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Information Sharing and Information Acquisition in Credit Markets*

ARTASHES KARAPETYAN† and LEON BOGDAN STACESCU‡

Abstract

We examine the effect of information sharing via credit bureaus or credit registers on banks' incentives to collect information about their borrowers. Information asymmetries have been identified as an important source of bank profits, and sharing knowledge about borrowers can reduce those rents. Despite that, we show that banks' incentives to collect information actually increase in the presence of information sharing. The reason is that

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when hard, standardized information is shared, banks' incentives to invest in soft, non-verifiable information increase. The result can be more accurate lending decisions and improved welfare.

Keywords: Bank competition, information sharing, bank relationship, hard information, soft information

JEL classification numbers: G21, L13

1 Introduction

Information acquisition by financial intermediaries is an essential function[1]. It can improve the allocation of credit in the economy, and it is one of the main sources of bank profits. Better knowledge of their loan applicants allows banks to weed out low-quality projects. At the same time, the information acquired over the course of a lending relationship allows an incumbent bank to hold up its borrowers and extract information rents[2]. Those rents compensate the bank for the cost of acquiring information.

Recent years have witnessed the spread of information sharing arrangements, such as private credit bureaus and public credit registers (Jappelli and Pagano (2000), Miller (2003), Djankov et al. (2007)). More and more countries have such arrangements that centralize and redistribute knowledge about borrowers, and banks use them quite frequently. Miller (2003) reports on a survey of Latin American banks which shows that 93% of the banks used credit information for their commercial loans (84% did so for consumer loans and 100% for mortgage loans). When information is shared, incumbent banks lose some of their advantage over their competitors. It seems reasonable to think that the loss of informational rents will endanger the incentives to find out more about their potential borrowers, thus reducing the accuracy of credit decisions.

We examine the effect of information sharing on information acquisition. We show that, contrary to what may seem probable at first sight, establishing a credit bureau or a credit register is likely to increase banks' investment in information. The intuition behind

[1]The importance of information collection by banks both before and during the relationship with their borrowers has been widely recognized (see for instance Boot (2000) and Allen and Carletti (2009)). The value-increasing effect of bank relationships, largely due to information acquisition, has been documented by a large empirical literature starting from James (1987).

[2]The role of asymmetric information as a source of bank profits has been analyzed for instance by Sharpe (1990). The key issue of weaker bank monitoring in the years leading to the recent financial crisis has begun to be documented (Xia and Wang (2012)).

this result is as follows. When hard, standardized and verifiable information becomes available to competitors, soft information, which is difficult to communicate reliably (Stein (2002), Petersen (2004)) will still remain the exclusive domain of the incumbent bank. We show that the sharing of hard information raises the marginal benefit from investing in the acquisition of soft information, the only remaining source of informational rents. This engenders a higher optimal investment in soft information, which acts as a substitute for hard information. As a result, the banks' overall knowledge of their borrowers may improve under information sharing, with likely positive welfare effects.

We build on the bank competition model in von Thadden (2004) and Hauswald and Marquez (2006). In each of the two periods two banks compete in interest rates for borrowers of high ability (creditworthy) and low ability (uncreditworthy). In the first period, competition is based on symmetric information, and each bank wins a certain market share. At the end of that period each incumbent bank faces two groups among its own clientele: defaulting borrowers and successful borrowers (those who have repaid). This information can be used to update the bank's knowledge of the borrowers' likely types. At the same time, this is hard information that can be shared with the outside, uninformed bank under an information sharing regime.

Because default information does not fully reveal a borrower's true type, each bank may monitor at a cost and acquire soft information about the true type. For second-period lending, the incumbent bank therefore differentiates borrowers based on two sources of information: hard information - default or success of its borrowers, and soft information - good or bad signal.

When hard information is shared, the rents the inside bank would derive from being the only one able to tell defaulting from successful borrowers disappear. At the same time, however, the effectiveness of investing in the soft signal also changes. Under no

information sharing, the defaulting borrowers are pooled with the successful ones from the outside bank's point of view. This means they sometimes receive relatively low interest rates from that bank. Thus a portion of the inside bank's investment in soft information goes to waste as it loses some of the unlucky high-type borrowers it had tried to identify. Under information sharing, the outside bank no longer bids so low for defaulting borrowers, and the inside bank is more likely to reap the fruits of its investment in monitoring. The result is that the marginal benefit from investing in the soft information is higher when hard information is shared.

The higher marginal benefit from monitoring results in a higher investment in soft information in the presence of a credit bureau. As a result, banks will have better knowledge of the borrowers' true quality. Uncreditworthy borrowers will be more likely to be denied credit, and this can improve welfare.

This is our core finding, that also shapes our main policy implication. The concern that sharing information will lead to insufficient information acquisition, and is therefore undesirable from a social point of view, is not well-founded. Supporting the establishment of information sharing arrangements can be a good idea.

The remainder of the article is organized as follows. Section I relates our paper to the existing literature. Section II presents a model of banking competition and information acquisition. We first derive the equilibrium of the banking competition with and without information sharing. We then look at interest rates, switching and welfare in Section III. Section IV concludes. Proofs are mostly relegated to the Appendix.

2 Relationship to Existing Literature

Our paper adds to the recent but growing research on information sharing among lending institutions. The existence of credit bureaus has been shown to decrease adverse selection (Jappelli and Pagano (1993)), induce higher effort from borrowers (Padilla and Pagano (1997) and Padilla and Pagano (2000)), and reduce excessive borrowing (Bennardo et al. (2009)). At the same time, information sharing may be used to reduce competition between banks (Bouckaert and Degryse (2006)). Empirically, information sharing is associated with better access to credit (Jappelli and Pagano (1993)), especially in developing countries with bad creditor rights (Djankov et al. (2007), Brown et al. (2009)), but lower lending to low-quality borrowers (Hertzberg et al. (2011)). To the best of our knowledge, we are the first to look at the strategic use of information acquisition in the context of information sharing.

Unlike some of the existing papers (Padilla and Pagano (1997), Padilla and Pagano (2000), Bennardo et al. (2009)), we do not look at moral hazard issues in the context of information sharing. However, in our model information sharing increases the gap between interest rates charged to successful and defaulting borrowers. One could think that the higher punishment for default will potentially induce borrowers to exert higher effort, and that intuition is in line with the results in Padilla and Pagano (2000).

A key element in our model is that information acquisition is costly. This sets our paper apart from existing papers (Jappelli and Pagano (1993), Padilla and Pagano (1997), Padilla and Pagano (2000), Bouckaert and Degryse (2006)) where the incumbent is freely endowed with full information on borrower types.

This article is also related to recent work on strategic information acquisition, such as Hauswald and Marquez (2003). One of their results is that if outside access to (hard)

information improves, that will erode the inside bank's rents and its incentives to invest. In contrast, we focus on two types of information. The interaction between hard information sharing and soft information acquisition, to the best of our knowledge, has not been studied before.

The importance of the distinction between hard and soft information has been increasingly recognized in the literature (Stein (2002), Petersen (2004), Berger et al. (2005), Degryse and Ongena (2005), Hertzberg et al. (2010)). Agarwal and Hauswald (2010) find that soft information significantly impacts both interest rates and credit availability. While technological change has allowed the development of automated lending, classical, in-person applications relying on soft information are still widely used and they cater for their own distinct groups of customers (Agarwal and Hauswald (2009)). Interestingly, their measure of soft information is by construction orthogonal to the hard information contained in the credit reports. This means that, as in our model, soft information can improve upon the knowledge derived from hard information. Rajan, Seru, and Vig (2010) show that securitization may decrease investment in soft information. In our case, banks keep the loans on their balance sheets, they reap the benefits of good lending decisions, and therefore they have the incentive to invest in soft information.

Our work has implications for relationship banking. We show that under information sharing - widely interpreted as an increase in competition - banks have incentives to invest more in acquiring proprietary information and deepen the relationship. This is because, paradoxically, they are more likely to retain their good relationship borrowers. The result is in contrast to Boot and Thakor (2000), where an increase in bank competition - modeled as an increase in the number of banks - means that existing borrowers are more likely to be lured away by the more abundant outside offers.[3]

[3]When Boot and Thakor (2000) introduce competition from capital markets, banks invest more in the relationship

Soft information may be difficult to communicate within the bank, not just across banks. It has therefore been argued that large banks will usually rely on hard information, while small banks will be more likely to collect and use soft information (Stein (2002), Berger et al. (2005)). Small banks have a lower cost of dealing with soft information, which in our model would mean that information sharing will lead to a higher bias towards soft information and increase the gap between them and large banks. Thus our model also has implications concerning the relationship between information sharing and the structure of the banking system.

3 The Model

We model the interaction between banks and borrowers over two periods. At the starting point, banks have symmetric information about the average ex-ante risk of the borrower population and the distribution of borrower types. During the first-period lending relationship, each bank acquires both default and relationship information about those borrowers who have initially contracted with it[4]. Following Petersen (2004) and Stein (2002), we label the former hard and the latter soft information[5].

There is a fair amount of information that is publicly available in the case of large firms. However, little is usually known about small or young firms for which banks are a crucial source of financing (Petersen and Rajan (1994)). There is also information that borrowers themselves can disclose voluntarily. Nevertheless, they are unlikely to disclose

because the lower entry into the banking industry means that there are fewer banks to make competing transactional bids.

[4]We have also analyzed the model where information is acquired during ex-ante screening, and the results are qualitatively similar. Lummer and McConnell (1989) show that the value-creating effect of a bank relationship mainly comes from monitoring over the lifetime of that relationship, and this explains our preference for the monitoring case.

