposition 1: To show that $\partial E(\pi_a^*)/\partial m < 0$, note that by Jensen's inequality $[pq_s + (1-p)q_r]^2 < pq_s^2 + (1-p)q_r^2$, so that $\lambda < 1$, i.e., $1 - \lambda > 0$. To show that $1 - \lambda$ is an index of heterogeneity, let a mean-preserving spread be an increase in q_s to $q_s' = q_s + \epsilon$ and a reduction in q_r to $q_r' = q_r - \epsilon p/(1-p)$. Then, $[pq_s' + (1-p)q_r']^2 = [pq_s + (1-p)q_r]^2$, but $pq_s'^2 + (1-p)q_r'^2 > pq_s^2 + (1-p)q_r^2$, implying that $\lambda(q_s', q_r') < \lambda(q_s, q_r)$, i.e., $1 - \lambda(q_s', q_r') > 1 - \lambda(q_s, q_r)$. Since $\partial E(\pi_a^*)/\partial(1-\lambda) < 0$, a mean-preserving spread (an increase in heterogeneity) decreases $E(\pi_a^*)$. Finally, differentiation of equation (7) shows that $\partial E(\pi_a^*)/\partial p > 0$, provided $pq_s > (1-p)q_r$.

Discussion of Proposition 3: The expected profit function is linear-quadratic in R_m. If both types borrow, it is

$$E(\pi_a) = \frac{1-m}{V}\left(\frac{V-R}{2}\right)^2 + \frac{m}{V}\Big\{-\left[pq_s^2 + (1-p)q_r^2\right]R_m^2 + [pq_s + (1-p)q_r](V+R)R_m - RV\Big\}.$$

If instead only risky types borrow, it becomes

$$E(\pi_b) = \frac{1-m}{V}\left(\frac{V-R}{2}\right)^2 + \frac{m}{V}\Big\{(1-p)\left[-q_r^2R_m^2 + (V+R)q_rR_m - RV\right]\Big\}.$$

Each expression is composed of two terms: the first, multiplied by $(1-m)$, is the profit obtained by lending to residents; the second, multiplied by m, is that obtained from loans to immigrants.

Case (a) occurs when the maximum of $E(\pi_a)$ is greater than the maximum of $E(\pi_b)$, and Case (b) occurs when the opposite is true. Here we concentrate on Case (b) and show that it may arise in two different contexts, as illustrated in Figures A1 and A2. In both figures we graph only the expected

