When do banks share customer information?

A comparison of mature private credit markets and markets in transition

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Abstract

Credit bureaus administering information sharing among lenders about customers reduce information asymmetry and should be key to modern credit markets. In contrast to former studies, we show using infinite period models with strategic behavior that willingness to share information depends on institutions and market concentration rather than on demand or other market characteristics such as, regional diversity or local monopolies. Lenders' interest to share information varies also by the type of information sharing arrangement. Sharing bad information only is the dominant strategy if banks think long-term. If they are myopic no information sharing may occur.

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I. Introduction*

The fast development of private credit markets in recent decades raised a series of questions about the institutions necessary to support a well-functioning financial system. Credit bureaus, public and private, that administer the information sharing among lenders about borrowers and thus reduce problems of information asymmetry, should be key pillars of modern credit markets. Credit is a non-conventional commodity as customers pay for it only well after the purchase, if ever.[1] Lending to unknown customers is a high-risk business. Consequently, information about customers is the most important input banks use in offering private loans. The more banks know about customers the cheaper it is to them, in terms of reduced risk and lower default rates, to offer loans provided that they can refuse to serve bad customers (Jappelli and Pagano, 2002). This should provide banks with strong incentives to share information about their customers but despite serious efforts of various third parties, including the World Bank, credit reporting institutions are slow to appear in emerging markets (Miller, 2002). The question this paper addresses is under what conditions are banks interested in sharing full or partial information about customers in mature and emerging markets. *We will show that banks do not have an incentive to share information about good customers while they all would be better off by sharing information about bad customers in a market where information sharing occurs through credit rating agencies.*

An additional, normative question is what an efficient market for credit information would look like. In markets where credit bureaus are successfully established, the trading in information looks curious. Banks pay twice in these systems. First when they hand over costly information about all their customers to the bureau for free, and then when they purchase each record from the agency. This seems strange for a large and a small bank would exchange information at different terms had they been able to transact information directly. This paper is a contribution to the literature on information sharing in imperfect markets.[2] We develop a simple infinite period model for oligopolistic private credit markets where banks arrive at the "current period" with unequal market shares.

II. Hypotheses

Our hypotheses are as follows:

1. In contrast to previous literature (Pagano and Jappelli, 1993), we claim it is the structure of the supply of credit and not characteristics of the demand side that plays the key role in information sharing. The banks' incentive to share or keep information can be explained by the size structure of the private credit market. Notably, in a market where a large bank has dominant market share, the incentive and capacity of large banks to share information will be profoundly different from the interest of the smaller banks. Because incentives are negatively and capacities are positively related to relative bank size, the more equal the banks' market shares the more likely that banks will share information about customers. In addition to market shares, we will show that the number of the banks in the market also has a decisive impact on banks' attitude toward information sharing.
2. Our second hypothesis is that there is an initial period effect in emerging markets but this effect does not have a lasting impact on the long-term structure of the market or on the optimal choice of information sharing assuming rational banks with an infinite horizon. This result seems surprising, for we would expect that a large bank refuses to share customer information since it can "poison" the customer base of other banks by turning away a large number of bad customers, and by doing so, the bank can further increase its market share. But we shall show that the market share of the "surviving" banks inevitably equalizes during infinite periods – while the smallest banks drop out from the market in each period – that renders information sharing about bad customers more attractive even to a large but fully rational bank than no information sharing.

We are especially interested in newly emerging private credit markets in post-communist countries we label "transition markets."[3] Unlike mature markets, transition markets had an "initial phase" in the recent past when the market for private credit was established to replace the state-owned savings bank that dominated private lending in the communist era.[4] We start with the more general case: with the mature market, then we turn to emerging markets.

3. The general wisdom is that full credit reporting is the most beneficial for financial systems, but we see that most countries have only black lists where banks share only negative information. We propose that the reason for this discrepancy is that banks individually would gain from sharing

information about bad customers but not about good ones, provided that banks operate in the market "forever."

4. We assume that banks are fully rational profit maximizers. But the time horizon of their profit maximization behavior matters. Banks would have a clear incentive to share bad information in an infinite period horizon but not in the short run. Banks lose in one period but they gain in the subsequent period from the lack of information sharing. If a bank knows that it will get many bad customers in the current period – who did not repay to other banks – but a larger share of non-paying bad customers will go to other banks in the subsequent period, this bank will have a "fluctuating" interest in information sharing. Since the share of non-paying bad customers changes from period to period, the short-term interest of a bank – to gain from the limited number of bad customers and the additional "bonus" that other banks may go under because of the large number of bad customers they receive – may be in conflict with the long-term incentive to minimize the number of bad customers for all banks. Consequently, it depends on the banks' time horizon whether they will initiate information sharing about bad customers if market shares are very unequal.

The structure of the paper is as follows: we describe the assumptions and notations in section 2. We outline the model of full information sharing in a mature market in section 3. We discuss the case of sharing information only about bad customers in section 4, and only about good customers in section 5. Section 6 presents the model of banks' competition without information sharing. We address the welfare implications of regulated information markets in section 7. We outline the model of the transition market in section 8. Discussion and conclusion follow in section 9.

III. Assumptions and notations

A. Customers

We assume that customers live exactly for two periods,[5] and that the number of customers is normalized to one. The size of the population is fixed.[6] Hence, half of the customers enter the market as "young" and half of them leave the market in each period. Customers are characterized by their "reliability type" – type can be "good" or "bad," – their valuation and their history. A fraction γ of the customers is "good type" and a fraction $(1 - \gamma)$ is "bad type." Customers' type does not change over time. "Good" customers always repay the loan, while "bad" customers never intend to pay up fully.

Customers may borrow \$1 or they don't borrow at all and can borrow only from one bank in one period. Customers have net valuation of the loan v so that their total benefit from a \$1 loan is $(1 + v)$. Customers' valuation does not change over time. For the sake of simplicity we assume that $v \in [0, 1]$ is uniformly distributed. We also assume that customers' valuation is independent of their type. This assumption asserts that customers' valuation is a matter of how they value the project they are borrowing for, while their type is exogenously given. Furthermore, we assume that good customers' valuation is always verifiable to the banks in the sense that banks know: only those good customers borrow whose valuation is equal to or larger than the market rate of interest banks charge.[7] We shall show that bad customers may have a strategic interest in repaying the loan in the first period in order to get the loan and not repay it in the second period, if there is information sharing among banks about bad customers. Consequently, bad customers' valuation also becomes verifiable to banks – but only in that case – if banks share "bad information."

The number of all customers who actually borrow in period t will be denoted Q_t. A customer will be labeled *experienced*, if she borrowed from any bank before, and *inexperienced* if she has not. In case there is no information sharing among banks, a customer who had borrowed from one or more banks before, but goes to a new bank will be regarded by this new bank as an *unknown customer*. The number of all unknown customers in period t will be denoted Q_t^U.

A customer's *history* consists of the fact that she entered the market in period $(t - 1)$ as "good" or "bad" with valuation v. In addition, the customer's history comprises everything that actually happened or could have happened to the customer in the former period(s): $h_t^C(i) = (v(i), r(G, B), A_{t-1}(i))$. A customer can take the following actions $\{A_t(i)\}$ in period t: borrow and repay the loan $(y_t(i))$; borrow and do not repay $(n_t(i))$; do not to borrow $(d_t(i))$. These are the only choices for a "young" customer. An old customer has a larger number of conceivable strategies as is shown in table 1 below.

TABLE 1. ABOUT HERE

A customer's strategy is a function that maps her type, valuation and history into the sequence of her conceivable actions:

(1) $\{0_t, y_t(i), n_t(i)\} = \phi\left(r(G,B), v, h_t^C(i)\right), \quad i \in N$,

where $r(G,B)$ is the type of the customer. If customers lived more than two periods, their history would be longer and each customer's strategy set would be much larger.

In theory, a customer can choose from nine strategy options if she or he lives for two periods as can be seen above. But our assumption that good customers always repay implies that we also assume: if a good customer did not repay, her payoff would decline to $-\infty$. Consequently, we can exclude the strategies, $(y_t(i), n_{t-1}(i))$, $(n_t(i), y_{t-1}(i))$, $(n_t(i), n_{t-1}(i))$, $(n_t(i), d_{t-1}(i))$, and $(d_t(i), n_{t-1}(i))$ for a good customer. Similarly, strategies $(y_t(i), y_{t-1}(i))$, $(y_t(i), d_{t-1}(i))$, $(y_t(i), n_{t-1}(i))$, $(d_t(i), y_{t-1}(i))$, $(d_t(i), d_{t-1}(i))$ are either unfeasible or will never be chosen by a bad customer. Thus, a bad customer can choose either $(n_t(i), y_{t-1}(i))$ or $(n_t(i), d_{t-1}(i))$ if banks share information about bad customers, or $(n_t(i), n_{t-1}(i))$ if banks do not share bad information.

A customer's pay-off is the expected discounted consumer surplus, denoted $u(i)$ of her or his actions during all periods she has been present in the market, contingent on the actions chosen by the banks. Denoting consumer *i*'s payoff u_t^i, her action a_t^i and bank *k*'s action $\{G_t, Q_t^U\}$ in period *t* – where $k \in [1, K]$, and *K* is the number of all banks in the market, G_t and Q_t^U are the numbers of known good and unknown customers served by all banks – the consumer's payoff from two periods will be:

(2) $U(i) = u_{t-1}^i\left(a_{t-1}^i, Q_{t-1}^u\right) + \delta u_t^i\left[a_t^i\left(a_{t-1}^i\right), G_t\right]$.

We could make the assumption that customers make myopic choices or they act strategically. Myopic customer behavior means that a customer's decision to borrow does not depend on future expected benefits. We assume strategic customer behavior. If a customer acts strategically, she may accept an initial loss in return for larger future benefits. But there is a substantial difference between the strategic behavior of a good and a bad customer. A good customer may always accept an initial loss denoted Δ_t in order to be recognized by the bank to be good.[8] A good customer who is willing to suffer an initial loss expects to get the loan at a lower interest rate in the next period. If banks sell loans to known customers at a lower, and to unknown customers at a higher interest rate we shall call such a pricing strategy of the banks "straight price discrimination."[9] A good customer's total expected consumer surplus (her expected payoff) from two periods with straight price discrimination will be:

(3) $$U^G = v - R_{t-1} + \delta(v - r_t),$$

where R_{t-1} and r_t are the high and the low interest rates, respectively, and $\delta \in (0, 1)$ is the discount factor. If banks ask a lower interest rate from known customers who repaid the loan than from unknown customers, a young good customer is willing to borrow at an initial loss if

(4) $$v - R_{t-1} + \delta(v - r_t) \geq \delta(v - R_t).$$

The initial loss will be $\Delta(t) = \Delta_t \in (0, 1)$. We can find the expression for Δ_t from the indifference condition of the *marginal* good customer. The marginal good customer will be the person whose valuation is $v^* = R_{t-1} - \Delta_t$. The marginal good customer is indifferent between borrowing at a loss Δ_t in the initial period but gaining a consumer surplus at a lower interest rate in the second period, or not borrowing the loan in the first period and gaining a surplus at a higher interest rate – which is charged to unknown customers – in the second period of her life. From the above conditions we have:

(5) $$v^* = R_{t-1} - \Delta_t; \quad -\Delta_t + \delta(v^* - r_t) = \delta(v^* - R_t) \Rightarrow \Delta_t = \delta(R_t - r_t).$$

Since all good customers who have higher valuations than v^* will borrow, the number of good customers who borrow in the period $(t - 1)$ will be:

(6) $$\frac{\gamma(1 - v^*)}{2} = \frac{\gamma(1 - R_{t-1} + \Delta_t)}{2}.$$

A young bad customer can also act strategically. He can borrow and repay the loan in the first period in order to get the loan and refuse to repay in the second period. Hence the young bad customer would act "against his type" if such a behavior results in a larger expected consumer surplus than not repaying. It is evident that bad customers will only choose such a behavior if they risk not to get the loan in both periods of their life.