[5]We use default information here, since it is the most basic type of hard information and also the most commonly shared. Hard information could also obviously be any type of information that can be shared by means of a credit bureau.

negative information and much of what they communicate to the bank may be difficult to verify. Thus, there is a significant amount of information that banks have to spend time and money to find out. Some of it is hard information - such as previous defaults or existing loans. That information can be shared via credit bureaus. Another significant part is represented by soft information difficult to fit meaningfully into a standardized database. Indeed, it has long been recognized that banks "collect information which is neither initially available in hard numbers (the ability of the manager, their honesty, the way they react under pressure), nor are they easily or accurately reducible to a numerical score" (Petersen (2004)). A given manager's business acumen[6], or the success probability of a given new product can be crucial for lending decisions, but they cannot easily be communicated across banks by means of a credit bureau.

We analyze banks' incentives to invest in soft information under two competitive environments. Without hard information sharing, both types of information are unavailable to the outside, uninformed bank. With information sharing, the success or default of each borrower becomes known to the uninformed bank. The soft information, however, cannot be shared and continues to generate a competitive advantage for the informed bank.

The soft information is useful to the informed bank since it provides it with a signal which is not perfectly correlated with the hard information, but it is still correlated with the true type of a given borrower. Under information sharing the outside bank adjusts its interest rates depending on the good or bad hard information available through the credit bureau. This in turn will allow the informed bank to recoup more of its investment in soft information. The marginal benefit from investing in soft information will therefore be higher under information sharing, thus increasing optimal investment.

[6]The importance of non-financial factors in making correct lending decisions has been emphasized in the literature. See for instance Grunert et al. (2005).

We present the setup of our model and the bank competition under the two information sharing regimes below.

3.1 THE SETUP

There are two banks and a continuum of borrowers on $[0, 2]$ who are active for two periods. In both periods, every borrower has access to a project that requires initial investment I. Because they have no initial wealth, they have to borrow the whole amount. We assume borrowers can only borrow from one of the two banks[7].

There are two types of borrowers. High-type borrowers represent a proportion λ in the population and have a probability p $(0 < p < 1)$ of producing a terminal cash flow $R > 0$. With probability $1 - p$ they produce 0. Low-type borrowers (proportion $1 - \lambda$) always fail, yielding 0[8].The final cash flows in both periods are observable and contractible by the current lender.

The proportions of borrowers and the success probabilities are common knowledge. Borrowers of a given type have identical (and independent) projects, are protected by limited liability and have no initial funds in either period. We assume a project's output cannot be stored, so that it does not generate resources for operations in the second period. We also assume that borrowers do not know their own type, or alternatively that there are no devices that allow perfect separation between types. It is generally acknowledged that

[7]Single-bank lending is a frequently used assumption (see for instance Rajan, Seru, and Vig (2010)). While "single banking appears to be broadly characteristic of the U.S." (Detragiache et al. (2000)), multiple bank relationships are more widespread in Europe (Ongena and Smith (2000)). However, switching to multiple bank relationships requires firms to be older (Farinha and Santos (2002)) and therefore less affected by issues of asymmetric information. Since we are interested in firms for which adverse selection is an important concern, and in order to reduce the complexity of our setup, we focus on single relationships.

[8]We have also solved the model for the case where low-type borrowers have a positive success probability ($p_L > 0$). The main results and insights are the same, but the algebra is more complex in that case. The alternative version is available upon request.

banks acquire information about their borrowers during the lending relationship (Sharpe (1990), Boot (2000)), and therefore they do not have perfect knowledge of their borrowers at the very beginning of their interaction. As long as there is no perfect initial separation between types, our results hold.

Banks can raise capital at a gross interest rate 1 and compete in interest rates given their respective information sets. They offer one-period contracts. For simplicity, the discount factor between the two periods is taken to be 1.

At the beginning of the first period banks only know the average risk of the population. As a result, they offer the same interest rate to all applicants. Monitoring begins after the first-period loans have been extended. It results in a signal η of borrowers' types. The quality of the signal is given by φ:

$$Pr(\eta = G|type = H) = Pr(\eta = B|type = L) = \varphi > \frac{1}{2}; \tag{1}$$

$$Pr(\eta = G|type = L) = Pr(\eta = B|type = H) = 1 - \varphi. \tag{2}$$

The signal is costly: getting a signal of quality φ requires an outlay of

$$C(\varphi) = c(\varphi - \frac{1}{2})^2 \tag{3}$$

We call φ the informativeness of monitoring. Banks will have to decide how much to invest in the monitoring technology.

At the end of the first period banks have therefore two types of information about their own borrowers:

- the signal generated by monitoring, $\eta = G$ or $\eta = B$;
- the repayment history - i.e., whether borrowers have defaulted or not. Their history is $h = D$ or $h = N$.

While default information is verifiable, the outcome of the monitoring process is "soft" information by assumption: it is prohibitively costly to communicate this information between banks. As a result, a credit bureau is only able to collect and share default information, and each bank will know which of the other bank's initial customers has defaulted. Without a credit bureau, both default and monitoring information are only available to incumbent banks[9].

The soft and hard information will allow the incumbent bank to distinguish between three groups among its first-period customers:

- borrowers that have defaulted and have also generated a bad signal when monitored (BD borrowers);
- borrowers that have defaulted, but have generated a good signal when monitored (GD borrowers);
- borrowers that have not defaulted (but generated either a good signal or a bad signal when monitored; we call those non-defaulting - N - borrowers).

The last group obviously consists only of high-type borrowers. The first groups include both high- and low-type borrowers, in a proportion that is influenced by the informativeness of first-period monitoring. Informed banks can discriminate between the three types in their second-period lending and interest decisions. We assume that $p_D R > I$, where

[9]The bank that has granted a loan to a given borrower in the first period is the "incumbent" bank for that borrower. It is also the informed bank in the second period, since it has both hard and soft information concerning the borrower. We use the two terms interchangeably below.

$p_D = P(h = D)$ is the success probability given the borrower has defaulted: it is efficient to grant a loan to defaulters.[10]

The timing of the game is summarized in figure 1.

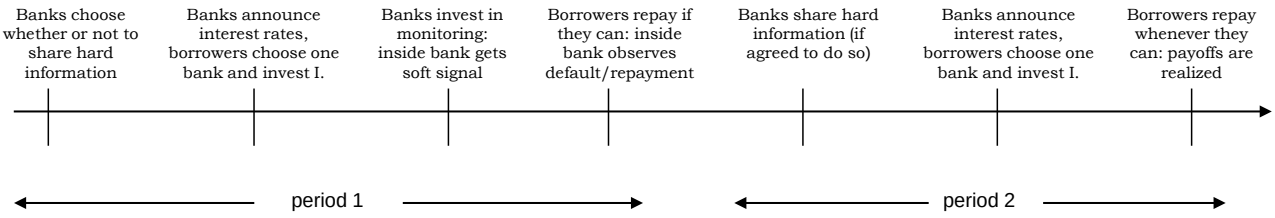

Figure 1: Timeline of the game

In the next two subsections we derive the Perfect Bayesian equilibrium of the game under information sharing and no information sharing, respectively. We then examine when information sharing is profitable for banks, analyze borrowers' surplus and welfare [11].

3.2 DEFAULT INFORMATION IS SHARED

We start with the case where hard information is shared. In that case, both banks can distinguish between defaulting and successful borrowers regardless of which of them made the initial loan. We solve the model through backward induction, starting from the second period.

[10] Obviously, the condition also implies it is ex-ante efficient to grant a loan to an average risk.

[11] In the on-line Appendix we also analyze the implications for borrower switching

3.2.1 *Preliminary Steps*

The banks will use the information they have to derive borrowers' second-period success probability. The incumbent, informed bank has both soft and hard information, while the outside, uninformed bank only has hard information. As a result, the incumbent can distinguish between the three groups of borrowers mentioned above: non-defaulters, defaulters that have generated a good signal, and defaulters that have generated a bad signal. The outside bank can only distinguish between defaulters and non-defaulters. Each of the two banks can choose to bid different interest rates for each of the groups it observes.

The break-even gross interest rate for each borrower group ($K = D, N, GD$ or BD) is equal to the investment I divided by the respective success probability, $\overline{r}_K = \frac{I}{p_K}$. For example, $p_{GD} = P(\eta = G, h = D)$ denotes the (Bayesian updated) success probability when the borrower has produced signal G and history D. For the overall population the rate is equal to $\overline{r} = \frac{I}{\bar{p}} = \frac{I}{\lambda p}$. The break-even interest rates will obviously be lower for better-quality borrower groups.

We denote by M_K the mass of borrower group K. We also define $\bar{\varphi}$ such that $p_{BD}R = I$. Whenever $\varphi > \bar{\varphi}$, bad-signal defaulting borrowers are not creditworthy and the incumbent bank will not bid for them. This threshold in the intensity of monitoring will play a role in the structure of the equilibrium described below.

3.2.2 *Lending Competition*

Banks move simultaneously to offer second-period interest rates, and thus do not observe each other's rates. Both the incumbent and the outside bank know that successful first-period borrowers are obviously high-type. The two banks will compete à la Bertrand, offering the break-even interest rate $\bar{r}_N = \frac{I}{p}$.

In the pool of defaulting borrowers, the informed bank can discriminate between good- and bad-signal borrowers, while the uninformed bank cannot. As shown in von Thadden (2004), there is no pure-strategy equilibrium in simultaneous-bid games where one lender knows more than the other[12]. There is however a mixed-strategy equilibrium in which banks randomize over intervals of interest rates. The second period of the game thus has a unique Perfect Bayesian Nash equilibrium in mixed strategies, the properties of which we analyze below.

The outside bank is faced with a pool of defaulting borrowers and cannot bid below r_D, their break-even interest rate without making a loss. The incumbent bank therefore also has no incentives to choose an interest rate below r_D. At the same time, if the incumbent were to bid above r_{BD} for either of the two subgroups of borrowers it can observe, the break-even interest rate for the bad-signal group, it could be easily undercut by the outside bank. This tells us that interest rates chosen by the banks have to be between r_D and r_{BD}.

