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Competition and Information Sharing Among Lenders: Grameen II

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Abstract

In this paper we show how in a paradigm of asymmetric information, sharing of information among the lenders about their borrower types in a credit market with constant borrower pool become inessential. However, such information sharing can turn out to be profitable, to lenders and borrowers alike, in a dynamic framework with growing population. We also construct a repeated game in information exchange where the lenders share information about borrowers' default and show that if they are sufficiently patient then there is an SPNE of the game where truthful revelation of information takes place. The result suggests that collusion among the lenders, via sharing of information about their defaulting borrowers, benefit them through increased profit. Finally, we show how heterogeneity among the borrower group reduces the interest rate faced by the disciplined (safe) ones.

JEL classification: *G21; D83; D41*
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1. Introduction

One of the major problems with competition among lenders when formal institutions do not exist, or are incapable of efficiently enforcing credit contracts, is that the incentive for strategic default by borrowers is higher than if there is a single lender. For this reason, information sharing arrangements, are sometimes statutorily enforced or built-up by lenders among themselves, or in many cases offered as a service by external private parties [Grief (1993); Malegam Committee Report (2012); Milgrom, North and Weingast (1990)].

In what follows, we have used the framework of the Grameen II (2000) model of individual lending where group members are not jointly responsible for each other's loan repayment. This emerged to replace the joint-liability Grameen I model as competition intensified among the lenders in these markets. The existing literature suggests that increased competition among the MFIs (Microfinance Institutions) lead to the problem of *double-dipping* (multiple loans)[1] by the borrowers which automatically reduces their repayment rate. The MFIs in turn react by increasing the interest rate to cover their costs of lending which further aggravates the problem of default. To address this problem, the practitioners of microfinance and the policy makers came up with certain relief tools such as market sharing according to geographical[2] as well as demographical characteristics[3], dynamic incentive mechanisms[4], etc. Strikingly, the most prominent among these is that of information sharing among the lenders through the formation of information sharing bureaus; a concept strongly advocated by Stiglitz (2000)[5] as a remedy tool in any paradigm of asymmetric information. Efficacy of credit bureaus in tackling the problem of default by the borrowers in markets asymmetric information is also established by Pagano and Jappelli (1993). They showed that, in demographics characterized by high degree of mobility and improved technology, the availability of these bureaus can actually benefit the lenders as is found in UK, US, Japan etc[6]. However, the benefits of these credit bureaus are nullified by the threat of the potential entrants in the credit market which make the bureaus unstable.

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[1]Vogelgesang (2001) showed in his empirical analysis that increased competition in the credit market leads to multiple borrowings, which automatically increases the default rate of the borrowers.
[2]McIntosh, Janvry, and Sadoulet (2005) in a survey done in Uganda, found how increased competition leads to the polarization of lenders spatially according to their types.
[3]Andersen and Moller (2006) supported the coexistence of both formal and informal lenders catering to different clienteles with differential lending contracts with respect to collateral requirements and interest rates. Navajas et al. (2003) have found the same result in Bolivian microcredit market.
[4]For further reading see Besley and Coate (1995), Morduch (1999a), and Tedeschi (2006).
[5]Stiglitz (2000) explained how perfect and complete information in the market can be a Pareto superior outcome over asymmetric information.
[6]See Jappelli and Pagano (2002).

The entire benefit of information sharing by the lenders about the borrowers can be ascribed to the *reputation effect* that it imparts[7]. A borrower with a healthy credit history has high-valued reputation in the credit market. Again, in a duopolistic market, the lenders sharing information about their borrower types always benefit through increase in the surplus generated by them [Malueg and Tsutsui (1996); Vives (1990)]. However, the time length of the information shared by the lenders can have a negative impact on this reputation effect. According to Vercammen (1995), too out-dated credit history of any borrower can increase his incentive to take up risky project that might reduce the welfare of the lenders through reduction in reputation effect. A similar indication has been found in the works of Padilla and Pagano (1997, 2000) where informational monopoly of the banks has a reverse impact on the reputational threat on the safe type borrowers whereby they are reluctant to put optimal effort level, thus reducing the project return. Hence, it is said that sharing partial *black* (past defaults) information about the borrowers is better than signaling the entire credit history i.e. *black and white* (current debt exposure, performance and riskiness) information about them. Also one-shot lending contracts (single period) necessitates information sharing contracts among the lenders, the urge of which becomes feeble with multi-period lending involving relationship banking [Brown and Zehnder (2005)].