This can only happen if there is information sharing about bad customers among banks. If banks do not share information about bad customers then a bad customer will borrow and refuse to repay in both periods. If there is information sharing about bad customers among banks – and banks apply straight price discrimination – the marginal bad customer will be the one who is indifferent between borrowing and repaying in the initial period then borrowing and not repaying in the second period, or borrowing and not repaying in the initial period:

$$(7) \qquad v^* - R_{t-1} + \delta v^* = v^*, \text{ or } v^* = \frac{R_{t-1}}{\delta}.$$

It is easy to see that the marginal bad customer would not accept an initial loss for his expected consumer surplus would be smaller than without the initial loss. The number of bad customers who borrow and repay in the initial period becomes:

$$(8) \qquad B_{t-1}^{G} = \frac{(1-\gamma)(1-v^*)}{2} = \frac{(1-\gamma)(\delta - R_{t-1})}{2\delta}.$$

A bad customer whose valuation is $v < R_{t-1}$ will only borrow in the initial period and gain consumer surplus: $1+v$. The number of bad customers who borrow and do not repay in the first period will be:

$$B_{t-1}^{B} = \frac{(1-\gamma)R_{t-1}}{2\delta}.$$

Banks can price discriminate in the opposite direction, too. Namely, they can offer loans at a higher interest rate to known and at a lower rate to unknown customers in order to induce more customers to borrow and repay. We labeled this pricing strategy "inverse" price discrimination.[10] It is obvious that good customers do not borrow at an initial loss if they can expect to pay a higher interest rate in the second period when they are experienced. It is also evident that a young good customer would prefer to remain unknown and borrow at a lower interest rate in both periods – provided that $r_t \leq R_{t-1}$ – than stay with her original bank and borrow at a higher interest rate in the second period. But in case if banks can identify known good customers and prevent them to borrow as unknown in both periods, a good customer has a strategy choice. She can borrow and repay in both periods or borrow and repay only in the second period if she expects a lower interest rate in the second than in the first period of her life in the market. Consequently, a fraction of good customers who have higher valuation than the interest rate when they are young postpone to take the loan, so they do not suffer an initial loss. The marginal good customer will be indifferent between these two options if:

(9) $$v^* - r_{t-1} = \delta\left(v^* - r_t\right) \Rightarrow v^* = \frac{r_{t-1} - r_t}{1-\delta} \Rightarrow \frac{\gamma\left(1 - v^*\right)}{2} = \frac{\gamma}{2}\left(1 - \delta + r_{t-1} - r_t\right).$$

It is important to note that the interest rate banks charge to unknown customers will *decrease* over time: $r_{t-1} > r_t$ as we show below.

If banks use inverse price discrimination the marginal bad customer will be that person who is indifferent between borrowing and repaying in the first then borrowing and defaulting in the second period, or borrowing and not repaying only in the second period:

$v - r_t + \delta v = v$. Thus, the number of bad customers who borrow and repay in the first period will be: $\frac{(1-\gamma)\left(\delta - r_t\right)}{2}$. Consequently, $\frac{(1-\gamma)r_t}{2}$ will borrow and refuse to repay in period *t*.

B. Banks

A number of "*K*" banks operate in the private credit market $\left(K = 1, 2, \ldots < \infty\right)$. For the sake of simplicity we assume that banks' marginal production cost of selling an additional unit of private loan is zero, and we also disregard banks' startup costs. Although there is an opportunity cost banks incur because they use their funds for extending private credits, we assume that the opportunity cost is zero. We also assume that banks do not pay money for the information they acquire about customers from a credit rating agency.[11] In addition, banks face the cost that is imposed upon them by borrowers who do not repay the loan. Banks' gross benefit from extending a \$1 loan equals (1 + *R*) if the loan is repaid, where *R* is the interest rate banks charge to customers.

We can make many different assumptions about how customers will allocate themselves among banks. We will assume that good customers go to banks according to the banks' market share in the former period – larger banks get more young good customers than smaller banks – while bad customers are uniformly distributed across banks.[12]

IV. The nature of the competition on the market

Proposition 1: Given the assumptions about the allocation of customers across banks we can write down the number of customers who borrow – hence, the quantity of the loan borrowed by different groups of customers – in terms of prices. That is, the number of unknown good customers who borrow from bank k in period t will be $\frac{s_{t-1}(k)\gamma(1-R_t+\Delta_{t+1})}{2}$*, provided that bank k serves all types of customers and banks apply straight price discrimination. (We shall separately discuss the case when bank k decides to serve only known good customers.) The number of young bad customers who repay can be written as:* $\frac{(1-\gamma)(\delta-R_t)}{2K\delta}$*, while the number of young bad customers who do not repay will be* $\frac{(1-\gamma)R_t}{2K\delta}$*. If banks rely on inverse price discrimination, the relevant formulas will be:* $\frac{s_{t-1}(k)\gamma(1-r_t)}{2}$*,* $\frac{(1-\gamma)(\delta-r_t)}{2K\delta}$ *and* $\frac{(1-\gamma)r_t}{2K\delta}$.

Proof: The proposition follows from the definitions in (6) – (9).

Banks announce their pricing strategy for unknown customers at each period before customers decide to borrow or not to borrow. Once a new customer learned the conditions of borrowing and signed a contract with the bank, there is no possibility of reneging on the banks' side, nor can the banks unilaterally alter the conditions of the loan. Banks can apply uniform pricing, straight price discrimination or inverse price discrimination. If banks pursue the strategy of straight price discrimination there are several ways how they can differentiate between the interest rates they charge to known and to unknown customers. Banks announce at the beginning of each period that the customers who borrowed and repaid in period (t – 1) will get the loan at a lower interest rate in period t for which: $\Delta_t(t,R_t)=\delta R_t-\delta r_t$ or Δ_t for short. The rewarding strategy of the banks may have many different forms. The general form of the initial loss would be: $\Delta_t(t,R_t)=\Delta(t,f(R_t))$. We will work with a simpler formula that is linear in R_t.

After customers allocated themselves across banks, banks make simultaneous decisions in a mature market. We assume that banks have entered the market with unequal market shares in mature markets and also in transition markets. But banks establish their initial market share in a non-simultaneous way in transition markets during the "initial" period. After then they engage in a simultaneous quantity setting competition for infinite periods. We can have at least two different settings for the banks' competition in the case of the transition market in the initial period. We can assume that there is a large old bank that had existed prior to the private credit market, and several small banks enter the market in the initial period. The small banks have capacity constrains in the initial period. Since all banks know that bad customers will turn randomly to banks, small banks will want to sell their total capacity in order to get as many good customers as possible. The large bank will act as a monopoly over residual demand in the initial period, assuming that banks have a large enough capacity to serve all customers who turn to them for the loan. Then banks play a simultaneous quantity competition in subsequent periods. In the other setting, the large old bank may act as a Stackelberg quantity leader in the initial period. Then banks play a simultaneous quantity competition in the second period when the smaller banks already established themselves in the market and they do not accept the large bank as a market leader anymore. We apply the first assumption about banks: the small banks have capacity constraints in the initial period, and the large bank chooses the quantity of borrowers as a monopoly over residual demand.

Banks know the customers' market demand function but banks cannot identify individual customers by the customer's valuation. Banks know the history of their known customers – the history of repayment – but banks do not have information, without information sharing, about unknown customers. Banks also know that a good customer will always remain good and a bad customer will remain bad over his lifetime in the market. We assume in the current paper that customers' valuation and type is independent of their income. Otherwise we should have dealt with issues of moral hazard and adverse selection that would have further complicated the analysis.

Banks maximize expected discounted profit from infinite periods by setting quantities in a *Cournot* competition game. Banks can also be represented by their history, strategy and payoff. Banks' history consists of *everything* that has happened to each bank until the current period. The question is how far should we go back in history? Banks' history is the infinite past in mature markets. But the knowledge a bank accumulates about customers during two successive periods becomes useless after these customers exit the market. New generations of customers will enter the market and information about each generation is relevant only for two periods.

"Everything" in the banks' history means how many customers borrowed in the market in previous periods. We denote the number of customers $q_t(k)$ bank *k* serves in period *t*. If banks know the number of customers who borrowed during the former period immediately implies how many customers *did not* borrow. In addition, banks' history consists of the information how many known good customers, denoted $g_t(k)$, did each bank serve. The number of unknown customers a bank sells to in a given period will be: $q_t^U(k) = q_t(k) - g_t(k) - b_{t-1}^G(k)$. Finally, history consists of the number of banks that served customers in subsequent periods. We assume that in case if a bank once decided to serve only its known good customers that is the number of its unknown customers is zero, then the bank cannot revert to selling to unknown customers again. Thus, the history of bank *k* is:

(10) $$h_t^B(k) = \{Q_{t-1}; q_{t-1}(k); g_{t-1}(k); b_{t-1}(k); K_{t-1}, ..., Q_{-\infty}; q_{-\infty}(k); g_{-\infty}(k); b_{-\infty}(k); K_{-\infty}\}.$$

The bank's strategy is a function that maps the bank's history into the number of unknown and known good customers they serve in the current period, $\left(q_t^U(k), g_t(k)\right)$:

(11) $$\left(q_t^U(k), g_t(k)\right) = f_t^k\left(h_t^B(k)\right).$$

A bank's strategy set consists of all conceivable strategies a bank can pursue. Given the total number of customers and the distribution of good and bad customers among banks and the number of banks in the market, a bank has the following strategy options given that the bank sold to known and to unknown customers in the previous period:

1. It sells to known good and to unknown customers at a uniform price $[q_t(R_t), q_{t-1}(R_{t-1})]$;
2. It sells to known good customers at a lower and to unknown customers at a higher price: $[\{g_t(r_t) q_t^U(R_t)\}, \{g_{t-1}(r_{t-1}) q_{t-1}^U(R_{t-1})\}]$;

3. It sells to known good customers at a higher and to unknown customers at a lower price: $\left[\left\{g_t(R_t)q_t^U(r_t)\right\},\left\{g_{t-1}(R_{t-1})q_{t-1}^U(r_{t-1})\right\}\right]$;

4. It sells only to known good customers in period *t*:

$\left[\left\{g_t(R_t)\right\},\left\{g_{t-1}(r_{t-1})q_{t-1}^U(R_{t-1})\right\}\right]$;

5. Does not sell (exit the market) if it sold only to good customers in the previous period: $\left[0_t, g_{t-1}(R_{t-1})\right]$

The bank's payoff from a certain strategy is the expected discounted profit from pursuing that strategy given the actions of its customers:[13]

$$\pi(k)=\sum_{t=0}^{\infty}\delta^t\pi_t^k\left(g_t(k),b_{t-1}^G(k)q_t^U(k)\right). \tag{12}$$

We define the equilibrium as follows: banks set quantities in the market for unknown customers that satisfy the Nash equilibrium conditions with the Markov property discussed above. That is, banks' quantities are best responses to all other banks' quantity choice, conditioned on the customers' history of being good or bad. Prices adjust to quantities in the market for known and for unknown customers. Customers allocate themselves among banks and market(s) clear in each period.

V. Information and information sharing

Customers learn the conditions of borrowing for two periods when they enter the market. Consequently they can make fairly simple strategic decisions. We need to separately discuss what happens if a bank decides to go out of business after the current period.

Banks have relevant information about their former customers – that is, on their known customers – when they offer the loan. In a more general setting – where, for instance, customers would live for more than two periods or they could borrow different amounts in subsequent periods – customers could migrate back and forth among banks. As we already discussed, it will not happen in our simple world.

Banks cannot discover the past history of the customers of other banks if there is no information sharing among banks. Banks cannot identify the valuation of individual customers. They can only know the valuation of the marginal customers and the aggregate valuation of all customers who borrow from them. Banks also know whether a known customer repaid the loan with interest or he did not. Consumers do not know whether they will obtain or not the loan before they actually borrow.

Banks can join three different types of information sharing systems. The first one is when banks share information only about their bad customers (a "black list"). When banks have access to a joint black list of customers they can avoid the known bad customers of other banks. Another form of information sharing system is when banks have access to information about other banks' good customers ("white list"). This gives banks an opportunity to steel the good customers of other banks. Finally, banks may share information on bad and on good customers ("full list"). Sharing full information encompasses all the opportunities that banks possess by having access to a black list and to a white list. As we shall see the information sharing regime banks choose is endogenous in the market model. In addition, the type of information sharing has a direct effect on how many customers can borrow at all in a given period.

What are the potential institutions of information sharing banks can rely on? One way of joining an information system for a bank has existed in the United States. Banks submitted the files of their served customers to credit bureaus without having financially compensated for these files. Then banks can purchase sets of customer information from the credit bureaus.[14]

Theoretically, it would be possible for banks to buy and sell directly to and from other banks. Moreover, banks could exchange information on a "one for one" basis, that is, bank *A* would disclose information about a certain number of its customers to bank *B* and it would get information on an equal number of customers from bank *B* in return. We do not see these direct transactions to happen between banks. It would need an extensive analysis why a "free market" of customer information does not exist. Such a study is beyond the scope and capabilities of this paper. We shall just briefly address the issue how banks would value customer information in an unregulated information market in the discussion section.