Suppose now that the outside bank adopts the pure strategy of choosing an interest rate r on the interval mentioned above. Then the inside bank can choose an interest rate slightly below r and lend just to the good-signal borrowers. The outside bank would end up lending at a loss to just the bad-signal borrowers. Intuitively, this points to the non-existence of a pure-strategy equilibrium.

There is however a mixed-strategy equilibrium. The inside bank only bids r_BD - the break-even interest rate - for the bad-signal borrowers, and chooses interest rates on the interval between r_D and r_{BD} for the good-signal borrowers. The outside bank chooses interest rates on the same $[r_D, r_{BD}]$ interval. (We denote by F^i_{GD} and F^i_{BD} the cumulative distribution function of interest rates offered by the informed bank to good- and bad-signal

[12]This is a result also known from the literature on auctions (Engelbrecht-Wiggans et al. (1982)).

borrowers respectively, and by $F_D^u(r)$ the one of interest rates offered by the uninformed bank to defaulting borrowers.)

The incumbent bank has no competitive advantage in terms of the bad-signal borrowers, since the outside bank knows that is the worse group of borrowers it can get. The inside bank therefore bids the break-even rate and makes zero profits on those borrowers. However, since the outside bank cannot isolate them, good-signal borrowers will receive above-break even interest rates and generate positive profits for the inside bank. Bidding a high interest rate however increases the probability of losing the borrower due to a more favorable offer from the outside bank. The incumbent therefore has to balance higher profits per retained good-signal borrower with higher probabilities of retention.

The outside bank usually attracts bad-signal borrowers and sometimes - if its bid is lower than that of the incumbent - it also lends to good-signal borrowers. Once again a lower bid increases the probability of attracting good-signal borrowers, and hence of profitable lending, while a higher bid increases profits conditional on success. We shall see below that, rather unsurprisingly, the uninformed bank faced with adverse selection will just break even on average, while the informed bank makes positive profits coming from good-signal borrowers.

We describe the equilibrium bidding strategies chosen by the two banks in the proposition below. When the signal of the inside bank is very accurate, bad-signal borrowers are no longer creditworthy, and the incumbent will prefer not to lend to them rather than bid the (now non-existent) break-even interest rate.

PROPOSITION 3.1 ***Equilibrium Strategies*** *The competition between the informed and the uninformed bank has a mixed-strategy equilibrium for defaulters. In this equilibrium,*

1. If $\varphi > \bar{\varphi}$ (monitoring is high and the worst group of borrowers is not creditworthy),

the informed bank bids

$$F^i_{GD}(r) = 1 - \frac{M_{BD}(I - p_{BD}r)}{M_{GD}(p_{GD}r - I)} \tag{4}$$

on $[\overline{r}_D, R)$ *and has an atom at* R*. It does not bid for the bad-signal, defaulting group.*

The uninformed bank bids

$$F^u_D(r) = \varphi F^i_{GD}(r), \tag{5}$$

on $[\overline{r}_D; R)$*. It does not bid with probability* $1 - F^u_D(R)$*.*

2. If $\varphi \leq \bar{\varphi}$ *(monitoring is relatively low and the worst group of borrowers is still creditworthy), both the informed and the uninformed bank always offer credit to all borrowers on* $[\overline{r}_D, \bar{r}_{BD}]$ *with* F^i_{GD}*, and* $F^u_D(r)$ *as above, respectively.*

Both banks bid pure-strategy $\bar{r}_N$ *for the non-defaulting group.*

Proof See the Appendix.

This equilibrium has an intuitive property that will hold true throughout the analysis: better borrower groups receive better loan terms from the incumbent. Indeed, non-defaulters N get as low as their break-even rate $\overline{r}_N$. At the same time, good-signal defaulters get higher rates in $[\overline{r}_D; R]$ (or $[\overline{r}_D; \overline{r}_{BD}]$), while bad-signal ones receive even higher interest rates ($\bar{r}_{BD}$) or are prevented from borrowing. Notably, compared to the informed bank's interest rates for good-signal defaulting borrowers, the uninformed bank's bidding strategy is less aggressive ($\varphi \leq 1$). The uninformed bank is obviously the one which is faced with the larger adverse selection problem.

As it may be expected, the incumbent bank gets information rents as a result of having exclusive soft information about its first-period borrowers. The information rents are given in the following proposition.

PROPOSITION 3.2 *The second-period profits (information rents) for the incumbent bank when default information is shared are given by*[13]

$$\Pi_{\text{sharing}} = I(1-\lambda)(2\varphi - 1) \tag{6}$$

The uninformed bank makes zero profits.

Proof See the Appendix.

The equilibrium bidding and profit are similar to the one derived in Hauswald and Marquez (2006). The incumbent bank is the one getting informational rents as a result of its exclusive soft signal. The rents are of course increasing in the informativeness of monitoring. They also increase in the proportion of low-type borrowers - an increase in that proportion increases the adverse selection problem faced by the outside bank and raises interest rates. The uninformed bank just breaks even on average, but it will sometimes lend to the good-signal borrowers.

3.3 NO INFORMATION IS SHARED

We now describe the case where there is no credit bureau in the economy. At the beginning of the second period, both default and monitoring information are known only

[13]We use Π for the (gross) information rents of the incumbent bank, and π for the net profits, which also consider the cost of monitoring.

to the incumbent bank. As in the case with information sharing, there is no pure-strategy equilibrium, but there is a mixed-strategy one.

In the absence of information sharing, the outside bank cannot make any distinction and is faced with the entire undifferentiated pool of its competitor's first-period borrowers. From the incumbent bank's point of view, the pool contains three types of borrowers: non-defaulting, good-signal defaulting and bad-signal defaulting borrowers, where the average success probability decreases from the first group to the last.

Once again, bidding takes place between the break-even interest rate for the whole pool and the break-even interest rate for the worst group (or R if the worst group is not creditworthy). The uninformed bank bids over the whole interval and just breaks even on average. The informed bank bids lower interest rates for higher quality borrowers to prevent their switching to the outside bank. It makes positive profits, and those profits come from non-defaulting and good signal borrowers, but not from the worst group of borrowers (bad signal and defaulting).

We now formalize the intuition. Let $F^u(r)$ denote cumulative distribution function of interest rates offered by the uninformed bank. The informed bank will choose different interest rates for successful, good- and bad-signal defaulting borrowers; let the cumulative distribution functions be denoted by F^i_N, F^i_{GD}, and F^i_{BD} respectively.

PROPOSITION 3.3 ***Equilibrium Strategies*** *The competition between the informed and the uninformed bank has a mixed-strategy equilibrium. In this equilibrium:*

1. *When $\varphi > \bar{\varphi}$ (monitoring is high), the informed bank*

- *bids only for non-defaulting borrowers on $[\bar{r}, \bar{r}_D]$:*

$$F_N^i = 1 - \frac{M_{BD}(I - p_{BD}r) + M_{GD}(I - p_{GD}r)}{M_N(p_N r - I)} \tag{7}$$

- *bids only for good-signal borrowers that have defaulted on* $[\bar{r}_D, R)$*:*

$$F_{GD}^i = 1 - \frac{M_{BD}(I - p_{BD}r)}{M_{GD}(p_{GD}r - I)} \tag{8}$$

  with an atom at R*.*

- *refrains from bidding for the bad-signal, defaulting group, which is not creditworthy in this case.*

  The uninformed bank bids

$$F^u(r) = 1 - \frac{p_N\overline{r} - I}{p_N r - I} = pF_i^N, \tag{9}$$

  on $[\overline{r}, \overline{r}_D]$*, and*

$$F^u(r) = 1 - (1-p)\frac{p_{GD}\overline{r}_D - I}{p_{GD}r - I} = p + (1-p)\varphi F_{GD}^i, \tag{10}$$

  on $[\overline{r}_D; R)$*. It does not bid with probability* $1 - F^u(R) = (1-p)\frac{p_{GD}\overline{r}_D - I}{p_{GD}R - I}$*.*

2. when $\varphi \leq \bar{\varphi}$ *(monitoring is low), both banks bid for all borrowers. The informed bank*

- *bids only for non-defaulting borrowers on* $[\bar{r}, \bar{r}_D]$*;*

$$F_N^i = 1 - \frac{M_{BD}(I - p_{BD}r) + M_{GD}(I - p_{GD}r)}{M_N(p_N r - I)} \tag{11}$$

- *bids only for good-signal borrowers that have defaulted on* $[\bar{r}_D, \bar{r}_{BD}]$*;*

$$F_{GD}^i = 1 - \frac{M_{BD}(I - p_{BD}r)}{M_{GD}(p_{GD}r - I)} \tag{12}$$

- *bids* $\bar{r}_{BD}$ *for the bad-signal, defaulting group.*

  The uninformed bank bids

$$F^u(r) = 1 - \frac{p_N\overline{r} - I}{p_N r - I} = pF_i^N, \tag{13}$$

  on $[\overline{r}, \overline{r}_D]$*, and*

$$F^u(r) = 1 - (1-p)\frac{p_{GD}\overline{r}_D - I}{p_{GD}r - I} = p + (1-p)\varphi F_{GD}^i, \tag{14}$$

  on $[\overline{r}_D; \bar{r}_{BD})$*. It has an atom at* $\bar{r}_{BD}$*.*

Proof See the Appendix.

In this proposition we go beyond existing results in the banking literature and describe an equilibrium for the case where there are more than two borrower groups which are pooled from the outside bank's point of view. As under information sharing, the uninformed bank faces adverse selection. In this case, however, it faces adverse selection from hard information as well, and it bids weakly higher interest rates. Once again, better

groups receive better interest rates from the incumbent. The equilibrium structure can be generalized to the case where the incumbent can distinguish between a finite number of borrower groups.