In this paper, we introduce competition among lenders and analyze its impacts on individual profits. The essential game is Bertrand in a dynamic framework where players maximize expected lifetime profits and do not face any capacity constraints on their ability to lend. For simplicity, we assume that lenders have a zero cost of lending and changing this does not qualitatively affect our results if the per unit cost of lending is constant.

We begin by isolating the core issue which is the problem of adverse selection that a lender faces when a borrower to whom he has not lent before approaches him for a loan. From the lender's point of view, exact identification is critical for profit maximization because a borrower who does not have a bad credit record with either lender has a higher bargaining power than one who has migrated from the other lender after defaulting on his loan with the latter. The lender who is approached for the loan can charge a monopoly interest rate to the borrower if he has a default history and a lower one to those without one. Misidentification can then lead to a loss of profits. In our simple world, where lenders operate with a single instrument, the rate of interest, offering a menu of contracts of interest rate and loan size combinations to allow self-selection is ruled out. Pagano and Jappelli (1993, 2000) explore the role of information sharing bureaus among the microfinance lenders. In particular, Padilla and Pagano (1997) consider a model where the population of borrowers does not

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[7]Greif (1993) shows that merchant laws and endogenous information sharing through the formation of overseas trading groups, helps the merchants to control their overseas trade relations.

change over time. In Section 2, we show that in such a world, there is no role for such an institution as lenders can clearly distinguish between borrowers who have a default history from those who do not, using a simple mechanism to dissuade strategic default in equilibrium. Once this has been ruled out, along the equilibrium path, the only new borrowers after the first period will be the ones who have defaulted out of compulsion because of bad state of nature that lowered their revenues to the point where repayment was not possible. We call this non-strategic default. In a world without debt renegotiation, such borrowers will be barred from getting new loans by their original lender. In case a borrower has defaulted on loans from both the lenders he has to leave the market. Extension to more than two lenders, as long as this number is finite, does not alter the story qualitatively.

The problem of adverse selection becomes more complex for a lender when we allow fresh borrowers to enter the market in each period. In such as case, a lender is unable to use the mechanism introduced in Section 2 to eliminate the agency problem because it is no longer possible to isolate the fresh borrowers from the non-strategic defaulters[8]. It is in this world that information sharing has a critical role. In particular, we show that truthful information sharing among lenders can completely eliminate the adverse selection problem and, hence, lead to an interest rate combination that is identical to that in the previous section. This is done in Sections 3 and 4. In Section 5, we ask the question: What incentive does a lender have to pass on correct information? We construct an infinitely repeated information exchange game, where we show that if the lenders are sufficiently patient then, truthful revelation of information can be supported in a Sub-game Perfect Nash Equilibrium of this game. What these result tells us is that in markets where lenders are in for the long run, tacit collusion to push up interest rates and sustain them is possible through an apparently innocuous device to protect lender’s interests in the face of informational asymmetries about borrower types. This, we believe, is also a critique of governmental efforts to introduce statutory institutions for information sharing, if such institutions are not accompanied by effective regulation of the interest rates charged by the lenders. In Section 6, we summarize the results.