A. Infinite period quantity competition among banks with and without information sharing in a mature market

After having outlined the modeling assumptions we write down the models with different information sharing systems.

a. Full information sharing

With full information sharing banks know all experienced good and bad customers. There will be two markets: one for known customers and another one for unknown customers. Known bad customers will be turned away by the banks. Banks have several options to choose from:

1. Banks can compete for known good customers and sell loans at a lower interest rate to known good and at a higher interest rate to unknown customers;
2. Banks can sell to their own known good customers – forgoing the opportunity to get the good customers of other banks – at a lower and to unknown customers at a higher interest rate;
3. Banks can compete for known good customers and sell loans at a higher interest rate to known good and at a lower interest rate to unknown customers;
4. Banks can sell to their own known good customers at a higher and to unknown customers at a lower interest rate;
5. Banks can sell loans at a uniform interest rate to all customers;
6. Banks can sell only to own known good customers.

If banks sell loans at different interest rates to known good and to unknown customers, good customers and young bad customers face different strategy choices contingent on the banks' pricing policy.

1. If banks sell at a lower interest rate to known good customers, a young good customer will accept an initial loss when she first acquires the loan with the anticipation that she will get a better deal from the bank after she will have repaid the loan after one period (straight price discrimination).
2. If banks sell at a lower interest rate to all unknown customers than to known good customers, a known good customer will not accept an initial loss (inverse price discrimination).

3. As we have seen young bad customers also have a strategy choice: they can take and repay the loan in the first period and they can refuse to repay in the next period. Or, they can default in the first period.

We shall only present the case of straight price discrimination. Inverse price discrimination can be described in a very similar way. In addition, banks do not need information about experienced good customers in order to apply straight price discrimination as we shall show. It is different with inverse price discrimination: banks need to know experienced good customers otherwise those customers would go to a new bank as inexperienced and would take the loan at the lower interest rate offered to unknown customers. Inverse price discrimination may dominate straight price discrimination if the share of bad customers is high in the banking population. But in case if banks incur costs with acquiring "good" information, straight discrimination may be more profitable than inverse discrimination even with a larger fraction of bad customers.

If young good customers borrow at an initial loss and a portion of young bad customers also borrow and repay the loan in the first period, the number of known customers who borrow will be in the next period:

$$\Gamma_t = \frac{\gamma(1 - R_{t-1} + \Delta_t)}{2} + \frac{(1-\gamma)(\delta - R_{t-1})}{2\delta}. \tag{13}$$

of which the known good customers are: $G_t = \frac{\gamma(1 - R_{t-1} + \Delta_t)}{2}$. The number of bad customers who repaid in the first period will be: $B_{t-1}^G = \frac{(1-\gamma)(\delta - R_{t-1})}{2\delta}$. Profit from known good customers becomes:

$$\pi_t^G = \frac{r_t s_{t-2}(k)\gamma(1 - R_{t-1} + \delta R_t - \delta r_t)}{2} - \frac{(1-\gamma)(\delta - R_{t-1})}{2K\delta}. \tag{14}$$

Only larger banks can earn positive profit from competition as (14) shows. A bank's market share must be: $s_{t-2}(k) > \frac{B_{t-1}^G}{K r_t G_t}$ to obtain positive profit from known good customers with competition, where B_{t-1}^G and G_t are the number of bad customers who repaid and the number of known good customers in the market, respectively, in period *t*. But the higher the ratio of good to bad customers $\gamma/(1-\gamma)$ or/and the larger the number of banks in the market the less restrictive the market share constraint on profit becomes.

If banks choose not to compete for known good customers, but they would rather keep all their own good customers the interest rate they need to charge to these customers is: $r_t = R_{t-1} - \Delta_t$. Banks' profit from known good customers without competition becomes in period *t*:

$$\text{(15)} \qquad \pi_t^G(k) = \frac{(R_{t-1}-\Delta_t)s_{t-2}(k)\gamma(1-(R_{t-1}-\Delta_t))}{2} - \frac{(1-\gamma)(\delta - R_{t-1})}{2K\delta}.$$

Banks can earn positive profit from known good customers if: $s_{t-2}(k) > \dfrac{B_{t-1}^G}{Kr_tG_t}$, where B_{t-1}^G and G_t are now the number of bad customers who repaid and the number of good customers in the market *without* competition in period *t*. Since the number of good customers will be larger if banks compete, competition among banks would set a softer constraint to banks' market share than the lack of competition. As can be seen from (15) the initial loss connects the two markets of the banks. Small banks – banks with a less than average market share – will have an interest to compete for known good customers of other banks for they cannot earn positive profits on this customer group. Competition would reduce the interest rate to known good customers. Consequently, more good customers would borrow. But the number of bad customers who do not repay when they are "old" would also increase. In addition, competition for known good customers would affect the interest rate banks can charge to unknown customers conflicting with the profit maximization objectives of the banks.[15]

We show first that banks will not choose to compete for known good customers of other banks. If small banks coax competition, banks find the lower interest rate from competing for known good customers. Banks maximize:

(16)

$$\pi^G(k) = \max_{g_t(k)} \sum_{t=0}^{T} \delta^t \left(1 - \frac{2\delta\Gamma_t}{\delta\gamma(1-R_{t-1}+\Delta_t)+(1-\gamma)(\delta-R_{t-1})}\right) s_{t-1}(k)\left(\Gamma_t - \frac{(1-\gamma)(\delta-R_{t-1})}{2\delta}\right)$$
$$- \frac{(1-\gamma)(\delta-R_{t-1})}{2K\delta} + \frac{\delta}{1-\delta}\overline{\pi}^G(k),$$

where $\overline{\pi}^{G}(k)$ is bank *k*'s profit from known good customers in equilibrium. In theory *T* can be finite or ∞. We shall show below that always $T < \infty$.

Lemma 1: Banks' competition for known good customers would result in an interest rate for known customers that cannot be a dominant strategy of the banks. (See the proof in the Appendix!)

We assume that banks will not compete for known good customers of other banks. They will only serve all own known good customers. Consequently, the interest rate they charge to these customers will be $r_t = R_{t-1} - \Delta_t$. Now we turn to unknown customers. We need to find which group of customers will actually be able and willing to borrow. We showed in *Proposition 1* that there will be three groups in each wave of customers. But theoretically, there could be a fourth group of good customers who borrow. This is the group of unknown "old" good customers who have a lower valuation than the interest rate charged to unknown customers minus the initial loss that the marginal good customer accepted when these customers were "young." These customers could borrow in the second period provided that the interest rate charged to unknown customers is lower in period *t* than it was in period *t* – 1. We show that this is not possible.

Lemma 2: It is an important consequence of the banks' competitive behavior that good customers who did not borrow in the first period will not be able to borrow when they grow "old," for $R_{t-1} \leq R_t$. *The interest rate banks charge to unknown customers cannot decrease. (See proof in the Appendix!)*

We can also see this if we think about the nature of competition among banks. Since banks get young good customers by their market shares while they get an equal number of young bad customers, the smallest banks cannot earn non-negative profits. Fewer banks will serve all customers and market concentration drives the interest rates higher.

After having shown that there will not be competition for known good customers among banks, and unknown customers who did not borrow in their first period in the market will not be able to borrow in their second period either, we can draw some important conclusions about the initial loss young good customers accept.

Given the assumptions about the size of the banking population, about the fraction of good and bad customers in each wave and about straight price discrimination we can formulate the following theorem.

Theorem 1: If banks apply straight price discrimination they do not need to share good information. (See proof in the Appendix!)

Now we need to deal with the infinite horizon of the banks' profit maximization problem. After we proved that the infinite horizon dynamic programming problem can be simplified to a chain of two period optimizations during finite periods plus a steady state optimization problem for infinite periods, we shall return to the original presentation of the model. Banks solve the following infinite horizon optimization problem:

$$(17) \qquad \Pi_k\left(g(k),b(k),q^U(k)\right)=\max_{g_t,b_t,q_t^U,b_t^U}\sum_{t=0}^{\infty}\delta^t\left(r_t g_t(k)+R_t\left(q_t^U(k)-\frac{B_t^B}{K}\right)-\frac{B_{t-1}^G+B_t^B}{K}\right)$$

with the constraint: $\Pi_k\left(g(k),b(k),q^U(k)\right)\geq 0$.

The transition functions are as follows:

(18)

$$g_{t+1}(k)=s_{t-1}(k)\left(\Gamma_t^U-B_t^G\right)\Delta_t;$$
$$b_{t+1}(k)=\frac{B_t^G}{K}+\frac{B_{t+1}^B}{K};$$
$$q_{t+1}^U(k)=s_t(k)\left(\Gamma_{t+1}^U-B_{t+1}^G\right)+\frac{B_{t+1}^G+B_{t+1}^B}{K}=s_t(k)\Gamma_{t+1}^U-\left(s_t(k)-\frac{1}{K}\right)B_{t+1}^G+\frac{B_{t+1}^B}{K},$$

where we denoted bad customers who act as good in one period $\left(B_t^G(k)\right)$and bad customers who act according to their type $\left(B_t^B(k)\right)$. The control variable of the dynamic optimization problem is given by: $\Delta_t=f\left(R_t\left(G_t,Q_t^U\right)\right)$.

It seems that we have the following standard dynamic programming problem:

(19)

$$\Pi_k\left(g(k),b(k),q^U(k)\right)=\max_{\Delta}\left\{\pi_k\left(g(k),b(k),q^U(k),\Delta\right)+\delta\Pi_k\left(g^*(k),b^*(k),q^{U^*}(k)\right)\right.$$
$$\left.|\Delta;\quad\left(g^*(k),b^*(k),q^{U^*}(k)\right)=\varphi\left(g(k),b(k),q^U(k),\Delta\right);\quad\Delta=h\left(g(k),b(k),q^U(k)\right)\right\}$$

We show that the infinite horizon model of banks' competition is not a standard dynamic programming problem, and it can be partitioned to a *finite* profit maximization problem that has the Markov chain property, and an infinite profit maximization problem with equilibrium values. That is, banks' profit maximization is a repeated two-period constrained optimization problem in a finite period of time – until banks' market share becomes equal – where the successive two-period parts of the game are independent from previous periods. After the market reached its steady state banks maximize equilibrium profit during infinite periods.

Proposition 2: The infinite period competition of banks has the Markov-chain property, that is, the two-period portions of a bank's history are independent of previous periods as regards information that banks learn about customers. In other words, the sequence of two-period games repeats itself in a bank's history.

Proof: The proposition immediately follows from the transition functions in (19) *and from the definition of the initial loss that young good customers may accept. The initial loss controls the choice of good customers only for two periods until those customers are present in the market. In addition, the initial loss cannot be stable for its successive values must adjust to the banks' market shares that converge to equality during finite periods.*

If banks do not compete for known good customers – and they will not as we have already seen – smaller than average size banks drop out from the market while larger than average size banks stay. We shall discuss the issue in detail when banks would decide to stop serving unknown customers in the section of information sharing about bad customers. For banks that leave the market in period *t* the profit maximization problem is finite: its last period is when banks serve their known good customers. Those banks that continue to serve all types of customers and arrive at steady state of the market during finite periods will have equal market shares and each of them earns the same profit.

Theorem 2: For banks which survive and are active when the market reaches its equilibrium, the profit maximization problem becomes "quasi-infinite" for they earn the same amount of profit in each period in equilibrium. (See proof in the Appendix!)

Since banks serve only own known good customers the lower interest rate in steady state becomes: $\bar{r} = \bar{R} - \bar{\Delta}$.

Lemma 3: the initial loss young good customers accept becomes zero in steady state: $\overline{\Delta} = 0$.

Proof: It follows from the definition of Δ *that* $\overline{\Delta} = \delta\left(\overline{R} - \overline{r}\right) = -\delta\overline{\Delta}$. *Since* $\Delta \geq 0$ *and* $\delta > 0$ *the equality can only hold if* $\overline{\Delta} = 0$. *Consequently, for the interest rates we have:* $\overline{r} = \overline{R}$. *That is, there will not be different interest rates for known and for unknown customers in equilibrium.*

We can also describe the optimum path of Δ_t beside former result that $\lim_{t \to T} \Delta_t = \overline{\Delta} = 0$.

Lemma 4: The initial loss young good customers accept if banks use straight price discrimination is a decreasing and concave function of R_t *:* $\frac{\partial \Delta\left(t, f\left(R_t\right)\right)}{\partial R_t} \geq 0, \ \frac{\partial^2 \Delta\left(t, f\left(R_t\right)\right)}{\partial {R_t}^2} \leq 0$.