The term $1-p=\frac{p_N\bar{r}-I}{p_N\bar{r}_D-I}$ comes from the pooling of non-defaulting and defaulting borrowers. With probability $p=1-\frac{p_N\bar{r}-I}{p_N\bar{r}_D-I}=F_u(\bar{r}_D)$ the uninformed bank bids below $\bar{r}_D$, and defaulting borrowers get an interest rate below their break-even rate. This is because, unlike in the case of information sharing, the uninformed bank does not observe first-period repayments. From the informed bank's point of view, this raises the probability of losing the good-signal, defaulting first-period borrowers.

The information rents of the incumbent are given below.

PROPOSITION 3.4 *The expected gross profits (i.e. profits not including monitoring costs) for the incumbent bank when default information is not shared are given by*

$$\Pi_{\text{no sharing}}=Ip(1-\lambda)+I(1-p)(1-\lambda)(2\varphi-1) \tag{15}$$

The uninformed bank makes zero profits.

Proof See the Appendix.

Under both regimes, informational rents are growing in the informativeness of the monitoring. This proposition therefore provides a theoretical counterpart to the empirical findings that bank rents grow with relationship intensity (Ioannidou and Ongena (2010)). Also, as in the case of information sharing, a higher proportion of low-type borrowers $(1-\lambda)$ increases information rents for the incumbent. Unlike in that case, however, we have an additional term as a result of having two sources of rents.

3.4 OPTIMAL MONITORING

We can now compare the optimal choices of monitoring with and without information sharing.

PROPOSITION 3.5 *The marginal return to soft information is higher under hard information sharing:*

$$\frac{\partial \Pi_{\text{sharing}}(\varphi)}{\partial \varphi} \geq \frac{\partial \Pi_{\text{no sharing}}(\varphi)}{\partial \varphi} \tag{16}$$

The optimal investment in monitoring is higher under information sharing:

$$\varphi_{\text{sharing}} = 0.5 + \frac{I}{c}(1-\lambda) \tag{17}$$

$$\varphi_{\text{no sharing}} = 0.5 + \frac{I}{c}(1-\lambda)(1-p) \tag{18}$$

Proof See the Appendix.

Under no information sharing, defaulting and successful borrowers are pooled from the uninformed bank's point of view. Consequently, the good-signal, defaulting borrowers are likely (with probability p) to receive outside bids below $\bar{r}_D$ and to switch to the uninformed bank. A portion of the inside bank's potential information rents is lost in this manner. The loss does not happen under information sharing, and as a result the marginal benefit from investing in monitoring is higher under the latter regime. The optimal level of monitoring is given by the point where the marginal benefit of monitoring equals its marginal cost, which results in higher optimal monitoring under information sharing.

The fact that monitoring increases under information sharing goes against the idea that information sharing destroys banks' incentives to collect information. Good information collection by banks is important for the economy given banks' role in the allocation of capital. We show below that information sharing can lead to higher welfare.

One possible concern with our result is that the quality of hard information may deteriorate once information sharing is introduced. We think that the downside potential in this case is not likely to be large, given that by definition hard information is verifiable and its quality can be established at a relatively low cost.

The main factors that determine optimal monitoring are summarized in the proposition below.

PROPOSITION 3.6 *1. Optimal investment in soft information is increasing in the risk parameters* $1-\lambda$, *and* $1-p$.

2. The gap between optimal monitoring under the two regimes is increasing in the risk parameter $1-p$.

3. The increase in optimal information acquisition is higher when the monitoring cost c *is lower.*

Proof Obvious and omitted.

As adverse selection increases, and monitoring costs decrease, monitoring becomes more attractive. At the same time, part (2) of the proposition shows that information sharing increases monitoring to a larger extent if hard information is less informative (there are more defaulting, but high-type borrowers). Our results should therefore be stronger among firms that are riskier and more opaque.

Information sharing leads to higher monitoring, and this can entail both higher informational rents and higher monitoring costs. Under certain conditions, the additional

rents exceed the additional monitoring costs, resulting in higher profits for the banks. The conditions are summarized below.

PROPOSITION 3.7 *If monitoring costs are low enough* ($c < I(1-\lambda)(2-p)$)*, the incumbent bank's net profits from monitoring will be higher under information sharing.*

Proof Indeed, plugging in optimal values, one can see that $\Pi^{\text{optimal}}_{\text{sharing}} = \frac{2I^2}{c}(1-\lambda)^2 > Ip(1-\lambda) + \frac{2I^2}{c}(1-\lambda)^2(1-p)^2 = \Pi^{\text{optimal}}_{\text{no sharing}}$ provides a condition under which information rents are higher under information sharing. Subtracting the monitoring costs ($c(\varphi - \frac{1}{2})^2$) (which are higher under information sharing), we get that net profits are higher under the more stringent condition ($c < I(1-\lambda)(2-p)$).

Profits are relatively higher under information sharing if there is more adverse selection (the share of creditworthy, high-type borrowers λ is lower). A lower success probability p means that there are more defaulting, but high-quality borrowers that make it worthwhile to invest in soft information.

The idea that information sharing may adjust competition is also present in Bouckaert and Degryse (2006), where the inside bank has free full information about types. In their model with switching costs, information sharing may increase profits by preventing the outside bank from bidding in the defaulters' market, while successful borrowers will only switch when their (exogenous) switching costs are not too high. In our model, the higher incentives to monitor under information sharing may result in higher informational rents and profits. The higher monitoring plays a key role in our model; if information about types was free for the incumbent bank, and there were no switching costs, banks would never choose to share information.

3.5 THE FIRST PERIOD

At the beginning of the first period banks compete for the whole population, under symmetric information about the overall proportion of the good and bad borrowers and their success probabilities. The result will be similar interest rates from both banks for all borrowers and an equal sharing of the market. The total profits across two periods are given by

$$\lambda p R_{1,\text{ sharing}} - I + \pi_{\text{sharing}} \tag{19}$$

and

$$\lambda p R_{1,\text{ no sharing}} - I + \pi_{\text{no sharing}} \tag{20}$$

for each of the two regimes. Banks compete in period 1 for second-period captive markets, and this will drive the total profits across the two periods to 0, like in Padilla and Pagano (2000). Given the anticipation of positive second-period profits, banks bid below-break even interest rates in the first period ($R_{1,\text{ sharing}} = \frac{I}{\lambda p} - \frac{1}{\lambda p}\frac{I^2}{c}(1-\lambda)^2$, $R_{1,\text{ no sharing}} = \frac{I}{\lambda p} - \frac{1}{\lambda p}(Ip(1-\lambda) + \frac{I^2}{c}(1-\lambda)^2(1-p)^2)$, where the break-even interest rate would obviously be $R_1 = \frac{I}{\lambda p}$).

We have so far looked at bank competition and monitoring without a direct analysis of the choice of the information sharing regime. In some cases, the establishment of the information sharing regime is decided by the government or central bank, and may be based on welfare considerations as presented in Section 3 below.

Nevertheless, in many cases the decision to share information is made by the banks themselves. In our model, given that profits over the two periods are zero, it may seem that banks are always indifferent between the two regimes. However, looking at banks that have made their initial loans, we can see that banks will choose to share information if informational rents from their current borrowers, less monitoring costs, are higher under that regime. Therefore banks will endogenously choose to share information if monitoring costs c are relatively low (less than $I(1-\lambda)(2-p)$), as stated in Proposition 3.7).

In practice, banks have a portfolio of existing borrowers when they decide to establish a credit bureau. If sharing information increases profits over the remaining lifetimes of their borrowers, banks can volunteer to communicate their hard information. From a theoretical point of view, the analysis of sharing incentives starting from incumbency positions has been the standard (see for instance Jappelli and Pagano (1993), Padilla and Pagano (1997), and Bouckaert and Degryse (2006)).

Second, let us now consider new borrowers - banks are now at the beginning of the first period on that particular market. Suppose that we are in a given information sharing regime - for instance there is no information sharing. If we have a large negative shock to the cost of monitoring c, then banks know that ex post they are going to prefer to share information, since that gives them larger profits. (Note that the decision to share information is based on the inside bank's incentives (profits) and not on outside pressure; the outside bank is competing as aggressively as possible given its information.) They will then charge a lower initial interest rate to support that, and that will be preferred by borrowers. We therefore have an endogenous switch from one regime to the other[14].

[14]For simplicity, we focus on monitoring costs as the main changing variable. The decision to share information may also be governed by changes in the proportion of types λ and success probabilities p relative to monitoring costs as given by the condition in Proposition 3.7.

4 Expected Interest rates and Welfare

4.1 INTEREST RATES

All borrowers receive the same interest rate in the first period under both regimes. During the second period, however, hard and soft information lead to different interest rates for different borrower groups.

PROPOSITION 4.1 *1. $F^i(r)$ and $F^u(r)$ for all groups of borrowers, as well as the minimum of the two rates for each borrower, are non-increasing in φ under both information sharing and no information sharing regimes. Expected interest rates paid by borrowers are non-decreasing in informativeness φ under both regimes.*

2. *Non-defaulting borrowers get lower expected interest rates under information sharing.*

3. *Defaulting borrowers (both good- and bad-signal, and defaulting borrowers as a group) get higher expected interest rates under information sharing.*

4. *Defaulting borrowers get higher expected interest rates than successful borrowers under both regimes.*

5. *Bad-signal borrowers get higher expected interest rates than good-signal borrowers under both regimes.*

Under low monitoring ($\varphi \leq \bar{\varphi}$):

- *High-type borrowers get higher expected interest rates under information sharing whenever the information rents are higher under that regime.*
- *Low-type borrowers always get higher expected interest rates under information sharing.*

Proof See the Appendix.

Increased monitoring enhances the informational advantage of the incumbent bank, and usually drives up the interest rates the outside bank needs to charge in order to break even. This will also increase the interest rates charged by the incumbent, as well as the interest rates effectively paid by borrowers.