2. The Basic Model without Entry of New Borrowers (Static Borrower Pool)

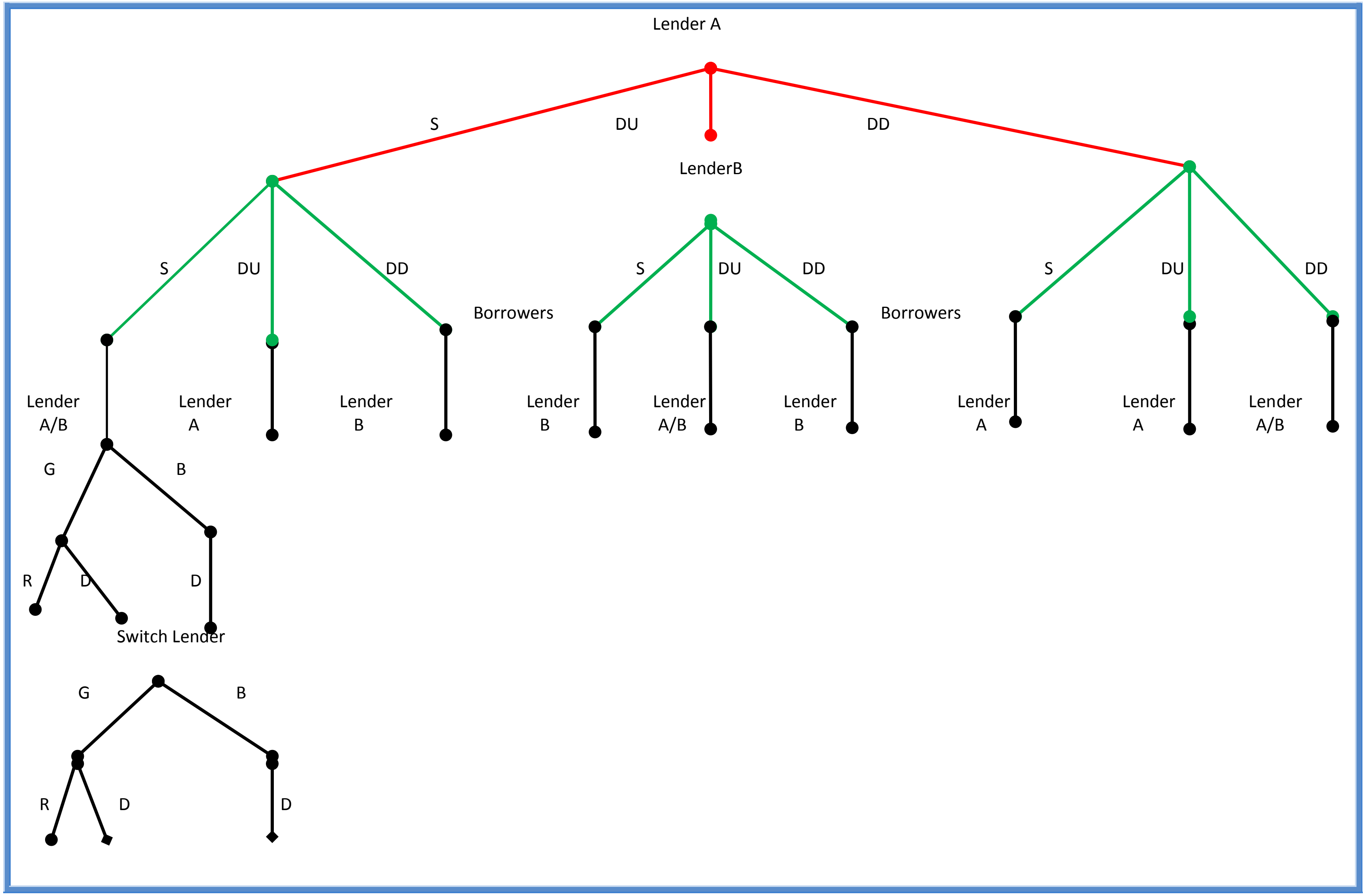
The basic framework of a competitive model is that here we have two identical lenders (lender A and lender B) operating in the same market whom the borrowers can borrow from. Each lender (principal) lends L unit of capital to a borrower (agent) for which, he charges an interest rate r. The borrower then invests this capital in some project and realizes a return Y with probability p, and 0 otherwise, with $0 \le p \le 1$. $(1-p)$ can thus be denoted as the

[8]We assume throughout in this paper that arbitrage in the credit market is not possible or profitable.

probability of facing a shock. However, after the output is realized, the borrower then decides whether to pay back the loan or not. Hence, we incorporate the possibility of strategic default, where the borrower decides expost whether to deafult in a good state. The specific feature of the model is that a borrower can default voluntarily, only if a good state occurs; in a bad state the borrower will automatically default (non-strategic). That is, a borrower can choose between repayment of the loan and strategic default only if a good state occurs. Thus, a decision to repay or strategically default on the part of a borrower in any period implies that a good state has occurred in that period.