The initial loss is a decreasing but convex function of t: $\frac{\partial \Delta\left(t, f\left(R_t\right)\right)}{\partial t} \leq 0, \ \frac{\partial^2 \Delta\left(t, f\left(R_t\right)\right)}{\partial t^2} \geq 0$. *In addition,* $\frac{\partial^2 \Delta_t(t, R_t)}{\partial R_t \partial t} \leq 0$. *(See proof in the Appendix!)*

The first two inequality conditions reflect the obvious assumption that banks want fewer customers to borrow with a low valuation at lower interest rates than at higher interest rates. But the banks incentive to increase the number of good customers who borrow is constrained by their profit maximization endeavor. The last three inequality conditions show that as time goes by the banks' interest in getting more good customers is weakened as small banks drop out from the market and market shares of the remaining banks equalize. Fewer banks will get the same number of bad customers that will reduce the banks' profit. But banks have a countervailing incentive to balance the losses from an increased share of bad customers. This is why they do not want to drastically reduce the value of the initial loss that young good customers accept. Finally, the *change* of the initial loss is a decreasing function of time for the margin narrows between the interest rate charged to unknown customers and the interest rate paid by known good customers.

If banks stay in the market their profit maximization problem becomes:

(20)

$$\Pi_k\left(g_k(R), b_k(R), \overline{g}_k\left(\overline{R}\right), \overline{b}_k\left(\overline{R}\right)\right) = \max_{R_t, \overline{R}} \sum_{t=0}^{T} \delta^t \left(r_t s_{t-1}(k) G_t - \frac{B_t^G}{K} + R_t s_{t-1}(k) \Gamma_t^U - \frac{B_t^U}{K} \right) + \frac{\delta}{1-\delta} \pi_k\left(\overline{R}\right).$$

It will suffice to find the interest rates banks charge to customers before steady state and in equilibrium. The banks' dynamic programming problem will be as follows:

(21)

$$\Pi_k\left(R, \overline{R}\right) = \max_{R_t, \overline{R}} \sum_{t=0}^{T} \delta^t \left(\frac{s_{t-1}(k)\left(R_{t-1} - \Delta_t\right)\gamma\left(1 - R_{t-1} + \Delta_t\right)}{2} - \frac{(1-\gamma)\left(\delta - R_{t-1}\right)}{2K\delta} \right) +$$

$$+ \sum_{t=0}^{T} \delta^t \left(R_t \left(\frac{s_{t-1}(k)\gamma\left(1 - R_t + \Delta_{t+1}\right)}{2} + \frac{(1-\gamma)\left(\delta - R_t\right)}{2K\delta} \right) - \frac{(1-\gamma)R_t}{2K\delta} \right) + \frac{\delta}{1-\delta} \overline{\pi}_k\left(\overline{R}\right).$$

Banks serve $Q_t^U = \frac{\gamma\left(1 - R_t + \Delta_{t+1}\right)}{2} + \frac{1-\gamma}{2}$ unknown customers in period t, thus the interest rate they charge to these customers becomes $R_t = \frac{1 + \gamma\Delta_{t+1}}{\gamma} - \frac{2Q_t^U}{\gamma}$. We already know that banks will charge $r_t = R_{t-1} - \Delta_t$ to their own known customers. We get the lower interest rate as $r_t = \frac{1}{\gamma} - \frac{2Q_t^U}{\gamma}$, and the number of known good customers as $\frac{\gamma\left(1 - r_t\right)}{2} = \frac{\gamma - 1 + 2Q_t^U}{2}$. We can use these results to write bank k's profit function in period t as follows:

(22)

$$\pi_t(k) = \left(\frac{1}{\gamma} - \frac{2Q_{t-1}^U}{\gamma} \right) s_{t-1}(k) \frac{\gamma - 1 + 2Q_{t-1}^U}{2} - \frac{(1-\gamma)}{2\delta K} \left(\delta - \frac{1 + \gamma\Delta_t}{\gamma} + \frac{2Q_{t-1}^U}{\gamma} \right)$$

$$+ \left(\frac{1 + \gamma\Delta_{t+1}}{\gamma} - \frac{2Q_t^U}{\gamma} \right) s_{t-1}(k) \left(Q_t^U - \frac{(1-\gamma)}{2} \right) + \left(\frac{1 + \gamma\Delta_{t+1}}{\gamma} - \frac{2Q_t^U}{\gamma} \right) \frac{(1-\gamma)}{2\delta K} \left(\delta - \frac{1 + \gamma\Delta_{t+1}}{\gamma} + \frac{2Q_t^U}{\gamma} \right)$$

$$- \frac{(1-\gamma)}{2\delta K} \left(\frac{1 + \gamma\Delta_{t+1}}{\gamma} - \frac{2Q_t^U}{\gamma} \right).$$

The first order condition for period *t* gives:

(23)

$$\frac{\partial \pi_t(k)}{\partial q_t^U} = -\frac{(1-\gamma)}{\delta\gamma K}\cdot\frac{d\Delta_t}{dR_t} + s_{t-1}(k)\left(2R_t - \frac{1+\gamma\Delta_{t+1}}{\gamma} + \frac{1-\gamma}{\gamma}\right) + \frac{2(1-\gamma)R_t}{\delta\gamma K} + \frac{(1-\delta)(1-\gamma)}{\delta\gamma K} = 0 .$$

Summing over all k and rearranging yields:

(24) $$R_t = \frac{\delta\gamma}{2(\delta\gamma+1-\gamma)}\Delta_{t+1} + \frac{1-\gamma}{2(\delta\gamma+1-\gamma)}\cdot\frac{d\Delta_t}{dR_t} + \frac{\delta+\gamma-1}{2(\delta\gamma+1-\gamma)}, \text{ or}$$

(25) $$\Delta_{t+1} = \frac{2(\delta\gamma+1-\gamma)}{\delta\gamma}R_t - \frac{1-\gamma}{\delta\gamma}\cdot\frac{d\Delta_t}{dR_t} - \frac{\delta+\gamma-1}{\delta\gamma} .$$

The expression in (25) is a difference equation of first order in *R*. Note that $\Delta(R)$ cannot be linear in (25) for it could not meet the *Samuelson* conditions for local stability.[16] If the term $\Delta(R)$ is quadratic in R, then we have:

(26) $\alpha R_{t+1}^2 + \beta R_{t+1} + \varepsilon = aR_t^2 + bR_t + c$, where $\alpha, \beta, \varepsilon$, and *a, b and c* are parameters obtained from (25). The equilibrium interest rate, denoted $\overline{R}$ can be obtained from:

(27) $(\alpha - a)\overline{R}^2 + (\beta - b)\overline{R} + (\varepsilon - c) = 0$.

In order to control for local stability, we need to linearize equation (26). Introducing $\hat{R} = R - \overline{R}$, substituting it into (26), then neglecting terms of second order, $\hat{R}_{t+1}^2$ and $\hat{R}_t^2$, and rearranging yields:

(28)

$$(2\alpha\overline{R} + \beta)\hat{R}_{t+1} = (2a\overline{R} + b)\hat{R}_t + (b-\beta)\overline{R} + (c-\varepsilon), \text{ or}$$
$$\hat{R}_{t+1} = \frac{2a\overline{R}+b}{2\alpha\overline{R}+\beta}\hat{R}_t + \frac{b-\beta}{2\alpha\overline{R}+\beta}\overline{R} + \frac{c-\varepsilon}{2\alpha\overline{R}+\beta}.$$

Now we have a linear equation in the form $\hat{R}_{t+1} = \theta\hat{R}_t + \rho\overline{R} + \omega$. The condition of local stability is fulfilled if $|\theta| < 1$.

Assume that banks have found these interest rates and the solution for (28). Then bank *k* will find the number of customers it serves in period *t* by plugging the results back into the relevant expressions in Proposition 1. There are two factors in competition that may prevent some banks from serving new customers: the banks' low market share in period *t* – 1, and the *shift* of their market share in period *t*. If a bank was very large in the former periods and its market share just slightly decreased in period t it may not be capable of serving new customers in period t. The other possibility is that a bank started period t as medium-sized and its market share increased to a large extent in period t then this bank may not be willing to serve new customers. If bank k serves customers in period t its profit becomes:

$$\pi_t(k) = \hat{R}_t\left(q_t(k) - \frac{1-\gamma}{2K}\right) - \frac{1-\gamma}{2K}. \tag{29}$$

Only those banks can earn positive profits whose market share fulfills:

$$q_t(k) > \left(\frac{1+\hat{R}_t}{\hat{R}_t}\right)\frac{1-\gamma}{2K}. \tag{30}$$

Since $q_t(k)$ depends on the bank's market share small banks will not be able to meet this condition. Banks with smaller market shares than what (30) implies will incur losses. Assuming perfect foresight of the banks until infinity this could not happen for small banks knowing that they will make losses would not sell loans to any customers. The market would and should be in its "golden age" equilibrium from the start. In case if small banks are still present in the market and they must leave in period t, fewer banks will serve the customers, but their market share will be reduced relative to their share in the previous period. The market converges to its steady state where banks' market share will equalize. It is also important to note that the magnitude of the initial loss will decrease to zero in equilibrium as we have shown before. The interest rate customers pay in equilibrium, and the number of customers they serve will be as shown in (28) before.

We need to distinguish between two classes of market outcomes. The first class is when banks have unequal market shares. Then the equilibrium interest rate will be stable if the *Samuelson* conditions for local stability are satisfied. It is not easy for banks to meet the conditions of local stability if banks have different market shares. The stability conditions can only be satisfied if the *difference* between the interest rates that banks charge to known and to unknown customers is fairly large (that is, Δ_t is large enough for any t.)

The other important case is when banks start competition with equal market shares. Now the market is in its steady state from the start. There is no more adjustment of the interest rates and market shares among banks.

But even in case when banks started with unequal market shares they will have identical market shares in equilibrium as we prove below.

Theorem 3: Market shares across banks will equalize in steady state. (See proof in the Appendix!)

The above results have profound consequences for how we can think of the competition among banks in a market with unequal market shares of the players. While the banks' market share equalizes – or is equal from the start – in both markets, the number of customers served, the interest rate charged, consequently consumer surplus and banks' profit will be different in the two markets until banks' market shares equalize.

An important conclusion from the above result is that large banks do not gain from sharing information about good customers if they sell loans at a lower interest rate to known good than to unknown customers.

Theorem 4: Full information sharing is not in the large banks' interest if they intend to charge a lower interest rate to known good than to unknown customers. Large banks are better off if they serve their own known good customers than if they try to steal other banks' known good customers.

Proof: Since large banks can block competition for known good customers they do not need information about good customers of other banks, for they will only serve own good customers.

Since the large banks' market share decreases period by period, this fact has countervailing effects on the large banks' profit from unknown customers. Namely, the banks' lower market share in the second period results in a smaller loss that comes from non-paying bad customers. This factor alone would increase the large banks' total profit from two subsequent periods. But the large banks' lower market share in the second period reduces their gain from repaying customers, too.

The position of the small banks just mirrors the large banks' position. Small banks may be worse off without than with competition for known good customers. Small banks suffer a larger loss from bad customers in the second period as their market share increases, but the countervailing effect of their growing market share on the first period loss from bad customers is also stronger in the first period. And small banks also gain from keeping more known good customers.

We need to address the question whether banks would want to charge uniform interest rates to all customers under special circumstances.[17] Since young good customers would not have an interest to borrow at an initial loss, in addition, more bad customers will not repay than under price discrimination, profit would be lower than with different prices to different customer groups. Consequently, banks will not choose to apply uniform pricing when they can price discriminate among customers if banks started with unequal market shares. But in case if market shares equalize, banks will not want to get an increasing number of customers. As a consequence, young good customers will not have the interest to accept an initial loss for banks do not offer a lower interest rate to known good customers. When the market reaches its steady state banks will charge uniform prices to all customers.

We have seen that large banks would not gain from joining a full information sharing agreement. But we cannot exclude the possibility that small banks form or join the credit bureau and share information about all customers they serve. If the market shares of these banks are identical they do not gain – they rather loose – from sharing information about good customers, for information sharing about good customers may induce competition that would result in a lower interest rate banks can charge to customers than without competition. If the small banks have different market shares, the lack of incentive to share information that we witnessed in the case of the large banks resurfaces among the small banks. Consequently, banks will not be motivated to voluntarily join a credit bureau.