Negative information, both soft and hard, will increase the interest rates faced by borrowers under both regimes. At the same time, if one is interested in the welfare of high-type borrowers, it is important to note that they will be charged higher expected interest rates under information sharing in the case when the incumbent's information rents are higher under that regime. This is not surprising, since the high-type borrowers are the source of those rents[15]. Low-type borrowers are charged higher interest rates under information sharing.

As it may seem natural, information sharing increases the gap between the expected interest rates for successful and defaulting borrowers. Because the uninformed bank faces a more serious case of winner's curse in the pool of defaulting borrowers (the successful first-period borrowers are missing from the pool), it bids less aggressively in equilibrium. The response by the informed bank is to bid less aggressively as well, leading to higher expected interest rates.

Our results allow us to get a more detailed view of interest rates for different borrower groups and information regimes. Thus we complement previous work that has shown that information sharing decreases overall interest rates (Brown et al. (2009), Jappelli and Pagano (2002)).

[15]The comparison is more complicated in the case of high monitoring ($\varphi > \bar{\varphi}$), since then we have the possibility that some borrowers do not receive any bids. However, the conclusion goes in the same direction.

4.2 WELFARE IMPLICATIONS

Monitoring can improve lending decisions since some of the low-quality borrowers do not receive credit[16]. At the same time, it generates additional costs. It may be interesting to see what is the balance between the two, and whether information sharing can increase welfare.

For low levels of monitoring, monitoring has a significant effect on the competition between banks, borrowers' expected interest rates and their switching. However, the effect on overall welfare will be simply given by the monitoring costs[17]:

$$\text{Welfare} = \lambda pR - I - c(\varphi - \frac{1}{2})^2 \tag{21}$$

Higher monitoring is welfare-reducing in this regime, and welfare can be lower under information sharing as a result of information sharing[18] . The outcome is different if monitoring is high ($\varphi > \bar{\varphi}$) and bad-signal defaulting borrowers will sometimes not receive credit. This is also the case in which those borrowers are not creditworthy on average, so the fact that they are denied loans increases welfare. Formally, welfare consists of the sum of the value created by all potential projects, less the possible losses avoided by not lending to BD borrowers, and less the costs of monitoring:

[16]Consistent with this, Hertzberg et al. (2011) and Doblas-Madrid and Minetti (2009) show that information sharing reduces access to finance for risky borrowers. Jappelli and Pagano (2002) find that information sharing is associated with lower default rates.

[17]To reduce clutter, we do not include the value created during the first period in the welfare equation; it does not depend on the information sharing regime and the intensity of monitoring.

[18]A countervailing effect could come from lower probabilities of large loan losses and bank bankruptcy. We have not included bank bankruptcy costs in our model, however.

$$\text{Welfare} = \lambda pR - I - M_{BD}(p_{BD}R - I)(1 - F_u(R)) - c(\varphi - \frac{1}{2})^2 \tag{22}$$

PROPOSITION 4.2 *1. If monitoring costs are low enough, monitoring can enhance welfare both with and without information sharing.*

2. Welfare is higher under information sharing than under no information sharing.

Proof See the Appendix.

Higher monitoring has three main welfare effects. First, it increases the losses that could result if bad-signal, defaulting borrowers get a loan ($M_{BD}(p_{BD}R - I)$), since better monitoring means that the quality of that group deteriorates. Second, the probability that those losses actually occur decreases. Higher adverse selection means that the outside bank is less willing to provide a loan, and the incumbent does not lend to the worst group of borrowers. Third, monitoring is costly, and higher monitoring will obviously result in higher costs. For low enough costs of monitoring, the benefit from low-quality borrowers not receiving a loan is higher than the cost of getting that result.

In the high-monitoring case examined above, the lending losses avoided and the monitoring costs incurred are both higher in the presence of information sharing. We show that the overall balance is favorable to the information sharing regime, under which overall welfare is always higher. If the scenario in which the worst-quality borrowers are not creditworthy and they are sometimes denied credit is the more realistic one, then information sharing will improve welfare.

5 Conclusions

The recent financial crisis has emphasized the need for adequate bank monitoring. It has also raised the practical issue of finding ways to enhance monitoring incentives for financial intermediaries. Our paper shows that the establishment of information sharing arrangements can lead to an increase in information acquisition. When credit bureaus make default histories or other pieces of hard information available to all lenders in the system, lenders' incentives to invest in acquiring additional, soft information such as firms' management quality increase. This is the result of a higher marginal benefit of investing in soft information. Information sharing may also reduce lending losses and improve overall welfare. Setting up information sharing arrangements such as private credit bureaus and public credit registers can therefore be a good policy.

Our findings have implications beyond credit financing. They suggest that an increase in publicly available information will stimulate rather than discourage information collection. Thus a reasonable increase in reporting requirements, improvements in accounting standards, and better data services can enhance rather than deter close relationships and informed financing.

Soft information can be difficult to communicate within banks as well as across banks. Recent research (Stein (2002), Berger et al. (2005)) has shown that this can lead to the specialization of small banks in the use of soft information, while large banks use standardized lending based on hard data. In light of their and our results future research could examine whether the introduction of information sharing increases the gap between large and small banks.

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7 Appendix A

Proof of Proposition 3.1 Define the success probabilities

$$
\begin{aligned}
p_N &= p \\
p_{GD} &= \frac{\lambda\varphi p(1-p)}{\lambda\varphi(1-p)+(1-\lambda)(1-\varphi)} \\
p_{BD} &= \frac{\lambda(1-\varphi)p(1-p)}{\lambda(1-\varphi)(1-p)+(1-\lambda)\varphi}
\end{aligned}
$$

and the respective break-even rates $\overline{r}_K = \frac{I}{p_K}$, for $K = D, N, GD$ or BD.

Under information sharing, both the incumbent and the outside bank compete à la Bertrand for borrowers who have repaid, offering $\bar{r}_N$.

In the case of defaulting borrowers, the incumbent bank can distinguish between good- and bad-signal borrowers. The construction of the mixing strategies is done in a sequence of standard arguments outlined here, similar to Hauswald and Marquez (2006). For more details, see Hauswald and Marquez (2000) or von Thadden (2004).

Let $F_u^K(r)$ the uninformed bank's bidding distribution over loan rate offers r, for defaulting ($K = D$) and non-defaulting ($K = N$) groups. $F_i^K(r)$ describes the bidding strategies for the informed bank for the good-signal defaulting ($K = GD$), bad-signal defaulting($K = BD$) and the non-defaulting ($K = N$) borrowers.

Let $\bar{\varphi}$ denote informativeness level that solves $p_{BD}(\varphi)R = I$.

a) Suppose first $\varphi > \bar{\varphi}$. This implies bad-signal, defaulting borrowers are not creditworthy. The informed bank will not bid for them and $F_{BD}^i(r) = 0$ for all r. It can be shown that $F_{GD}^i(r)$ and $F^u(r)$ are continuous, strictly increasing, and atomless on some common support $[\underline{r}, \bar{R})$ (see Hauswald and Marquez (2000)).For $K = GD$, the informed

bank gets expected profits for any r

$$\Pi^i_{GD}(r) = M_{GD}(p_{GD}r - I)(1 - F^u_D(r)),$$

while the profits of the outside bank can be written as

$$\Pi^u_D(r) = M_{GD}(p_{GD}r - I)(1 - F^i_{GD}(r)) + M_{BD}(p_{BD}r - I)(1 - F^i_{BD}(r)).$$

It can be shown (Engelbrecht-Wiggans et al. (1982)) that the uninformed bank has to break even in equilibrium, implying that $\Pi^u_D(r) = 0$. To calculate the lower bound of the common support, observe that the uninformed bank wins the defaulter almost surely at that rate and gets $p_D\underline{r} - I$, implying $\underline{r} = \bar{r}_D$. For the upper note that none of the banks will clearly bid above cash flow R. Thus, in the case with $\varphi > \bar{\varphi}$ the support is $[\bar{r}_D, R)$.

b) Suppose then that $\varphi < \bar{\varphi}$ (the bad-signal defaulting borrowers are creditworthy). Clearly, $r^i_{BD} \geq \bar{r}_{BD}$ because anything lower than that yields losses. Repeated undercutting arguments establish that the informed bank bids pure strategy break-even $\bar{r}_{BD}$ for bad-signal defaulting borrowers. The remainder of the proof is similar to the previous case, except that the common support is now $[\bar{r}_D, \bar{r}_{BD})$.

Equilibrium profits for each bank in the mixed-strategy equilibrium must be constant for any $r \in [\bar{r}_D, \bar{r}_{BD} \wedge R)$. We have

$$M_{GD}(p_{GD}r - I)(1 - F^D_u(r)) = \text{ constant.}$$

so that

$$M_{GD}(p_{GD}\bar{r}_D - I) = M_{GD}(p_{GD}r - I)(1 - F^u_D(r)).$$

because the uninformed bank starts bidding from $\bar{r}_D$, $1 - F_D^u(\bar{r}_D) = 1$. This gives us the expression for $F_D^u(r)$:

$$F_D^u(r) = 1 - \frac{p_{GD}\bar{r}_D - I}{p_{GD}r - I}.$$

Similarly,

$$M_{GD}(p_{GD}r - I)(1 - F_{GD}^i(r)) + M_{BD}(p_{BD}r - I) = 0$$

which yields

$$F_{GD}^i(r) = 1 - \frac{M_{BD}(I - p_{BD}r)}{M_{GN}(p_{GD}r - I)}.$$

over $r \in [\bar{r}_D, \bar{r}_{BD} \wedge R)$, where $M_{GD} = \lambda\varphi(1-p) + (1-\lambda)(1-\varphi)$, $M_{BD} = \lambda(1-\varphi)(1-p) + (1-\lambda)\varphi$. It is now easy to verify that $\varphi F_{GD}^i(r) = \frac{p_{GD}r - p_{GD}\bar{r}_D}{p_{GD}r - I} = F_D^u(r)$. Since both banks randomize over the full support of their distribution functions, they cannot profitably deviate from their mixed strategies. Therefore, the distributions above represent the unique equilibrium of the bidding game for a given borrower. Observe that $F_{GD}^i(R^-) = 1 - \frac{M_{BD}(I - p_{BD}R)}{M_{GD}(p_{GD}R - I)} < 1$, so that there is an atom at R. Moreover, $F_D^u(R) = \varphi F_{GD}^i(R) < 1$, so that the uninformed does not bid with probability $1 - F_D^u(R)$ whenever $\varphi > \bar{\varphi}$.