Any borrower can default on his loan from a lender and reapply for credit from the second one. We assume that the lenders do not have any information sharing arrangements between themselves. Hence, neither of the lenders can ever know the credit history of any of the borrowers unless once cheated by that borrower, or if the borrower has a clean credit history with him. It follows that a borrower can cheat each lender only once after which, his history will be known to both the lenders. Thus, a borrower will be able to default atmost twice in this framework, once for each lender. However, in any particular period, the borrower can get access to credit from a particular lender, only if he has no default history, strategic or otherwise, with that lender. Similarly, when charging the equilibrium interest rate, a lender has to decide whether to charge the same (S) as the other lender, or deviate upwards (DU) or downwards (DD). For the borrowers, the decision to repay and default are denoted by R and D respectively. The good, or adverse state of nature are denoted by G, and B respectively. We depict this in the following time line diagram in Figure 1.

Figure 1: Decision tree of infinitely repeated lending game with two competing lender



As is given in Figure 1, for any identical borrower the decision follows from each branch of lender's strategy combinations. Let us look at the game tree from the borrower's point of view once he has startegically defaulted on his loan with the first lender and borrows from the second one. Given a constant population and no information sharing arrangement between the lenders, it is common knowledge to both the lenders that along the equilibrium path, from the second period onward, any new borrower whom the lender has not lent to before has already defaulted (strategic or involuntary) his original lender in the preceding period. Hence, the second lender is a monopolist since, this borrower can only borrow from the second lender from here on. From the deliquent borrower's point of view, the repayment condition to the second lender is given by the following.

Any borrower will repay his loan in the second period of borrowing if and only if, expected payoff from repayment $\geq$ payoff from cheating, i.e.[9],

$$Y \leq \left[Y - L(1+r)\right] + \delta_B p \ \left[Y - L(1+r)\right] + {\delta_B}^2 p^2 \left[Y - L(1+r)\right] + \ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

or, $$r \ \leq \frac{Y}{L} p\delta_B - 1 \qquad (1)$$

where, $0 < \delta_B < 1$ is the discount factor of the borrower.

Lemma 1: The highest rate of interest that can be charged by the second lender to avoid default in a good state is, $r_M = \frac{Y}{L} p\delta_B - 1$. (2)

Proof: Follows trivially from equation (1).

Given equation (1), it is always in the best interest of the borrowers not to default strategically if their first lender charge them any interest rate less than $r_M = \frac{Y}{L} p\delta_B - 1$. As long as the interest rate faced by the non-delinquent borrowers are less than r_M , the borrowers will not default strategically. However, it is to figure out whether it be in the best interest of the lenders to charge an interest rate less than r_M to those borrowers who maintain a good credit history? To answer this question let us consider the following situation where both the lenders charge the same interest rate to all the borrowers in all the period throughout the entire life of lending.

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[9]For non-negative value of the interest rate r_M , we need the additional condition that $\delta_B pY \geq L$.

Proposition 1: With competing lenders in a constant population model, the maximum interest rate that the lenders can charge in order to ensure no strategic default is $r_{ND} = \frac{\delta_B{}^2 pY}{L} - 1 < \frac{\delta_B pY}{L} - 1 = r_M$.