Finally, a large bank can also engage in predatory pricing, forcing the smaller banks to exit the market and remain as a monopoly in the market for infinite periods. We cannot exclude but we shall ignore this possibility for we do not discuss the issues of price competition in this paper.

b. Information Sharing About Good Customers

Each bank knows all good customers but banks maintain private information about bad customers. If banks serve known good and also unknown customers, known good customers could be allocated among banks by competition as in the full information sharing case. But banks can also keep all their known good customers by charging an interest rate that is adjusted to the interest rate good customers paid in the first period of their existence: $r_t = R_{t-1} - \Delta_t$.

The allocation of bad customers will substantially change compared to previous modeling assumptions. Notably, each bad customer who is in the market will get the loan, for a known bad customer can go to another bank and take the loan as unknown in the second period. Bad customers never repay the loan – we saw that it is a dominant strategy to bad customers if they can acquire the loan without paying in both periods – that alters the number of known customers, too, who apply for the loan in the second period. The number of known good customers who borrow in the second period is:

$G_t = \frac{\gamma(1 - R_{t-1} + \Delta_t)}{2}$, or $G_t = \frac{(1 - R_t)\gamma(1 - r_{t-1})}{2}$, depending on the fact whether banks apply "straight" or in "inverse" price discrimination.

As we have already shown in the full information sharing case – and it is also true with good information sharing – larger banks will attain higher profits on known good customers if they just keep their own known good customers and do not compete for the known good customers of the other banks. It would be even more so with good information sharing than in case of banks sharing full information, for banks cannot offer a very low interest rate to unknown customers since they can expect to receive more bad customers who never repay with good information sharing than in the full information sharing case. We shall discuss the allocation of unknown bad customers in a later section, when we turn to the case of no information sharing. While information sharing only about good customers has similar consequences to the competition for known good customers as in the case of full information sharing, information sharing only about good customers is identical to no information sharing as regards the allocation of bad customers across banks.

c. Information Sharing About Bad Customers

With information sharing about bad customers there will be two markets: banks serve their own known good customers and unknown customers at different interest rates. Some banks may decide to serve only the own known good customers. Banks turn known bad customers away. Young bad customers may repay the loan in the first period for the same reason as in the full information sharing case. Banks have the same alternatives with regard to pricing as in the full information sharing case. All the results that we have seen in the case of full information sharing will be identical if banks share information only about known bad customers. This is an important reason why banks will not have an interest in engaging in full information sharing.

A distinctive feature of "bad information sharing" is that known good customers could go to another bank in their second period as unknown customers if banks would offer the loan at a lower interest rate to unknown than to known customers. This can only happen if banks apply inverse price discrimination. And this can be a good reason why banks would actually decide to choose inverse price discrimination. It is important to note that good customers who could not borrow in the first period may be able to borrow in the second period for the interest rate to unknown customers decreases. Banks serve $Q_t^U = \frac{(1-\delta)(1-\delta\gamma)+\delta r_{t-1}}{2(1-\delta)} - \frac{\delta r_t}{2(1-\delta)}$ unknown customers and bank *k* will maximize:

(31)

$$\Pi_t^U(k) = \sum_{t=0}^{T} \delta^t \left(\left(\frac{(1-\delta)(1-\delta\gamma)+\delta r_{t-1}}{\delta} - \frac{2(1-\delta)Q_t^U}{\delta} \right) s_{t-1}(k) \left(Q_t^U - \frac{(1-\gamma)r_t}{2\delta} \right) - \frac{(1-\gamma)r_t}{2\delta K} \right)$$
$$+ \frac{\delta}{1-\delta} \overline{\pi}^U(k).$$

The first order condition gives:

(32) $$\frac{\partial \pi_t^U(k)}{\partial q_t^U} = 2r_t + \frac{(1-\delta)(1-\gamma)}{\delta^2} r_t - r_{t-1} - \frac{(1-\delta)(1-\delta\gamma)}{\delta} + \frac{(1-\delta)(1-\gamma)}{\delta^2} = 0$$, which yields

$$r_t = \frac{\delta^2 r_{t-1}}{2\delta^2 + (1-\delta)(1-\gamma)} + \frac{(1-\delta)(\delta(1-\delta\gamma)-(1-\gamma))}{2\delta^2 + (1-\delta)(1-\gamma)}.$$

The formula in (32) is a difference equation of first order with the solution in general form:

(33) $$r_t = a^t \left(r_0 - \frac{b}{1-a} \right) + \frac{b}{1-a},$$ where r_0 is the value of the state variable in the initial stage, and

$a = \frac{\delta^2}{2\delta^2 + (1-\delta)(1-\gamma)}$, $b = \frac{(1-\delta)(\delta(1-\delta\gamma)-(1-\gamma))}{2\delta^2 + (1-\delta)(1-\gamma)}$ are the parameters from equation (32). The interest rate in steady state becomes:

(34) $$\bar{r} = \frac{b}{1-a} = \frac{(1-\delta)(\delta(1-\delta\gamma)-(1-\gamma))}{\delta^2}.$$

Since $\left|a\right|<1$, as can be seen directly from (33), the lower interest rate will be locally stable around its equilibrium value.

In addition to unknown customers, banks will serve in total:

$\Gamma_t = \frac{(1-R_t)\gamma(1-\delta+r_{t-1}-r_t)}{2} + \frac{(1-\gamma)(\delta-r_{t-1})}{2\delta}$ known customers and bank k's profit becomes:

(35)

$$\pi_t^G(k) = \left(1 + \frac{(1-\gamma)(\delta-r_{t-1})}{\delta\gamma(1-\delta+r_{t-1}-r_t)} - \frac{2\Gamma_t}{\gamma(1-\delta+r_{t-1}-r_t)}\right)s_{t-1}(k)\left(\Gamma_t - \frac{(1-\gamma)(\delta-r_{t-1})}{2\delta}\right) - $$
$$- \frac{(1-\gamma)(\delta-r_{t-1})}{2\delta K}.$$

Now the interest rate banks charge to known good customers is not connected to the interest rate that banks apply to unknown customers through Δ_t. It is easy to show that Banks will charge $R_t = \frac{1}{2}$ to known customers that maximizes their profit from known good customers.

The interest rate banks would charge to unknown customers would only be feasible if:

(36) $$\frac{(1-\delta)(\delta(1-\delta\gamma)-(1-\gamma))}{\delta^2} < \frac{1}{2} \Rightarrow \frac{4\delta-3\delta^2}{\delta+\delta^2-\delta^3-1} < \gamma .$$

The numerator will be positive at any positive value of δ. But the denominator will be zero if δ is close to unity. Consequently, inverse price discrimination is only feasible if the discount factor is relatively low. In addition to the constraint in (36), inverse price discrimination is extremely sensitive to the ratio of good and bad customers. If the share of bad customers is low, banks lose more on good customers who cannot borrow in the second period than the gain banks get from bad customers who borrow and repay in the first period. We have the following theorem.

Theorem 5: Inverse price discrimination cannot be a long-term equilibrium solution for banks if the discount factor is close to unity.

Proof: Theorem 5 follows from (35) and (36).

An interesting and important case in “bad information sharing” is when J banks $\left(J = 0, 1, ... < K\right)$ decide to serve only their known good customers. This can happen to banks that are small enough to incur losses had they continued to serve all customers. If some banks decide to sell exclusively to their own known good customers this will be the banks' last period in the market, for known good customers exit after the current period. (And we assumed that once a bank stopped serving unknown customers it would not serve unknown customers again.) A bank will choose to sell only to its known good customers – then exit the market – if its profit from known good and from unknown customers during infinite periods is smaller than its profit from the two customers groups until last period plus the profit it makes on known good customers in the current period:

(37) $$\frac{1}{\delta}\pi(k) < \frac{(1-\delta)\pi(k)}{\delta} + \pi^{G}(k) \Rightarrow \pi(k) < \pi^{G}(k).$$

If a bank decides to serve only its known good customers it will charge the same – higher – interest rate other banks ask from their unknown customers with “straight” price discrimination, for good customers would be unknown to other banks. Consequently, they could get the loan only with the same terms as young unknown customers. Denoting the joint market share of banks that serve only good known customers $\sigma_t(J) = \sum_{j=1}^{J} s_t(j)$, the number of known good customers served by the J banks becomes:

(38) $$G_t(J) = \sigma_{t-2}(J)\left(\frac{\gamma\left(1-R_{t-1}+\Delta_t\right)\left(1-R_t\right)}{2} + \frac{(1-\gamma)\left(\delta - R_{t-1}\right)}{2\delta}\right).$$

Banks that will have both known good and unknown customers serve

$$G_t(J) = \sigma_{t-2}(K-J)\left(\frac{\gamma\left(1-R_{t-1}+\Delta_t\right)\left(1-R_t\right)}{2} + \frac{(1-\gamma)\left(\delta - R_{t-1}\right)}{2\delta}\right) \text{known,}$$

$$\Gamma_t^{U}(K-J) = \sigma_{t-1}(K-J)\left(\frac{\gamma\left(1-R_t+\Delta_{t+1}\right)}{2} + \frac{(1-\gamma)\left(\delta - R_t\right)}{2\delta}\right) \text{ repaying unknown,}$$

and $B_t^U = \sigma_{t-1}(K-J)\dfrac{(1-\gamma)R_t}{2\delta}$ non-paying unknown customers in period *t*. As we showed in the full information sharing case banks that sell to known and to unknown customers will charge $r_t = R_{t-1} - \Delta_t$ to their known good customers.

Banks that sell to all customers may not know that some banks will sell only to known good customers. There are different ways to tackle this problem. We assume that the *J* banks announce first that they will serve only their good known customers. From this point on banks that serve all types customers maximize profits as in the full information sharing case. The only difference between the two models is that banks' market share on the market for unknown customers will increase for each bank gets $\dfrac{s_{t-1}(k)}{\left[1-\sigma_{t-1}(J)\right]}$ good customers and $1/J$ bad customers in period *t*.

A bank that serves only own good known customers will get

$$g_t(j) = \frac{s_{t-2}(n)\gamma\left(1+\Delta_t - R_{t-1}\right)\left(1-R_t\right)}{2} + \frac{(1-\gamma)\left(2\delta - 1 - R_{t-1}\right)}{2K\delta} \tag{39}$$

known good customers and earn the following profit during the current period:

$$\pi_t^G(j) = \frac{s_{t-2}(m)\gamma\left(1+\Delta_t - R_{t-1}\right)\left(1-R_t\right)R_t}{2} - \frac{(1-\gamma)\left(\delta - R_{t-1}\right)}{2K\delta}. \tag{40}$$

A bank will choose to serve only known good customers and then leave the market if the bank's profit in the current period from known good customers at the interest rate set by $\left(K-J\right)$ banks exceeds the profit it could have earned had he served unknown customers and by doing so it would have increased the number of banks in the market for unknown customers from $\left(K-J\right)$ to $\left(K-J+1\right)$. The condition can be obtained by adjusting the number of banks that serve known good and unknown customers to $\left(K-J+1\right)$.

Finally, we need to discuss what happens if banks decide to serve all customers at a uniform interest rate. This case is identical with what we have already seen in the full information sharing case. Consequently, banks will not choose this strategy, for it is dominated by the strategy of price discrimination.

d. No Information Sharing

If banks do not share information there will be two markets: one for known good customers and another one for unknown customers. Banks sell to their own good customers. Old bad customers may go to another bank they have not banked with. The no information-sharing regime is identical with information sharing about good customers as regards banks' strategy options and optimum strategy choices. Banks will not sell loans at a uniform interest rate to all customers. Thus, banks sell to known good customers at the interest rate $r_t = R_{t-1} - \Delta_t$ and earn profit $\pi_t^G(k) = \frac{s_{t-1}(k)\gamma(1 - R_{t-1} + \Delta_t)(R_{t-1} - \Delta_t)}{2}$ on known good customers, for there will not be bad customers who would repay when they are young. (Bad customers can go to another bank in their second period on the market.) Banks set $\Delta_t(R_t)$ after they found R_t from profit maximization on the market for unknown customers.