Proof of proposition 3.2

During the second period, the incumbent bank distinguishes between three borrower groups. Under information sharing, it makes zero profits on non-defaulting borrowers, given the Bertrand competition with the outside bank for those borrowers. It either does not bid for bad-signal, defaulting borrowers or bids only the break-even interest rate for them, again resulting in zero profits. The second-period profits are positive on good-

signal, defaulting borrowers, however. Expected profits are the same for any interest rate the incumbent bank chooses on $[\bar{r}_D, r_{BD} \wedge R$ and are equal to

$$\begin{aligned}\Pi^i_{share} &= M_{GD}(p_{GD}\overline{r}_D - I) \\ &= \Big[\lambda\varphi p(1-p)\frac{\lambda(1-p)+1-\lambda}{\lambda p(1-p} - \big(\lambda\varphi(1-p) + (1-\lambda)(1-\varphi)\big)\Big]I \\ &= (2\varphi - 1)(1-\lambda)I\end{aligned}$$

Thus second-period profits are linearly increasing in φ. These are the information rents resulting from monitoring. The "net profits" from monitoring can be obtained by subtracting the cost $c(\varphi - \frac{1}{2})^2$.

As indicated in the proof of Proposition 3.1, the uninformed bank makes zero profits.

Proof of Proposition 3.3

If the first-period monitoring is high, and the defaulting, bad-signal borrowers are not creditworthy, the incumbent bank will not bid for them. The second-period profits from bidding interest rate r for non-defaulting and defaulting, good-signal borrowers are given by:

$$\begin{aligned}\Pi^i_N(r) &= M_N(p_N r - I)(1 - F^u(r)) \\ \Pi^i_{GD}(r) &= M_{GD}(p_{GD} r - I)(1 - F^u(r))\end{aligned}$$

while the outside bank's profit when bidding r is given by:

$$\Pi^u(r) = M_N(p_N r - I)(1 - F_N^u(r)) + M_{GD}(p_{GD} r - I)(1 - F_{GD}^i(r)) + M_{BD}(p_{BD} r - I).$$

The informed bank bids for N borrowers on $[l_N^i, u_N^i]$ and for GD borrowers on $[l_{GD}^i, u_{GD}^i]$. The uninformed bank bids on $[l^u, u^u]$.

1. $l_N^i \geq \bar{r}_N$ and $l_{GD}^i \geq \bar{r}_{GD}$, i.e. the incumbent bank does not bid below break-even rates.

2. $l^u \geq \bar{r}$. (The outside bank does not bid below $\bar{r}$, the break-even rate for all borrowers.) This is because the best the outside bank can do is to lend to all borrower groups.

3. The previous step implies that the incumbent bank's lowest interest rate for N or GD borrowers is greater or equal to $\bar{r}$.

4. $u^u \geq u_N^i$. This is because, since the bidding starts from $\bar{r}$, the informed bank makes strictly positive profits on non-defaulting borrowers. If we had $u^u < u_N^i$, then the incumbent bank would be making zero profits on non-defaulting borrowers on $(u^u, u_N^i]$.

5. There is no overlap between the intervals over which the incumbent bank bids for the two borrower groups. $[l_N^i, u_N^i]$ and $[l_{GD}^i, u_{GD}^i]$ have at most one point in common.

Suppose we have r_1 and r_2 with $r_1 < r_2$ and $r_1 \in [l_N^i, u_N^i]$, $r_2 \in [l_N^i, u_N^i]$, $r_1 \in [l_{GD}^i, u_{GD}^i]$ and $r_1 \in [l_{GD}^i, u_{GD}^i]$. The incumbent bank should make the same profits on $N(GD)$ borrowers whether bidding r_1 or r_2:

$$M_N(p_N r_1 - I)(1 - F^u(r_1)) = M_N(p_N r_2 - I)(1 - F^u(r_2))$$
$$M_{GD}(p_{GD} r_1 - I)(1 - F^u(r_1)) = M_{GD}(p_{GD} r_2 - I)(1 - F^u(r_2))$$

Dividing the first equation by the second we get:

$$\frac{p_N r_1 - I}{p_{GD} r_1 - I} = \frac{p_N r_2 - I}{p_{GD} r_2 - I},$$

equivalent to $p_N I(r_2 - r_1) = p_{GD} I(r_2 - r_1)$ or $p_N = p_{GD}$, which is not true (except in the special case of full monitoring $\varphi = 1$).

We have therefore two intervals on which the incumbent bank bids for each of the two groups.

6. The outside bank makes zero profits (as also shown in (Engelbrecht-Wiggans et al. (1982)).

Let $F_u(r)$ be some equilibrium bidding strategy for the informed and the uninformed bank, respectively. If $F_u(r)$ has an atom at l^u, then the informed will bid above l^u when he has non-negative return $U_i = p_K l^u - I \geq 0$, where K ($K = GD, BD, GN, BN$) is a random variable observed only by the informed bank. Let E be the event that $p_K l^u - I \geq 0$. If $P(E) = 1$, then the informed will always bid above l^u, and therefore the uninformed's expected payoff when it bids $l^u + \epsilon$ will be $O(\epsilon)$. If $P(E) < 1$, then letting $\bar{E}$ denote the complement of E and $U_u = p_K l^u - I$, the uninformed bank's expected payoff conditional on winning with a bid of $l^u + \epsilon$ is

$$E[U_u|\bar{E}] \times P(\bar{E}) + (1 - P(\bar{E}))O(\epsilon) = E[E[p_K l^u - I|K]|\bar{E}] \times P(\bar{E}) + (1 - P(\bar{E}))O(\epsilon)$$

Now if $p_K l^u - I < 0$, then almost surely

$$E[U_u|K] = E[U_i|K] = p_K l^u - I < 0$$

Thus, total profits of the uninformed bank can never be positive. Similarly, if $F_u(r)$ has no atom at l^u, then the informed can never win by bidding $\underline{r}$ or less but it can have non-negative return by bidding more than l^u whenever $U_i = p_K \underline{r} - I \geq 0$. As before, when the uninformed bids $l^u + \epsilon$, either its probability of winning or its conditional expected payoff must be $O(\epsilon)$, yielding $O(\epsilon)$ expected payoff. In equilibrium, the uninformed must be indifferent among all bids. The payoff must be constant, and for bids above $l^u + \epsilon$ equal to $O(\epsilon)$. Its expected payoff is thus 0.

7. $u_N^i \leq l_{GD}^i$, i.e. the interval on which the incumbent bank bids for non-defaulting borrowers is below the interval on which it bids for good-signal, defaulting borrowers.

Suppose the incumbent bank bids lower interest rates for GD borrowers than for N borrowers.

7a. If $\bar{r} < \bar{r}_{GD}$, the incumbent bank's bidding would have to start from above $\bar{r}_{GD}$. Then the outside bank can bid $\bar{r}_{GD} - \varepsilon$, capture the whole market and make strictly positive profits. This cannot be an equilibrium. Therefore the incumbent bank's bidding for N borrowers starts at rates below $\bar{r}_{GD}$.

F_N^i is continuous on $[l_N^i, u_N^i)$. (Suppose that it is not. Then there must be $\hat{r} \in [l_N^i, u_N^i)$ such that $F_N^i(\hat{r}^-) < F_N^i(\hat{r})$. Then, since $p_N \hat{r} - I > 0$ we must have $\Pi^u(\hat{r}^-) > \Pi^u(\hat{r})$. By the right-continuity of F_N^i and Π^u there is an $\varepsilon > 0$ such that $F^u(\hat{r}) = F^u((\hat{r}) + \varepsilon)$. Therefore F_N^i cannot have any mass on $[\hat{r}, \hat{r} + \varepsilon]$ and $F_N^i(\hat{r}^-) = F_N^i(\hat{r})$. We have a contradiction.)

It can next be shown that $u_N^i \geq l_{GD}^i$.

Suppose $u_N^i < l_{GD}^i$ (the incumbent never bids on (u_N^i, l_{GD}^i)).

Suppose first that $u_N^i < u^u$. Then the outside bank will not bid on $[u_N^i, l_{GD}^i)$ (any interest rate in that interval can be improved by bidding higher, still below l_{GD}^i). Therefore the outside bank only bids on $[l_{GD}^i, u^u]$ above u_N^i. The incumbent bank has a profitable deviation: it can switch some of the mass on below u_N^i to a point below l_{GD}^i and increase

profits.

Alternatively, if $u_N^i = u^u$, the outside bank has a profitable deviation by switching some of the mass from below u^u to a point below l_{GD}^i.

Summing up, the incumbent bank bids for N borrowers on $[l_N^i, u_N^i]$ and for GD borrowers on $[u_N^i, u_{GD}^i]$. F_N^i is continuous on $[l_N^i, u_N^i)$.

7b. If $\bar{r} > \bar{r}_{GD}$, suppose again that the incumbent bank starts bidding for GD borrowers from $\bar{r}$. (A higher starting point would lead to the outside bank undercutting and profitably taking over the whole market). Then, following the same reasoning as in the previous case, it can be shown that F_{GD}^i is continuous on $[l_{GD}^i, u_{GD}^i]$ and that $u_N^i \geq l_{GD}^i$. We have that $u_N^i = l_{GD}^i = r_x$.