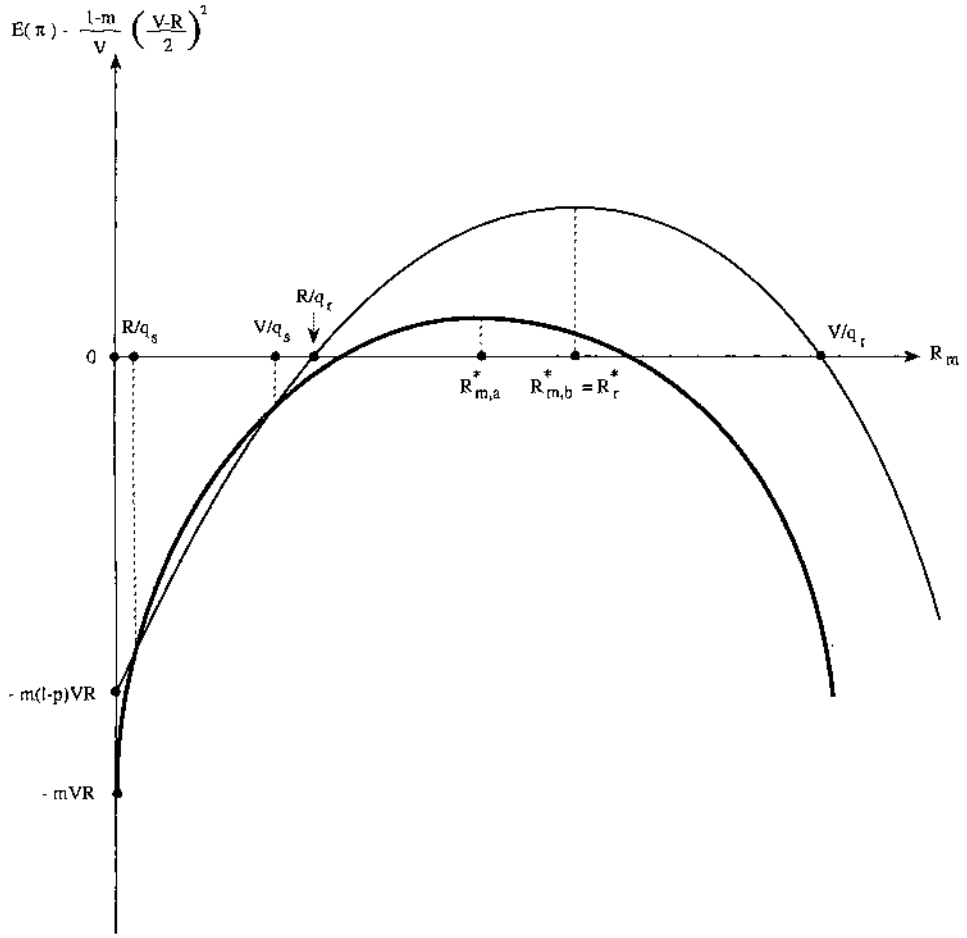

Figure A1. Expected profits from lending to immigrants when $R^*_{m,a} > V/q_s$. The figure graphs the expected profits that banks earn on the pool of immigrants as a function of the interest rate charged to them (R_m). The *thick line* represents profits earned when both safe and risky immigrants obtain credit; the *thin line* graphs profits when only risky immigrants borrow. The parameter V is the maximum value that households place on the loan, R the cost of capital, m the proportion of immigrants, p the proportion of safe borrowers, and q_s and q_r are the repayment probabilities of safe and risky borrowers, respectively. Here the interest rate that maximizes profits when both types of borrowers apply for credit ($R^*_{m,a}$) is too high to attract safe borrowers, because V/q_s is the maximum interest rate that the latter are willing to pay. As a result, the relevant profit function is that drawn under the assumption that only risky borrowers apply for credit (the *thin line*).