Banks sell to $Q_t^U = \frac{\gamma(1 - R_t + \Delta_{t+1})}{2} + 1 - \gamma$ unknown customers. Banks maximize:

(41)

$$\Pi_k(R_t, \overline{R}) = \sum_{t=0}^{T} \delta^t \left(s_{t-1}(k) \frac{(R_{t-1} - \Delta_t)\gamma(1 - R_{t-1} + \Delta_t)}{2} + \frac{R_t s_{t-1}(k)\gamma(1 - R_t + \Delta_{t+1})}{2} \right) -$$
$$- \sum_{t=0}^{T} \delta^t \frac{(1 - \gamma - b_t(k))}{K} + \frac{\delta}{1-\delta} \overline{\pi}_k(\overline{R})$$

where $b_t(k)$ is the number of "surviving" bad customers whom bank *k* served in the previous period. The first order condition for profit maximization is in period *t*:

(42) $$\frac{\partial \pi_t(k)}{\partial q_t^U} = s_{t-1}(k)\left(R_t - \frac{2Q_t^U}{\gamma} + \frac{2(1-\gamma)}{\gamma} \right) = 0$$, which yields:

(43) $$R_t = \frac{\Delta_{t+1}}{2} + \frac{1}{2} - \frac{3(1-\gamma)}{4\gamma}, \text{ or } \Delta_{t+1} = 2R_t - \frac{5\gamma - 3}{2\gamma}.$$

We can find the interest rates banks charge to unknown customers in period *t* by solving the difference equation in (43). What was written before with regard to (25) holds now, too: the initial loss cannot be a linear function of *R*. If $\Delta(R)$ is quadratic in *R*, the equilibrium interest rate obtains from:

(44) $$\alpha \overline{R}^2 + (\beta - 2)\overline{R} + \left(\varepsilon + \frac{5\gamma - 3}{2\gamma} \right) = 0 .$$

The interest rate banks charge to unknown customers will be higher than with full information sharing or with information sharing about bad customers for there are more bad customers in the market who will be served. In addition, bad customers never repay the loan that further reduces the banks' expected profit. Profit will be lower without information sharing than with information sharing about bad or all customers. Banks earn a lower profit on unknown customers without information sharing than with full or with "bad" information sharing. But banks' profit on unknown customers will be the same with no information sharing and with information sharing about good customers. On the other hand, banks' profit on known good customers may be higher with no information sharing or with good information sharing than with other information sharing arrangements, for bad customers do not repay in the first period and they do not return to their original bank as "good" in the second period. A countervailing force that will reduce profit from known good customers results from the fact that the interest rate banks charge to unknown customers will be higher than with full or with bad information sharing. Consequently, the number of good customers who borrow when young will be lower without information sharing or with information sharing about good than in other arrangements.

Before the market reaches its steady state, banks' market share and the number of bad customers they serve will change period by period with no information sharing, or with information sharing only about good customers. The large bank that had a high proportion of all unknown bad customers in the previous period – which means a high number of bad customers, too – will get a much smaller share of bad customers from the other banks in the current period. Consequently, it may want to increase the number of customers it serves in the current period, for it can be sure that most of its new customers will be good. But the smaller banks will have the opposite intentions now, which will result in a higher interest rate for unknown customers than the large bank would have wanted. The interest of the banks will be reversed in the next period. As a result, the market share of the large banks decreases and the market share of the small banks increases in that period when the large banks get fewer bad customers of the other banks. And the market share of the large banks grows again, while the market share of the smaller banks drops in periods when the large bank gets more bad customers from other banks.

While no information sharing leads to lower profits for the whole group of banks than full information sharing or information sharing about bad customers, the allocation of profit will cyclically change period by period. Banks will earn higher profits when the share of bad customers in their individual customer pool is relatively low, while the same banks lose profits when their customer base is "poisoned" by many bad unknown customers. Consequently, banks do not have an unambiguous attitude to no information sharing. They will find no information sharing much more attractive than any form of information sharing in some periods that reduces the incentive to join an information sharing regime.

Theorem 6: Banks' short-term interest not to share information is in conflict with their long-term interest to share information about bad customers if banks arrive at the current period with different numbers of bad customers. (See proof in the Appendix!)

We need to add that no information sharing can only dominate information sharing about bad if the number – not just the market share – of the banks changed over time, for it would not have been possible for the banks to get bad customers in different numbers in subsequent periods. If the number of banks has always been *K* then the number of bad customers a bank gets without information sharing in period *t* will be: $\frac{(2K-1)(1-\gamma)}{2K^2}$. But in case if the number of banks has changed over time it is possible for a bank to receive bad customers in fluctuating numbers.

We can conclude that banks' interest to share information depends on their size and also on the number of banks that operate in the market. Banks do not gain from full information sharing and they may lose from good information sharing. The best choice banks have is to share information about bad customers. Although information sharing about bad customers is beneficial to all banks in the long run it may not be in the banks' interest in the short run. Consequently, myopic banks with large market shares may choose not to share information.

VI. Welfare

If the private credit market is regulated, the social planner seeks to maximize total social welfare from private loans. There are several ways to implement market regulation.

A. Benchmark: No Learning

If there is no persistent customer history, banks – and customers – cannot learn from previous periods. It may still be a reasonable objective to maximize social benefit from private loans. If social planners disregard the utility of bad customers and everyone gets the loan who claims to have a high enough valuation then the banks' total profit in period *t* becomes:

$\Pi_t = \gamma R_t(1-R_t) - \frac{1-\gamma}{2}$, and good customers' surplus will be $CS_t = \frac{\gamma(1-R_t)^2}{2}$. Maximizing social welfare, *W* leads to:

(45) $$R_t = \frac{5\gamma - 1}{4\gamma}, \quad \Pi_t = -\frac{1-\gamma}{2}\left(1 + \frac{5\gamma - 4)}{8\gamma}\right), \quad \overline{CS} = \frac{(1-\gamma)^2}{32\gamma} \quad W < 0.$$

As can be seen from (45) social welfare will always be negative.

If we assume full information sharing or information sharing about bad customers then banks will avoid losses by not giving loans to known bad customers. If truthful information sharing can be enforced, banks may compete – and we assume that regulators are capable of inducing them to compete – for known good customers. Unknown customers may accept an initial loss in order to be recognized as reliable in the next period. Banks' profit becomes:

(46)

$$\Pi\left(r_t, R_t, \bar{r}, \overline{R}\right) = r_t \frac{\gamma(1 - R_{t-1} + \Delta_t)}{2} - \frac{(1-\gamma)(\delta - R_{t-1})}{2\delta} + \frac{\gamma R_t(1 - R_t + \Delta_{t+1})}{2} + \\ + \frac{(1-\gamma)(\delta - R_t)R_t}{2\delta} - \frac{(1-\gamma)R_t}{2\delta} + \frac{\delta}{1-\delta}\overline{\Pi}.$$

The social planner neglects the welfare of bad customers. Thus, consumer surplus in period *t* is given by:

(47)

$$CS_t = \frac{(1-r_t)^2\gamma(1-R_{t-1}+\Delta_t)}{4} + \frac{\gamma(1-R_t)(1-R_t+\Delta_{t+1})}{4} + \frac{(1-\gamma)(1-R_t)(\delta-R_t)}{4\delta} +$$
$$+\frac{\delta}{1-\delta}\overline{CS}.$$

Maximizing social welfare yields the following first order condition for the lower interest rate:

(48) $$\frac{3\delta\gamma r_t^2}{4} - \frac{r_t\gamma(1-R_{t-1}+\delta R_t)}{2} + \frac{\delta\gamma}{4} = 0\,.$$

We get:

(49) $$r_t = \frac{1-R_{t-1}+\delta R_t}{3\delta} \pm \sqrt{\left(\frac{1-R_{t-1}+\delta R_t}{3\delta}\right)^2 - \frac{1}{3}}\,.$$

We can find the lower interest rate after we solved for the higher interest rate banks charge to unknown customers. From the first order condition for the higher interest rate we get the implicit function for R_{t+1}:

(50) $$\Delta_{t+1}(R_{t+1)}) = 2\left(\frac{\delta\gamma-(1-\gamma)}{\delta\gamma}\right)R_t + \delta r_{t+1}^2 + \frac{2(1-\delta)(1-\gamma)+\delta^2\gamma}{\delta\gamma}.$$

Solving the simultaneous equations (49) and (50) yields the interest rates banks charge to known good and to unknown customers. Similarly, we get the equilibrium interest rates by solving the simultaneous equations:

(51) $$2\left(\frac{\delta\gamma-(1-\gamma)}{\delta\gamma}\right)\overline{R} + \delta\overline{r}^2 + \frac{2(1-\delta)(1-\gamma)+\delta^2\gamma}{\delta\gamma} = 0; \quad \frac{3\delta\gamma\overline{r}}{4} - \frac{\overline{r}\gamma(1-(1-\delta)\overline{R})}{2} + \frac{\delta\gamma}{4} = 0.$$

Regulators would favor full information sharing or information sharing about bad customers to other arrangements for social welfare would be larger under these regimes than with no information sharing. It can be seen that consumer surplus will always be positive and banks' profit is also positive if the share of good customers is not extremely low.

B. Banks' competition in transition markets

We turn now to transition markets. Transition markets differ from mature markets at least in one important respect: there is an initial period in newly emerging markets when competition among banks unfolds. We need to see whether this initial period effect has lasting consequences on how the market develops after the initial phase.

a. The initial period

Banks establish their market share in the initial period by selling to customers in a number of $q_0(1),.....,q_0(n)$. We may think of these banks as a group that consists of a large bank – usually the former state-owned monopoly in the private accounts market – and (*n* – 1) smaller banks. The large bank will be called bank 1, and we denote the number of customers it serves in period *t* $q_t(1)$. We already made the assumption that the smaller banks have capacity constraints in the initial period and they sell to customers up to their capacity. That is, total capacity *C* of the small banks is $Q_0 - q_0(1) \leq C < Q_0$. In addition, we assume that each small bank is capable of serving 1/*n* of all customers who want to borrow: $\hat{q}_0(j) \geq \frac{Q_0}{n}$. Then the large bank faces residual demand that has not been served by the small banks. This simplifying assumption renders the analysis more tractable, without reducing the generality of our main findings about banks' strategic behavior with regard to information sharing. The small banks sell to $\sum_{j\neq 1} \hat{q}_0(j) = \hat{Q}_0(-1)$, and bank 1 sells to the remaining customers: $q_0(1) = Q_0 - \hat{Q}_0(-1)$, where Q_0 is the total number of customers served, $\hat{q}_0(j)$ is the capacity of bank *j*, *j*≠1, and $Q_0(-1)$ is the number of customers served by all small banks, but not by bank 1 in the initial period. Since the two alternative assumptions about the banks' behavior do not result in qualitatively different behaviors of the banks, we shall choose the second alternative where the small banks sell up to their capacity. Each customer is unknown in the initial period, consequently banks cannot price discriminate. But banks can sell to good customers who are willing to suffer an initial loss. We present only this alternative now, we do not deal with the uniform price case. The large bank serves the following number of customers in the initial period:

(52) $$q_0(1) = \gamma(1 - R_0 + \Delta_1) - \gamma\hat{Q}_0(-1) + \frac{1-\gamma}{K}.$$

Bank 1's expected profit in the initial period is given by:

(53) $$\pi_0(1) = R_0\left(\gamma\left(1 - R_0 + \Delta_1\right) - \gamma\hat{Q}_0(-1)\right) + \frac{R_0(1-\gamma)\left(\delta - R_0\right)}{K\delta} - \frac{(1-\gamma)R_0}{K\delta}.$$

A small bank will earn the following profit[18]:

(54) $$\hat{\pi}_0(j) = R_0\left(\hat{q}_0(j) - \frac{(1-\gamma)R_0}{K\delta}\right) - \frac{(1-\gamma)R_0}{K\delta}.$$

Taking the first order condition, summing over all *k* and rearranging yields the following solution for R_0:

(55) $$R_0 = \frac{\delta}{2\left(\delta\gamma + (1-\gamma)\right)}\Delta_1\left(R_1\right) + \frac{\delta(1-\gamma)}{2\left(\delta\gamma + (1-\gamma)\right)}\hat{Q}_0(-1) + \frac{K\delta\gamma - (K-\delta)(1-\gamma)}{2K\left(\delta\gamma + (1-\gamma)\right)}.$$

Now we shall address the banks' profit maximization problem in the second and in the successive periods.[19]

b. Current and future periods

Banks start the second period, $t = 1$ with market shares $s_0(i) = \frac{q_0(i)}{Q_0}; \quad i = 1,...,K$.[20] We assume that the small banks can also sell $q_1(j) \geq \hat{q}_0(j)$ loans to customers in the current period, that is, no bank has capacity constraints from the first period on. Whatever information sharing system – or no information sharing – exists in the market, banks' profit in the second period becomes:

(56) $$\pi(k) = \pi_0(k) + \delta\pi_1(k, I),$$

where $\pi_0(k)$ is bank *k*'s profit in the initial period and $\pi_1(k, I)$ is the bank's profit in the second period depending on the information sharing arrangement in the market. We already know that banks prefer to share information about bad customers to sharing information about good customers or to full information sharing. In addition, banks choose not to share information rather than sharing information only about good customers.