On $[\bar{r}, r_x]$, the expected profits for the incumbent bank when bidding for GD borrowers have to be the same for any interest rate chosen in that interval. We have $M_{GD}(p_{GD}r - I)(1 - F^u(r)) = M_{GD}(p_{GD}\bar{r} - I)$ for $r \in [\bar{r}, r_x]$, which implies that $1 - F^u(r) = \frac{p_{GD}\bar{r} - I}{p_{GD}r - I}$.

The informed bank has a profitable deviation in this case. Suppose it bids for N borrowers lower (at $r_x - \varepsilon$ instead of r_x):

$$M_N(p_N r_x - I)\frac{p_{GD}\bar{r} - I}{p_{GD}r_x - I}$$
$$M_N(p_N(r_x - \varepsilon) - I)\frac{p_{GD}\bar{r} - I}{p_{GD}(r_x - \varepsilon) - I}$$

The deviation is profitable:

$$M_N(p_N(r_x - \epsilon) - I)\frac{p_{GD}\bar{r} - I}{p_{GD}(r_x - \epsilon) - I} > M_N(p_N r_x - I)\frac{p_{GD}\bar{r} - I}{p_{GD}r_x - I},$$

equivalent to $(p_N - p_{GD})\varepsilon > 0$, which is true.

Therefore, just like in the previous case the incumbent bank bids for N borrowers on $[l^i_N, u^i_N]$ and for GD borrowers on $[u^i_N, u^i_{GD}]$. F^i_N is continuous on $[l^i_N, u^i_N)$.

8. $l^u = \bar{r}$. At l^u the outside banks wins the entire market almost surely (the incumbent will not start bidding below l^u). Also, the outside bank's profits are zero for any interest rate it chooses. Therefore $\bar{p}l_u - I = 0$, which implies $l_u = \bar{r}$. This also implies $l^i_N = \bar{r}$.

9. $l^i_{GD} = \bar{r}_D$. We know that $u^u \geq u^i_N$. At u^i_N, the outside bank get all defaulting borrowers, and make zero profits; therefore $u^i_N = \bar{r}_D = l^i_{GD}$.

10. $u^u \geq u^i_{GD}$ and F^i_{GD} is continuous on $[l^i_{GD}, u^i_{GD})$. The proof is similar to the proof in the case of non-defaulting borrowers.

11. $u^u = u^i_{GD} = R$. Neither of the banks will bid above the highest possible payoff, and the outside bank can never undercut the incumbent on GD borrowers.

The proof in the case of low monitoring (where BD borrowers are creditworthy) is similar. The upper limit in that case is r_{BD}, the break-even rate for the lowest-quality group of borrowers, and the the incumbent bids for BD borrowers at r_{BD}.

We can next derive the explicit expressions for the cumulative distribution functions.

For the informed bank, the rents on non-defaulting borrowers $\Pi_N(r) = M_N(p_N r - I)(1 - F_u(r))$ are constant across all r on $[\bar{r}, \bar{r}_D]$. This implies that on that interval $F_u(r) = 1 - \frac{p_N\bar{r}-I}{p_N r - I} = \frac{\lambda p r - I}{\lambda(pr-I)}$.

The rents on good-signal, defaulting borrowers $\Pi_{GD}(r) = M_{GD}(p_{GD}r - I)(1 - F_u(r))$ are again constant for every r on $[\bar{r}_D, \bar{r}_{BD} \wedge R)$. This implies that $\Pi^{GD}(\bar{r}_D) = M_{GD}(p_{GD}\bar{r}_D - I)(1 - F_u(\bar{r}_D)) = M_{GD}(p_{GD}\bar{r}_D - I)\frac{p_N\bar{r}-I}{p_N\bar{r}_D - I}$ for any r in the interval and therefore the cumulative distribution function for the uninformed bank is $F_u(r) = 1 - \frac{p_N\bar{r}-I}{p_N\bar{r}_D-I}\frac{p_{GD}\bar{r}_D - I}{p_{GD}r - I} = 1 - \frac{\frac{1}{\lambda} - I}{\frac{\lambda(1-p)+(1-\lambda)}{\lambda(1-p)} - I}\frac{p_{GD}\bar{r}_D - I}{p_{GD}r - I} = 1 - (1-p)\frac{p_{GD}\bar{r}_D - I}{p_{GD}r - I}$.

The BD group either yields zero profits when it is creditworthy, or does not get an

offer.

The outside bank makes zero profits for all interest rates it bids:

$$\begin{aligned}\Pi_u(r) =& M_N(p_N r - I)(1 - F_i^N(r)) + M_{GD}(p_{GD} r - I)(1 - F_i^{GD}(r)) + \\ &+ M_{BD}(p_{BD} r - I)(1 - F_i^{BD}(r)) = 0.\end{aligned}$$

To get the expression for $F_i^N(r)$, note that $F_i^{GD}(r)$,$F_i^{BD}(r)$ are equal to 0 in $[\overline{r}, \overline{r}_D]$. Thus, in equilibrium, the incumbent bank's strategy for N is characterized by the following cumulative density function:

$$F_i^{GN}(r) = 1 + \frac{M_{BD}(p_{BD} r - I) + M_{GD}(p_{GD} r - I)}{M_{GN}(p_{GN} r - I)} = \frac{\lambda p r - I}{\lambda p (p r - I)}$$

over the $[\overline{r}, \overline{r}_D]$.

Similarly, for non-defaulting borrowers we have

$$F_i^{GD}(r) = 1 + \frac{M_{BD}(p_{BD} r - I)}{M_{GD}(p_{GD} r - I)}$$

on $\bar{r}_D, \bar{r}_{BD}]$ and $\bar{r}_D, R)$ respectively. In the latter case (high monitoring)the incumbent's distribution function for GD bids has an atom at R.

Proof of Proposition 3.4

In the absence of information sharing, the incumbent bank will make positive profits on both non-defaulting N and good-signal, defaulting GD borrowers - both groups are offered interest rates above the bank's break-even level.

On $[\bar{r}, \bar{r}_D]$, the informed bank bids for non-defaulting borrowers, and expected profits

are the same at any point on the interval. Evaluating profits at $\bar{r}$ we get

$$\Pi_{\text{N, no sharing}} = M_N(p_N\bar{r} - I) = Ip(1-\lambda).$$

Similarly, evaluating profits on good-signal, defaulting borrowers at $\bar{r}_D$ we get

$$\Pi^{GD}_{nosharing} = M_{GD}(p_{GD}\bar{r}_D - I)(1 - F_u(\bar{r}_D)) = I(1-p)(1-\lambda)(2\varphi - 1).$$

Total informational rents (or second-period profits for the incumbent) are

$$\Pi_{nosharing} = Ip(1-\lambda) + I(1-p)(1-\lambda)(2\varphi - 1)$$

Proof of Proposition 3.5

Under information sharing, the incumbent bank chooses an informativeness level φ to maximize the following net profits from monitoring:

$$\pi_{\text{sharing}} = \Pi_{\text{sharing}} - c(\varphi - 0.5)^2 = I(1-\lambda)(2\varphi - 1) - c(\varphi - 0.5)^2$$

Solving the maximization problem we get

$$\varphi^*_{\text{sharing}} = 0.5 + \frac{I}{c}(1-\lambda).$$

Without information sharing, the net profits to be maximized are:

$$\pi_{\text{no sharing}} = \Pi_{\text{no sharing}} - c(\varphi - 0.5)^2 = Ip(1-\lambda) + I(1-p)(1-\lambda)(2\varphi - 1) - c(\varphi - 0.5)^2,$$

resulting in optimal informativeness

$$\varphi^*_{\text{no sharing}} = 0.5 + \frac{I}{c}(1-\lambda)(1-p) \leq \varphi^*_{share} = 0.5 + \frac{I}{c}(1-\lambda).$$

Information rents (second-period profits) are increasing in φ under both regimes, but the slope (the marginal benefit from investing in soft information) is higher under information sharing:

$$\frac{\partial \Pi_{\text{sharing}}(\varphi)}{\partial \varphi} = 2I(1-\lambda) \qquad \frac{\partial \Pi_{\text{no sharing}}(\varphi)}{\partial \varphi} = 2I(1-\lambda)(1-p) < 2I(1-\lambda).$$

Proof of Proposition 4.1

Let $F_K(r)$ denote the cumulative distribution function for the rate paid by a borrower in group $K = GD, N, BD$. Borrowers will obviously pay the minimum of the rates offered by the incumbent and the outside bank.

$$F_K(r) = F_K^{\min}(r) = 1 - (1 - F^u(r))(1 - F^i_K(r))$$

It can be shown that F^i, F^u and $F^{\min}$ are non-increasing in φ. For instance, for good-signal, defaulting borrowers, under information sharing the cdf of the informed bank will be:

$$F^i_{GD}(r) = 1 + \frac{M_{BD}(p_{BD}r - I)}{M_{GD}(p_{GD}r - I)} = \frac{\lambda p(1-p)r - \big(\lambda(1-p) + (1-\lambda)\big)I}{\lambda\varphi p(1-p)r - \big(\lambda\varphi(1-p) + (1-\lambda)(1-\varphi)\big)I},$$

therefore

$$\frac{\partial F^i_{GD}(r)}{\partial \varphi} = \frac{-\Big(\lambda^2(1-p)^2(pr-I)^2 - (1-\lambda)^2 I^2\Big)}{\Big(\lambda\varphi p(1-p)r - \big(\lambda\varphi(1-p) + (1-\lambda)(1-\varphi)\big)I\Big)^2} \leq 0$$

because $r \in [\bar{r}_D, R \wedge \bar{r}_{BD}]$, so that $r > \bar{r}_D$, which implies $pr > \frac{\lambda(1-p)+1-\lambda}{\lambda(1-p)} I$.