Proof: Consider a borrower who has borrowed from lender A and has no credit history with lender B. In a good state, the borrower will strategically default in any period, if the present value of expected lifetime gain from defaulting on his loan and borrowing from lender B at the monopoly rate of interest from the next period onwards exceeds the gain from not defaulting on his current period loan, i.e.[10],

$$[Y - L(1+r)] + \delta_B [p\{Y - L(1+r)\} + (1-p)\{0 + \delta_B pA\}] + \delta_B{}^2 p[p\{Y - L(1+r)\} + (1-p)\{0 + \delta_B pA\}].... \geq Y + \delta_B pA$$

where, $A = [Y - L(1+r_M)] + \delta_B p[Y - L(1+r_M)] + ... = \frac{[Y - L(1+r_M)]}{(1-\delta_B p)} = \frac{Y(1-\delta_B p)}{(1-\delta_B p)} = Y$

which on algebraic manipulation yields,

$$\Rightarrow \delta_B{}^2 pY \geq L(1+r)$$

Hence, solving for r we get,

$$r \leq \frac{\delta_B{}^2 pY}{L} - 1 \tag{3}$$

It follows that the maximum rate of interest that a borrower who has no default history with either lender will be willing to pay is[11],

$$r_{ND} = \frac{\delta_B{}^2 pY}{L} - 1 < \frac{\delta_B pY}{L} - 1 = r_M . \tag{4}$$

The inequality in equation (4) implies that all borrowers will default on their loan to the first lender from whom they borrow, and hence, no one would be willing to lend as the first lender for a borrower as long as $r > \frac{\delta_B{}^2 pY}{L} - 1$. It is thus impossible to sustain the market for any positive

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[10]For derivation of equation (3) see Appendix A1.

[11]To guarantee non-negative value of the interest rate $r_{ND} = \frac{\delta_B{}^2 pY}{L} - 1$, we need the additional condition that $\delta_B{}^2 pY \geq L$. For the derivation of the non-negativity condition see Appendix A2.

value of interest rate $r > r_{ND} = \frac{\delta_B{}^2 pY}{L} - 1$. Given $r_{ND} = \frac{\delta_B{}^2 pY}{L} - 1 < \frac{\delta_B pY}{L} - 1 = r_M$, it can be said that with two competing lenders without any information sharing contract between themselves, borrowers will always choose to default strategically in their first period of borrowing if they are not offered a lower interest rate in their first period of borrowing and as long as they do not default this interest rate will prevail. We summarize this in Corollary 1.

Corollary 1: In an infinitely repeated credit market game characterised by Bertrand competition, a borrower will repay his loan, in a good state, if and only if he is offered a discounted interest rate relative to that charged to a delinquent borrower, i.e., $r_{ND} < r_M$.

Formally, we need to look for the unique Sub-game Perfect Nash Equilibrium of the infinitely repeated lending game. In this SPNE, the interest rate combination will be such that it is in the best interest of each of the lenders to stick to their optimal strategy given that they believe that their competitor will do so and such beliefs must be credible. In order to do so let us consider a strategy combination for the two lenders.

Consider the strategy combination $s^* = (s_A^*, s_B^*)$, where

$s_i^* \equiv$ *(In period zero charge* $r_{ND} = \frac{\delta_B{}^2 pY}{L} - 1$. *For any* $t > 0$ *, charge* $r_{ND} = \frac{\delta_B{}^2 pY}{L} - 1$ *if the borrower has not defaulted in period* $(t-1)$, *and do not lend to the borrower otherwise; charge* $r_M = \frac{Y}{L} p\delta_B - 1$, *to any borrower who has not borrowed from him at* $t = 0$*; if at* $(t-1)$, $(r_i^*, r_j^*) \neq (r_{ND}, r_{ND})$, *then charge* r^* *to all the borrowers forever), where* $i.j = A, B$, *and* r^* *is the break-even interest rate.*

The strategy requires each lender to charge an interest rate r_{ND} to all the borrowers without any history of default with him, charge a monopoly rate r_M to those borrowers whom he has not lent to at $t = 0$ period, since all such borrowers will have come to him because the borrowers have defaulted on their loans to the other lender, and in any period $t > 0$ charge the break-even interest rate r^* to all the borrowers if either of the lenders has deviated from the optimal interest rate r_{ND} in $(t-1)$.