Banks will play the same game in transition markets as in mature markets from the second period on. Other conditions – market regulation, the regime of information sharing, the rewarding strategy toward good customers, the fraction of good and bad customers, the discount factor – being equal, they find the profit maximizing interest rate and the optimum number of customers by maximizing the same expected profits from infinite periods. Banks in transition market can apply the same profit maximization rules as banks in mature market with one important exception. Since “transition” banks know how the interest rates of subsequent periods will affect the interest rate in the initial period they can use this knowledge to solve the optimization problem. Say that banks established the profit maximizing interest rate they are going to charge to unknown customers in the second period as: $R_1 = f^{-1}(\Delta_2(R_2))$. Then banks need to find the profit maximizing interest rate of the initial period from the simultaneous equations:

(57)

$$R_1 = f^{-1}(\Delta_2(R_2));$$
$$R_0 = \frac{\delta}{2(\delta\gamma + (1-\gamma))}\Delta_1(R_1) + \frac{\delta(1-\gamma)}{2(\delta\gamma + (1-\gamma))}\hat{Q}_0(-1) + \frac{K\delta\gamma - (K-\delta)(1-\gamma)}{2K(\delta\gamma + (1-\gamma))}.$$

It is obvious from (57) that banks find the interest rate they charge to unknown customers the same way from the second period on as banks do in mature markets. That is, the difference equation they need to solve will have the form:

(58) $R_t = f^{-1}(\Delta_{t+1}(R_{t+1}))$.

We already know from (25) that this equation is of first order but it is non-linear. If (58) is quadratic than (58) will have the form: $\alpha R_{t+1}^2 + \beta R_{t+1} + \varepsilon = aR_t^2 + bR_t + c$, with the usual parameters as in (25). The solution for (58) can be found the same way as in (26)–(28). The only difference between mature and transition markets is that bank 1 will find the optimal interest rate of the initial stage R_0 from (57) in a transition market, while there is no such an initial interest rate in mature markets.

The above analysis yields the following result:

Theorem 7. *The equilibrium path of the transition market will differ from the equilibrium path of the mature market because of the “initial stage effect,” but the interest rate will be set the same way in the two markets in steady state if more banks operate on the market. With more banks in the market, the “initial stage effect” will not have an impact on how the structure of the market develops nor on the choice of the system of information sharing. Market shares will equalize and fully rational banks will favor information sharing about bad customers to any other form of information sharing.*

Another important issue in a transition market is how would the initial period influence a bank's decision about whom it wants to sell loan to in subsequent periods? A bank will choose to serve only its known good customers during the second period – and exit the market – if its expected profit is larger than the profit it could earn during two periods:

(59) $\pi_0(k) + \delta\pi_1^G(k) > \pi_0(k) + \delta\pi_1(k, I) \Rightarrow \pi_1^G(k) > \delta\pi_1(k, I)$.

Banks may be better off to earn "quick" profits on reliable customers then leave the market rather than tagging along if the future is very uncertain, that is, the discount factor is high. This is not an unknown phenomenon in the transition markets (that usually develop in transition countries). But banks have different perspectives about the future if they have different market shares. It may seem at the first glance that a large bank will be the one who may favor current profit to future – uncertain – profits, for the large bank starts with a large share of good customers, and bad customers allocate themselves uniformly across banks in the initial period. But the large bank has brighter prospects for future periods than the small banks. The large bank's prospects are better if banks share information only about bad customers or in case if there is no information sharing, and its prospects are gloomier if banks share information about good customers or about all customers. Sharing information about good customers or about all customers may expose the large bank to fiercer competition for known good customers from smaller banks. Sharing information only about good customers is the worst case for banks and especially for large banks, for they may loose many good customers while the share of bad customers does not monotonously decline. If the large bank has many young bad customers in the current period, these customers leave the bank and go to other banks in the next period. But the large bank can expect a massive inflow of bad customers again after the next period, many of those coming from other banks.

The small banks earn smaller profit on good customers in the initial period for their capacity is constrained and they get an equal share of bad customers. But the smaller banks can expect lower profits – it may be even negative – in the long run, especially if there is no information sharing or there is information sharing only about bad customers among banks. Consequently, it is the smaller rather than the larger banks that would choose to sell private loans to known good customers then exit the market.

After the initial period passes banks in the transition market will behave as the banks in mature markets. But the initial period may have a decisive effect on how can banks develop in the future: are they facing low or even negative expected profits as small banks and will be forced to leave the market before it reaches its steady state, or can earn positive profits and witness the convergence of the market to steady state with banks having equal market shares.

We need to mention here that we ignored the possibility that small banks form a coalition against one or more larger banks. Small banks would be fairly successful in doing so if their joint market share does not lag far behind the market share of the large bank. If small banks jointly have a larger market share than the large bank, they may become the dominant player if they collude.

It is also clear from the discussion that the smaller banks would favor other information sharing arrangements than the large banks. Sharing information about good customers or about all customers is more beneficial to a small than to a large bank. This is why large and small banks can hardly agree, what kind of an information sharing arrangement they should implement. The platform banks may agree on is no information sharing or information sharing only about bad customers.

VII. Discussion

The literature on information sharing among banks is very rich. But we have found only a few papers that address the issue of information transfer among economic actors when the same piece of private information can be "good news" or "bad news" depending on the actors' economic strength.[21] Athey and Bagwell (2001) analyze collusive behavior in a price competition setting where agents have different market shares. They conclude that collusion requires that large agents relinquish market share. Novshek and Sonnenshein (1982) conclude that full information sharing or no information sharing can equally support Nash equilibria in oligopolistic competition. We have seen that this is not the case in private credit markets when banks need to decide what information sharing arrangement they are ready to implement. Gal-Or (1985) asserts that no information sharing is the unique Nash equilibrium in Cournot competition if agents have private information about demand. This conclusion seems to have a limited relevance especially in credit card markets. Li (1985) argues that no information sharing is the unique equilibrium if information sharing would be about a common parameter of the market or the agents' efficiency. Ziv (1993) points to the fact that information sharing may be hampered by moral hazard if agents use private information strategically in competition. Finally, Vives (2002) argues that having private information is a much more powerful tool in oligopolistic competition than having large market share. We arrived at different conclusions than most of the authors mentioned above. Namely, we did not find information sharing and especially its form neutral to competition. We can agree with Vives that private information may be more relevant than market share, but in case if a large actor has private information he can use it in a completely different way than if a small actor has the same piece of information. We have also found that no information sharing is not a focal Nash equilibrium in market settings when sharing information has strategic implications to the actors' expected benefits. At this point we need to emphasize that the two-period game most papers discuss does not always suit to the problem that is going to be addressed in that framework. We have found that an infinite horizon approach may be much more appropriate if competition has important dynamic aspects. Another important lesson we learned was that it is critical whether the analyst chooses a quantity competition or a price competition model to address information sharing. We decided to apply a quantity competition model but we can see its shortcomings and constraints. Price competition may be more appropriate to analyze markets with well-known characteristics. We could have explained competition for known good customers in a more realistic way in a price competition model than in a *Cournot* model. We decided to apply the quantity competition approach for we wanted to focus on the credit market for unknown customers. It may be an important topic for future research whether the two approaches can be usefully mixed within one model.[22]

The model we outlined above works with several simplifying assumptions. We ignored the opportunity of changing customer behavior: learning from past experience and exerting effort if the banks reward such a behavior. (That is, we ignored the issues of adverse selection and moral hazard.) We worked with simple demand functions. We made fairly restrictive assumptions about customer behavior. We did not always control for boundary conditions. But all these shortcomings notwithstanding, the models outlined above allow us to draw some important conclusions.

If one compares banks' profit from known good and from unknown customers with information sharing about good customers, and profit from the same groups of customers without information sharing, it is clear that no information sharing results in higher expected profits to banks than information sharing about good customers if collecting and sharing information has some additional costs. Comparing no information sharing and information sharing about bad customers leads to the conclusion that information sharing about bad customers is more beneficial to banks in terms of expected profits than no information sharing. We have also seen that information sharing about bad customers beats full information sharing and banks will also prefer it to good information sharing. We conclude that – under identical market characteristics – banks would benefit from sharing information about bad customers but they would not want to share information about good customers.

We could also see that the large banks have different incentives to information sharing than small banks. A large bank has less incentive to share information about its bad customers when it releases a large number of such customers to the market and "poisons" the customer base of other banks. This incentive becomes weaker when bad customers are now at the smaller banks in a large number and the large bank can expect many bad customers to come in the next period. It is also true that a large bank would sooner refuse to share information about good customers than the small banks for it would loose more than a small bank in the competition for good customers.

What kind of a bank has more incentive to serve only its known good customers? The answer to this question depends on the proportion of good and bad customers and the number of banks in the market. In addition, it depends on the discount factor. We have seen that with no information sharing or with information sharing about good customers a small bank can easily end up with negative profits for it can get the same number – or even a larger number – of bad customers in some periods as the larger bank. But a large bank may also have a strong incentive to serve only its good customers then exit if the share of bad customers is large in the market.

Banks that stay in the market will witness convergence to equalized market shares. The speed and the smoothness of this convergence are again affected by the former distribution of market shares and by the information-sharing regime banks can rely on. A market with strongly unequal market shares and with no information sharing will converge to steady state after more fluctuations than a market with more balanced market shares and with information sharing about bad customers. If the market stars up with banks having equal market shares, steady state is reached in the current period and banks have identical incentives to share information.

We have worked with an infinite horizon model but we were able to simplify it to a finite horizon dynamic programming problem plus an infinite horizon optimization in steady state. An important aspect of the infinite horizon deserves special attention. Since banks compete for unknown customers, the number of unknown bad customers will be smaller for large banks and this number will be larger for small banks than what their markets share would imply. Consequently, large banks lose and small banks gain market share in subsequent periods. Ultimately, market shares equalize in steady state. And as we have seen, banks with different market shares have opposing interests while banks with equal or very similar market shares can easily agree on information sharing. But until the market shares of the banks are different, their contradictory interests can be sufficiently described with a quasi-infinite model.

An exciting issue of strategic information sharing is why do banks form or join a credit bureau at all? Would it not be more beneficial to banks to directly trade with information? There may be cost saving effects of joining a credit bureau, but are there other considerations that render a joint information pool more desirable to banks than to deal with information transacting directly? If information sharing is a strategic decision – and we have seen it is – then a credit bureau may serve as an implicit contract among banks not to abuse private information in competition. This is a huge topic that we cannot address in the current paper.

Finally, banks will face an "initial period effect" in transition markets that may force small banks to exit before the market stabilizes. And as we saw if the number of banks that serve unknown customers changes it alters the game among the surviving banks. The large bank would benefit from sharing information about bad customers in the transition market, but the magnitude of its benefit depends on the proportion of the good customers within the entire banking population. Since information sharing about bad customers is not against the interest of the large bank – and as we saw before it enhances social welfare – it would make everyone better off if this information-sharing regime was implemented. Consequently, regulatory agencies could have an important role to play in shaping the private credit markets in transition markets. Transition markets become mature markets after the first two initial periods and banks that survive will behave as their peers in mature markets.

Appendix

Proof of Lemma 1

From the first order condition of (16) we have:

(L1.1) $$r_t = \frac{1}{2} - \frac{(1-\gamma)(\delta - R_{t-1})}{2\delta\gamma(1 - R_{t-1} + \Delta_t) + (1-\gamma)(\delta - R_{t-1})}.$$

It is straightforward from (L1.1) that $r_t < \frac{1}{2}$ at any values of γ and δ which cannot be a dominant strategy of the banks. It is also obvious from (L1.1) that $\frac{\partial r_t}{\partial B_{t-1}^G} < 0$, that is, the lower interest rate decreases with a growing number of bad customers who repaid in the first period. The larger the share of bad customers the bigger the banks' loss on known good customers becomes because of the too low interest rate. *Consequently, banks will not want to compete for known good customers of other banks at any cost.*

Proof of Lemma 2: The interest rate banks charge to known good customers with straight price discrimination is given by:

$$\left.\begin{aligned} r_t &= R_t - \frac{\Delta_t}{\delta}; \\ r_t &= R_{t-1} - \Delta_t \end{aligned}\right\} \Rightarrow R_t - R_{t-1} = \frac{(1-\delta)\Delta_t}{\delta} \geq 0.$$

Proof of Theorem 1: Each bank will know that only good experienced customers would go to another bank if that other bank offered the loan with better terms than the rest of the banks, for bad experienced customers will not repay. Thus, the group of unknown customers banks serve will consist of three sub-groups: the sub-group of "young" good unknown customers, the sub-group of bad unknown customers who repay the loan,

(T1.1) $$\Gamma_t^U = G_{t+1} + B_t^G = \frac{\gamma(1 - R_t + \Delta_{t+1})}{2} + \frac{(1-\gamma)(\delta - R_t)}{2\delta}$$

and the sub-group of the bad unknown customers who do not repay

(T1.2) $B_t^B = \dfrac{(1-\gamma)R_t}{2\delta}$.