For the uninformed bank

$$F^u_D(r) = \varphi F^i_{GD}(r)$$

From the above

$$\begin{aligned}\frac{\partial F^u_{GD}(r)}{\partial \varphi} =& F^i_{GD}(r) + \varphi \frac{\partial F^i_{GD}(r)}{\partial \varphi} \\ =& -\frac{-(1-\lambda)I(\lambda(1-p)(pr-I) + (1-\lambda)I(2\varphi-1))}{\Big(\lambda\varphi p(1-p)r - \big(\lambda\varphi(1-p) + (1-\lambda)(1-\varphi)\big)I\Big)^2} < 0.\end{aligned}$$

Therefore,

$$\frac{\partial F^{min}_{GD}(r)}{\partial \varphi} = \frac{\partial F^i(r)}{\partial \varphi}(1 - F^u(r)) + \frac{\partial F^u(r)}{\partial \varphi}(1 - F^i(r)) \leq 0$$

Similar proofs show that the cumulative distribution functions for the incumbent and outside bank, as well as for the minimal (actually paid) interest rate for all borrower groups are nonincreasing in φ. For expected interest rates, first take the low monitoring case ($\varphi < \bar{\varphi}$). Under information sharing, non-defaulting borrowers get the break-even interest rate $\bar{r}_N = \frac{I}{p}$ from both banks. The rate does not depend on monitoring informativeness φ. In the absence of information sharing, the expected interest rate will always be above $\bar{r} = \frac{I}{\lambda p}$ and thus obviously higher. Both the incumbent and the outside bank bid for N

borrowers on $[\bar{r}, \bar{r}_D]$. The cumulative density function is given by

$$F_N^{\min}(r) = 1 - (1 - F^u(r))(1 - F_N^i(r))$$

where

$$F^u(r) = 1 - \frac{p_N \bar{r} - I}{p_N r - I}$$
$$F_N^i = 1 + \frac{M_D p_D r - I}{M_N p_N r - I}.$$

We have that

$$E(r_N) = \int_{\bar{r}}^{\bar{r}_D} \frac{M_D}{M_N}(p_N \bar{r} - I) \frac{-p_D(p_N r - I) + 2(p_N - p_D)I}{(p_N r - I)^3} \, \mathrm{d}r$$

or equivalently

$$E(r_N) = \bar{r} + \frac{1-\lambda}{\lambda p} I \Big(1 - \frac{1-p}{p} \ln \frac{1}{1-p}\Big),$$

which again does not depend on φ. The expected interest rate is obviously higher in the absence of information sharing.

Using a similar procedure we get the following expected interest rates:

Expected rate	Sharing	No Sharing
Group N	$E(r_N) = \bar{r}_N = \frac{I}{p}$	$E(r_N) = \bar{r} + \frac{1-\lambda}{\lambda p} I \Big(1 - \frac{1-p}{p} \ln \frac{1}{1-p}\Big)$
Group GD	$\bar{r}_D + \frac{2\varphi-1}{\varphi} \frac{1-\lambda}{\lambda p(1-p)} I \Big(1 - \frac{1-\varphi}{\varphi} \ln \frac{1}{1-\varphi}\Big)$	$\bar{r} + \frac{1-\lambda}{\lambda p} I + \frac{2\varphi-1}{\varphi} \frac{1-\lambda}{\lambda p} I \Big(1 - \frac{1-\varphi}{\varphi} \ln \frac{1}{1-\varphi}\Big)$
Group BD	$\bar{r}_D + \frac{1-\lambda}{\lambda p(1-p)} \frac{2\varphi-1}{\varphi} \ln \frac{1}{1-\varphi} I$	$\bar{r} + \frac{1-\lambda}{\lambda p} \ln \frac{1}{1-p} I + \frac{1-\lambda}{\lambda p} \frac{2\varphi-1}{\varphi} \ln \frac{1}{1-\varphi} I$

It is obvious that defaulting borrowers pay higher expected interest rates than successful ones under both regimes. The same is true when comparing bad-signal to good-signal borrowers:

$$E(r_G) = P(N|G)E(r_N) + P(D|G)E(r_{GD})$$
$$E(r_B) = P(N|B)E(r_N) + P(D|B)E(r_{BD})$$

We have $E(r_{BD} > E(r_{GD}$ and $P(D|B) > P(D|G)$ (the hard and the soft signal are positively correlated.)

The expected interest rate paid by GD borrowers is higher under information sharing (since $\bar{r}_D > \bar{r} + I\frac{1-\lambda}{\lambda p}\ln\frac{1}{1-p}$ and $g(\varphi) = \frac{2\varphi-1}{\varphi}\Big(1 - \frac{1-\varphi}{\varphi}\ln\frac{1}{1-\varphi}\Big)$ is increasing in φ; optimal monitoring is higher under information sharing.) The same arguments show that the expected interest rate for BD borrowers is higher under information sharing.

Similarly, it can be shown that the interest rate for defaulting borrowers is higher under information sharing.

$$\begin{aligned}
E(r_D) &= P(GD|D)E(r_{GD}) + P(BD|D)E(r_{BD}) \\
E(r_{D,\text{no sharing}}) &= \bar{r} + I\frac{1-\lambda}{\lambda p}\ln\frac{1}{1-p} + I\frac{1-\lambda}{\lambda p}\frac{2\varphi-1}{\varphi}\frac{1}{\lambda(1-p)+1-\lambda} \\
&\quad \times \Big[\lambda(1-p)\varphi + (1-\lambda)(1-\varphi) + (1-\lambda)\frac{2\varphi-1}{\varphi}\ln\frac{1}{1-\varphi}\Big] \\
E(r_{D,\text{sharing}}) &= \bar{r}_D + I\frac{1-\lambda}{\lambda}\frac{1}{p(1-p)}\frac{2\varphi-1}{\varphi}\Big[\lambda(1-p)\varphi + (1-\lambda)(1-\varphi) \\
&\quad + \frac{2\varphi-1}{\varphi}(1-\lambda)\ln\frac{1}{1-\varphi}\Big].
\end{aligned}$$

We have again $\bar{r}_D > \bar{r} + I\frac{1-\lambda}{\lambda p}\ln\frac{1}{1-p}$ and $h(\varphi) = \lambda(1-p)\varphi + (1-\lambda)(1-\varphi) + \frac{2\varphi-1}{\varphi}(1-\lambda)\ln\frac{1}{1-\varphi}$ is increasing in φ.

Proof of Proposition 4.2

When monitoring is high (BD borrowers are not creditworthy), welfare could increase as a result of monitoring, if the losses avoided when BD borrowers do not get a loan exceed monitoring costs.

$$\text{Welfare} = \lambda(pR - I) - (1-\lambda)I - M_{BD}(p_{BD}R - I)(1 - F_u(R)) - c(\varphi - \frac{1}{2})^2$$

Under information sharing, we have that

$$M_{BD}(p_{BD}R - I) = \lambda(1-p)(1-\varphi)(pR - I) - (1-\lambda)\varphi I$$
$$1 - F_u(R) = \frac{p_{GD}\bar{r}_D - I}{p_{GD}R - I} = \frac{I(1-\lambda)(2\varphi-1)}{\lambda(1-p)\varphi(pR-I) - (1-\lambda)(1-\varphi)I}$$

Monitoring is welfare-enhancing if $c < \frac{2}{3}I(1-\lambda)\frac{\lambda(1-p)(pR-I)+(1-\lambda)I}{\lambda(1-p)(pR-I)-(1-\lambda)I}$.

Without information sharing we have:

$$M_{BD}(p_{BD}R - I) = \lambda(1-p)(1-\varphi)(pR - I) - (1-\lambda)\varphi I$$
$$1 - F_u(R) = (1-p)\frac{p_{GD}\bar{r}_D - I}{p_{GD}R - I} = (1-p)\frac{I(1-\lambda)(2\varphi-1)}{\lambda(1-p)\varphi(pR-I) - (1-\lambda)(1-\varphi)I}$$

Monitoring increases welfare if $c < \frac{2}{3}I(1-\lambda)(1-p)\frac{\lambda(1-p)(pR-I)+(1-\lambda)I}{\lambda(1-p)(pR-I)-(1-\lambda)I}$. (We have a stricter condition compared to the information sharing regime).

Welfare is higher under information sharing.

$$\frac{\lambda(1-p)(\varphi^{IS}-1)(pR-I)+(1-\lambda)\varphi^{IS}I}{\lambda(1-p)\varphi^{IS}(pR-I)+(1-\lambda)(1-\varphi^{IS})I}I(1-\lambda)(2\varphi^{IS}-1)-c(\varphi^{IS}-\frac{1}{2})^2>$$
$$>\frac{\lambda(1-p)(\varphi^{NS}-1)(pR-I)+(1-\lambda)\varphi^{NS}I}{\lambda(1-p)\varphi^{NS}(pR-I)+(1-\lambda)(1-\varphi^{NS})I}I(1-\lambda)(1-p)(2\varphi^{NS}-1)-c(\varphi^{NS}-\frac{1}{2})^2$$
$$2\frac{\lambda(1-p)(\varphi^{IS}-1)(pR-I)+(1-\lambda)\varphi^{IS}I}{\lambda(1-p)\varphi^{IS}(pR-I)+(1-\lambda)(1-\varphi^{IS})I}-1>\Big(\frac{\lambda(1-p)(\varphi^{NS}-1)(pR-I)+(1-\lambda)\varphi^{NS}I}{\lambda(1-p)\varphi^{NS}(pR-I)+(1-\lambda)(1-\varphi^{NS})I}-1\Big)(1$$

This is true since $\frac{\lambda(1-p)(\varphi-1)(pR-I)+(1-\lambda)\varphi I}{\lambda(1-p)\varphi(pR-I)+(1-\lambda)(1-\varphi)I}$ is increasing in φ.