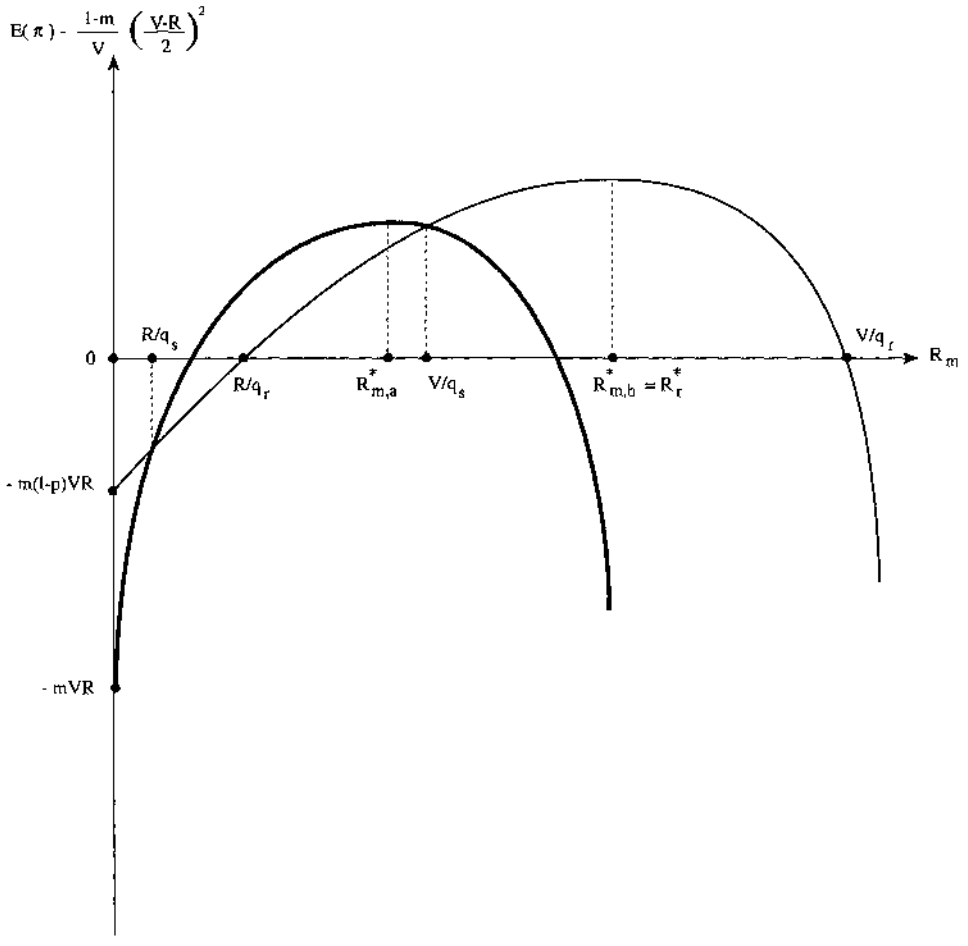

Figure A2. Expected profits from lending to immigrants when $R^*_{m,a} < V/q_s$. The figure graphs the expected profits earned on the pool of immigrants as a function of the interest rate charged to them (R_m). The *thick line* represents profits earned when both safe and risky immigrants obtain credit; the *thin line* graphs profits earned when only risky immigrants borrow. The parameter V is the maximum value that households place on the loan, R the cost of capital, m the proportion of migrants, p the proportion of safe borrowers; and q_s and q_r are the repayment probabilities of safe and risky borrowers, respectively. In contrast with Figure A1, here safe immigrants are willing to borrow at the interest rate that maximizes profits when both types borrow ($R^*_{m,a}$). However, banks can increase profits by setting the higher rate R^*_r, thus pricing safe borrowers out of the market. As a result, the relevant profit function is that drawn under the assumption that only risky immigrants borrow (the *thin line*), as in Figure A1.

profits obtained by lending to immigrants, i.e., the second terms in $E(\pi_a)$ (the thick line) and $E(\pi_b)$ (the thin line).

It can be shown that the two functions intersect twice, at $R_m = R/q_s$ and at $R_m = V/q_s$. If $E(\pi_a)$ is increasing at $R_m = V/q_s$ as in Figure A1, then its maximum $E(\pi^*_a)$ lies below $E(\pi_b)$, so that $R^*_{m,a} > V/q_s$. The relevant condi-

tion ensuring that $E(\pi_a)$ is increasing at V/q_s,

$$\frac{1-\lambda}{p} > \left(\frac{V-R}{V+R}\right)^2\left(1+\frac{p}{1-p}(q_s/q_r)^2\right),$$

is more stringent than the condition in Proposition 3—it is sufficient but not necessary for $E(\pi_a^*) < E(\pi_b^*)$. Intuitively, $R^*_{m,a}$ is too high to attract any safe borrower.

If instead $E(\pi_a)$ is decreasing at $R_m = V/q_s$ as in Figure A2, then its maximum $E(\pi_a^*)$ lies above $E(\pi_b)$, so that $R^*_{m,a} < V/q_s$. Here the above condition is not met but Proposition 3 is still satisfied. Intuitively, safe types would be willing to borrow at $R^*_{m,a}$, but the bank chooses to charge $R^*_{m,b} = R^*_r$ and to price out safe borrowers.

Proof of Proposition 4: (i) Conditions (11a) and (11b) are obtained respectively by subtracting (7) and (9) from (10). (ii) The expected volume of loans extended to immigrants is $pi_{ms} + (1-p)i_{mr}$. With no information sharing, it takes different values in Cases (a) and (b), denoted by i^a_m and i^b_m respectively. Given information sharing, the volume of loans is i^f_m. To compute i^a_m, one evaluates $pi_{ms} + (1-p)i_{mr}$ by using (3) for i_{ms} and i_{mr}, and substituting $R^*_{m,a}$ from (6):

$$i^a_m = \frac{m}{V}\left[V - \frac{\lambda}{2}(V+R)\right].$$

To compute i^b_m, one evaluates $pi_{ms} + (1-p)i_{mr}$ at $i_{ms} = 0$ and i_{mr} at $R^*_{m,b} = R^*_r$ from (5):

$$i^b_m = \frac{m}{V}(1-p)\frac{V-R}{2}.$$

Finally, i^f_m is obtained by evaluating i_{ms} at R^*_s and i_{mr} at R^*_r from (5), and substituting the results in $pi_{ms} + (1-p)i_{mr}$:

$$i^f_m = \frac{m}{V}\frac{V-R}{2}.$$

Information sharing reduces lending to immigrants in Case (a) and raises it in Case (b):

$$i^f_m - i^a_m = -\frac{m}{V}(1-\lambda)\frac{V+R}{2} < 0, \quad \text{and} \quad i^f_m - i^b_m = \frac{mp}{V}\frac{V-R}{2} > 0.$$

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