The total number of customers who acquire the loan will be:

(T1.3) $Q_t = 1 - \dfrac{\gamma\left((R_{t-1} - \Delta_t) + (R_t - \Delta_{t+1})\right)}{2} = 1 - \dfrac{\gamma(r_t + r_{t+1})}{2}$.

Theorem 1 is a direct consequence of the results we obtained about the banks' competitive behavior and about the optimum strategy of good and bad customers. It is sufficient for banks to know the fraction of bad customers and they can infer the expected behavior of good customers from this piece of information.

Proof of Theorem 2: Say that bank k is active in the market in steady state. Its profit will be:

$$\overline{\pi}(k) = \frac{\overline{r}\gamma\left(1-\overline{R}+\overline{\Delta}\right)}{2} - \frac{(1-\gamma)\left(\delta-\overline{R}\right)}{2\delta} + \overline{R}\left(\frac{\gamma\left(1-\overline{R}+\overline{\Delta}\right)}{2} + \frac{(1-\gamma)\left(\delta-\overline{R}\right)}{2\delta}\right) - \frac{(1-\gamma)\overline{R}}{2\delta},$$

where the upper bar over variables stands for steady states values. The only question is whether banks arrive at steady state within finite periods. But this is inevitable, for banks with smaller than average market shares will only serve their known good customers during one period and then they drop out from the market. Consequently, the market share of the banks will equalize during (K – 1) periods at maximum. From that period on the market is in steady state.

Proof of Lemma 4.

Since $\Delta_t = \dfrac{\delta(R_t - R_{t-1})}{1-\delta}$, *it immediately follows that* $\dfrac{\partial \Delta_t}{\partial R_t} \geq 0$. *The concavity of the initial loss function is a direct consequence of the concavity of the upper bound of* Δ_t: $\Delta_t \leq R_t$. *In addition,* $R_t \leq 1$ *must always be satisfied. The initial loss must decrease in time for* $\lim_{t \to T} \Delta_t \to \overline{\Delta} = 0$, *and* Δ_t *is a monotonous function of* R_t. *The convergence occurs with* $|R_t - R_{t-1}| \leq \varepsilon$ *where* ε *is an arbitrarily small non-negative number.*

Proof of Theorem 3: Writing down the equilibrium market shares we have:

$$\bar{s}(k)=\frac{\bar{s}(k)\bar{G}+\frac{\bar{B}}{K}}{\bar{G}+\bar{B}}$$. *Collecting terms obtains:* $\frac{\bar{s}(k)\bar{G}+\frac{\bar{B}}{K}}{\bar{G}+\bar{B}} \Rightarrow \bar{s}(k)\left(\bar{Q}-\bar{G}\right)=\frac{\bar{B}}{K} \Rightarrow \bar{s}(k)=\frac{1}{K}$.

Proof of Theorem 6: A bank's profit will be larger in period t without information sharing than with information sharing about bad customers if:

$$\pi_{t-1}^{G}(k)+\pi_{t}^{G}(k)-\frac{(1-\gamma)\left(2R_t-R_{t-1}\right)}{2K\delta}<\pi_{t-1}^{G}(k)+\pi_{t}^{G}(k)-\frac{\left(1-\gamma-b_t(k)\right)}{K}\Rightarrow$$
$$\Rightarrow b_t(k)>(1-\gamma)\left(1-\frac{2R_t-R_{t-1}}{2K\delta}\right).$$

A bank that had bad customers in period t – 1: $b_t(k)>\frac{1-\gamma}{2K}$ *can earn higher profit without than with information sharing in period t.*

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Tables

Table 1. Conceivable strategies of an “old” customer

The customer’s action in period t	The customer’s action in period $t-1$		
	Borrowed and repaid	Borrowed and did not repay	Did not borrow
Borrow and repay	$\left(y_t(i), y_{t-1}(i)\right)$	$\left(y_t(i), n_{t-1}(i)\right)$	$\left(y_t(i), d_{t-1}(i)\right)$
Borrow and do not repay	$\left(n_t(i), y_{t-1}(i)\right)$	$\left(n_t(i), n_{t-1}(i)\right)$	$\left(n_t(i), d_{t-1}(i)\right)$
Do not borrow	$\left(d_t(i), y_{t-1}(i)\right)$	$\left(d_t(i), n_{t-1}(i)\right)$	$\left(d_t(i), d_{t-1}(i)\right)$

Endnotes

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[1] Banks may require a deposit from customers before they sell the loan, or they may ask for collateral from customers. These aspects of the transaction are extensively discussed by Stiglitz and Weiss (1981). Our assertion still holds that customers pay the price of the loan after the transaction.

[2] The only articles we have come across on information sharing in credit card markets is Pagano and Jappelli (1993), Vercammen (1995), and Padilla and Pagano (1997). The first paper analyzes a market with regional

monopolies that may have been the past in the US credit card markets but do not exist in the US nor in other countries today. Vercammen presents a moral hazard *cum* adverse selection approach to information sharing without explicitly addressing the banks' optimization problem. Padilla and Pagano also focus on reputation games driven by the borrowers' effort and welfare. Novshek and Sonnenschein (1982), Crawford and Sobel (1982), Clarke (1983), and Gal-Or (1985) present models of information sharing in two-stage games but their focus has been the noisy nature of information. Ausubel (1991) discussed the case of the US credit card markets without engaging deeply in the analysis of information sharing.

[3] The paper covers only a small portion of the research we have done about emerging credit card markets. The members of the research team conducted interviews with bank officials in eleven countries, including China, Vietnam, South Korea and eight Central and East European countries. In addition, they collected information from Visa, from Fair Isaac, and from other organizations in the US.

[4] The state-owned bank was a monopoly and held the accounts of all citizens in the country, but it did not have relevant information about its customers' credit history as retail credit had been severely limited.

[5] We could have assumed that customers live for $T > 2$ periods. Such a generalization would have had two important implications: (1) Customers' options to act strategically would be more numerous than in case if customers live only for two periods. (2) The number of periods would have had an additional impact on the customer base if that number were larger than the number of banks that operate in the market. Old bad customers who already went to all banks would drop out from the market before they "decease." Until the number of periods is not larger than the number of banks, we could have changed the share of customers who exit the market at the end of each period from 1/2 to $1/T$. Consequently, the share of surviving customers would have been $(T - 1)/T$.

Dealing with $T > 2$ periods would have complicated the analysis to a considerable extent without adding much to the insight we intend to gain about banks' interest in information sharing. Consequently, we assume that $T = 2$, and the number of banks is not smaller than the number of periods customers live through.

[6] This assumption could have been easily relaxed by saying that the market population is increasing with a λ rate. In order to keep the model simple, we disregard the change in the size of the market population.

[7] We shall see later that good customers may accept an initial loss when they borrow. Then the above assumption will read: good customers' valuation is always verifiable to the banks in the sense that banks know: only those good customers borrow whose valuation is equal to or larger than the market rate of interest banks charge plus the initial loss good customers accept.

[8] We are grateful to Joel Sobel for suggesting that we should assume strategic customer behavior and proposing the idea of an initial loss that a good customer is willing to accept.

[9] It is also possible – as we shall discuss in a later section – that banks offer loans to unknown customers at a lower and to known customers at a higher interest rate. We shall call this pricing strategy "inverse price discrimination."

[10] We could also call this pricing rule introductory pricing.

[11] In reality, there is a moderate amount charged by the credit bureau to banks for each record they acquire, but we shall ignore this cost.

[12] We could have assumed uniform distribution of all customers or the allocation of customers by market share. Or, young good customers could distribute themselves uniformly while bad customers allocate themselves across banks by market share. If all customers allocate themselves according to banks' market shares large banks will remain large and small banks would remain small "forever." With uniform distribution of all customers banks' market share would equalize during one period. We could have made a weaker assumption about the allocation of bad customers. If we assumed that small banks get bad customers in a smaller, and large banks receive bad customers in a larger proportion than $1 - \gamma$, the share of bad customers in the entire banking population the analytical results would be the same, but algebra would have been more tedious. We made the above assumption to keep the analysis as simple as possible.

[13] The reader may recall that customers' strategy set consisted of nine strategy options and banks can choose from five different strategies the payoff matrix will have 45 cells. But we also know that good customers will only choose from among six strategies and bad customers will choose between two strategies at maximum. Consequently, a good customer faces a payoff matrix of 30 cells and a bad customer needs to deal with a payoff matrix of 10 cells.

[14] In the late 1990s, with the concentration of retail lending, credit reporting in the United States started to change requiring regulatory intervention (Robert Hunt 2002). We will leave the analysis of these changes to a later paper.

[15] We could have addressed this issue more deeply only in the framework of a price competition model.

[16] If (24) was linear in R then the equation would have the form $R_{t+1} = aR_t + b$, where a and b are parameters obtained from (24) with the solution $R_t = a^t\left(R_0 - \frac{b}{1-a}\right) + \frac{b}{1-a}$.

The solution would be locally stable if $|a| < 1$, but this condition cannot be satisfied given the parameters and a constant term for Δ_t' in (24). See the conditions for local stability in the case of first order linear difference equations, for instance, in Sydsæter and Hammond (1995, p. 734).

[17] Banks would serve $Q_t = \frac{\gamma(1-R_t)(2-R_{t-1})}{2} + 1 - \gamma + \frac{(1-\gamma)R_{t-1}}{2\delta}$ customers in period t, and the interest rate they would charge in period t becomes: $R_t = \frac{2\delta - (\delta\gamma - (1-\gamma))R_{t-1}}{\delta\gamma(2-R_{t-1})} - \frac{Q_t}{\gamma(2-R_{t-1})}$.

The banks' profit in period t directly obtains from the above expressions:

$$\pi_t(k) = R_t s_{t-1}(k)\left(Q_t - (1-\gamma) + \frac{(1-\gamma)R_{t-1}}{2\delta}\right) + R_t \frac{(1-\gamma)(\delta - R_t)}{2\delta K} - \frac{(1-\gamma)(\delta - R_{t-1})}{2\delta K} - \frac{(1-\gamma)R_t}{2\delta K}.$$

[18] The equation in (57) requires that $\hat{q}_0(j) \geq \frac{(1+R_0)(1-\gamma)}{KR_0}$, otherwise small banks would not stay in the market.

[19] There is an opportunity for banks in the initial period that deserves special attention. Namely, bank 1 may use the initial period to gain as large a market share as possible. The interest rate at which the large bank could break even in the initial period can be derived from:

$\pi_0(1) = R_0\left(q_0(1) - \frac{1-\gamma}{K}\right) - \frac{1-\gamma}{K} = 0 \Rightarrow R_0 = \frac{1-\gamma}{Kq_0(1)-(1-\gamma)}$. We need to see later whether a bank would choose a strategy by which it just breaks even in the initial period and maximizes profits in subsequent periods.

[20] We cannot fully exclude the possibility that the large bank engages in predatory pricing in the initial period in order to wipe out competition. Then the large bank will set the interest rate so that it earns zero profit in the initial period, but it collects monopoly profit from the next period until "eternity." The large bank will find the predatory price for the initial period by setting (53) equal to zero. Then it finds the monopolistic price during subsequent periods by maximizing:

$$\pi_t^M = \frac{r_t\gamma(1-r_t)}{2} - \frac{(1-\gamma)(\delta - R_{t-1})}{2\delta} + \frac{R_t\gamma(1-R_t+\Delta_{t+1})}{2} + \frac{R_t(1-\gamma)(\delta - R_t)}{2\delta} - \frac{(1-\gamma)R_t}{2\delta}.$$

The interest rate the monopoly will charge to unknown customers can be found by solving

$\Delta_{t+1} = \frac{2(\delta\gamma+1-\gamma)}{\delta\gamma}R_t - \frac{\delta+\gamma-1}{\gamma}$. The lower interest rate will be $r_t = R_{t-1} - \Delta_t$. But we assume that regulation prevents banks from using predatory pricing. Thus, we disregard this possibility in the current analysis.

[21] Milgrom (1981) discusses strategic settings when information can be good or bad news.

[22] Kreps and Scheinkman (1983) suggested a similar approach to problems with quantity pre-commitment.