Proposition 2: The strategy profile $s^* = (s_A^*, s_B^*)$ ***is a Nash equilibrium for the infinitely repeated game if and only if*** $r_{ND} \geq \dfrac{\delta(1-p)\{1-p(1+r_M)\}+(1-\delta p)}{p(1-\delta p)} - 1$***, where*** $0 < \delta < 1$ ***is the discount factor of the lender.***

Proof: We wish to check if this strategy profile is a Nash Equilibrium profile, i.e., if strategy profile is mutually consistent. Consider any period where lender A has to select an interest rate. His strategy says that he should charge r_{ND} to all borrowers who have not defaulted on loans made by him and there has been no deviation by either lender in the previous period. The question is, is it in his best interest to do so if he believes that his partner will stick to his strategy? Suppose lender A deviates from r_{ND} in period t. Then both lenders will cut down their interest rate from the next period onwards and charge the break-even interest rate r^*. This means that the present value of the lifetime expected profits of the deviator is 0. If he does not deviate then his present value of the expected lifetime profit is $\dfrac{1}{2}L[\dfrac{\{p(1+r_{ND})-1\}}{(1-\delta p)} + \delta(1-p)\dfrac{\{p(1+r_M)-1\}}{(1-\delta p)^2}]$.

Comparing these, deviation pays if and only if[12] $r_{ND} \geq \dfrac{\delta(1-p)\{1-p(1+r_M)\}+(1-\delta p)}{p(1-\delta p)} - 1$ [13].

Also, deviation from r_M does not pay ever. Since, an upward deviation will lead to negative profits on loans to borrowers who have no other option as such borrowers will always strategically default for interest rates above r_M and a deviation below will reduce profits.

We next check for Sub-game Perfection. However, before we proceed with it, it is worthy to check what will be the optimal reaction of the borrowers when either of the lenders is deviating from his equilibrium strategy by charging an interest rate $r_{ND} - \varepsilon$, where $\varepsilon > 0$. The borrowers decides whom to take the loan from after the lenders have declared there interest rates. However, the declaration of the interest rate for any period t is done at the end of period $(t-1)$ before the borrowers have repaid their loan for the previous period, i.e., $(t-1)$. In this case we want to check whether a borrower will repay his loan to the lender whom he has borrowed from in period

[12]For the derivation see Appendix A3.

[13] Notice if $p > \delta_B$, then the right hand side of the SPNE condition $r_{ND} \geq \dfrac{\delta(1-p)\{1-p(1+r_M)\}+(1-\delta p)}{p(1-\delta p)} - 1$ becomes negative. In this case for any δ the SPNE condition will be satisfied.

$(t-1)$ and reapply for fresh credit at reduced interest rate $r = r_{ND} - \varepsilon$, or stategically default on his loan in period $(t-1)$ and apply for fresh credit in period t. To check this we need to compare the present value of the lifetime expected payoff of a borrower by either strategically defaulting the lender in period $(t-1)$ and then switching lender or repaying the previous credit of period $(t-1)$ and then reapplying for fresh credit in period t. Strategic default is a better outcome if,

$$\left[Y - L(1+r_{ND})\right] + \delta_B[\,p\{Y - L(1+r)\} + (1-p)\{0 + \delta_B pA\}]$$

$$+\delta_B{}^2 p[\,p\{Y - L(1+r)\} + (1-p)\{0 + \delta_B pA\}]\ldots. < Y + \delta_B p\left[Y - L(1+r)\right] + \ldots\ldots..$$

where, $A = \left[Y - L(1+r_M)\right] + \delta_B p\left[Y - L(1+r_M)\right] + \ldots. = \dfrac{\left[Y - L(1+r_M)\right]}{(1-\delta_B p)} = \dfrac{Y(1-\delta_B p)}{(1-\delta_B p)} = Y$

which on algebraic manipulation yields[14],

$$\Rightarrow \delta_B < 1 \tag{5}$$

Since, equation (5) is always true hence, a borrower will never repay his loan to the first lender before applying for fresh credit from the second one at a lower interest rate $r = r_{ND} - \varepsilon$.

Lemma 2: A borrower always strategically defaults on his loan to the first lender if the second lender offers credit at any rate $r^* \le r = r_{ND} - \varepsilon$***, where*** $\varepsilon > 0$.

Proof: Follows from equation (5) and Appendix A4.

Proposition 3: The strategy profile $s^* = (s_A^*, s_B^*)$ ***is a Sub-game Perfect Nash equilibrium for the infinitely repeated lending game, if and only if*** $r_{ND} \ge r^*$.

Proof: From Proposition 2, the strategy profile is a Nash Equilibrium for the game. To show that the strategy profile is also an SPNE we need to prove that any off-equilibrium deviation by either of the lenders will not be optimal for the deviating lender. Now for any lender sticking to the strategy profile is optimal if he expects that the other lender will actually stick to his strategy after this deviation, i.e., for any $\varepsilon > 0$ if lender A charges an interest rate $r_{ND} - \varepsilon$, then from next period onwards lender B will actually cut down his interest rate to r^*. Suppose that lender A deviates in period (t-1). Both lenders in the off-equilibrium path Sub-game are required,

[14]For algebraic derivation see Appendix A4.

by the strategy, to charge r^* in period t. For lender B charging the any interest rate r with $r_{ND} \geq r > r^*$ in any period t if lender A charges r^* , will lead to a loss of all his borrowers (apart from those who have non-strategically lender A in earlier periods) to lender A and will thus earn no profits from lending to borrowers without default history. However, if lender B sticks to his strategy of charging r^* to all the borrowers in this off-equilibrium path Sub-game (other than those over whom he has a monopoly control) then, given that lender A sticks to his strategy of charging r^* in period t, lender B does not lose any borrowers to lender A and still earn zero profits from lending to borrowers over whom he has no monopoly control as all his free borrowers have already defaulted in period (t-1) and moved to lender A [Lemma 2]. We notice that in this case also lender B gets to cater only those who have non-strategically defaulted lender A in some period. Hence, lender B is indifferent between sticking to his strategy and charging interest rate to r^* and deviating to an interest rate r, $r_{ND} \geq r > r^*$. Thus, lender B's threat to reduce interest rate to r^* is credible for lender A.

3. The Basic Model with Entry of New Borrowers

From Propositions 2 and 3 in Section 2 we noticed that two competing lenders charging an interest rate r_{ND} to borrowers with no history of default with either of the lenders, can avoid stratgic default [equation (4)] by the borrowers and this interest rate combination is also the SPNE of strategy profiles. However, in each period a fraction of the borrowers will always default because of adverse shock of nature. In the next period these borrowers will switch to the other lender for fresh credit as long as they have not defaulted on their loan from that lender earlier. Hence, even after taking appropriate steps to control strategic default, the lenders cannot cope with non-strategic default, which is unavoidable. In equilibrium, the only borrowers who switch lenders are the ones who have defaulted because they faced a bad state of nature in the last period. This means that a lender facing a new borrower, in a world where there are no new entrants in the market, will know that the borrower has defaulted on his loan to the other lender in the preceding period. This inference is possible in equilibrium because strategic default has been prevented by the choice of the interest rate r_{ND} by the two lenders.

Things however, are not the same once we introduce a credit market with growing population, i.e., where fresh borrowers enter the market every period. In this case, a lender from whom a new borrower applies for credit is unable to distinguish between a fresh entrant in the market and a borrower who has defaulted on his loan to the other lender in the immediately preceding period. This means that the lender does not know whether to charge this borrower the interest rate r_{ND} or the interest rate r_M . A lender, in this case, cannot charge a new borrower he faces in period $t > 0$ a monopoly interest rate. Assuming a fresh borrower to be a non-strategic defaulter of the preceding period can lead to default, if any fresh entrant borrower, from second period onwards, without any default history with either of the lenders, is charged a monopoly interest rate $r_M = \frac{\delta_B pY}{L} - 1 > r_{ND} = \frac{\delta_B{}^2 pY}{L} - 1$, then he will surely default on his loan with the first lender strategically [Proposition 1]. On the other hand, charging the interest rate r_{ND} to avoid strategic default from any new borrower that he faces in period $t > 0$ leads to the loss of the opportunity to earn a monopoly rent from the preceding period's non-strategic defaulters, that the lender could have earned by charging them the monopoly interest rate. This is the problem of adverse selction that allowing new borrowers to enter the market creates in the model. Thus, unlike the constant population model, where the problem of adverse selection can be resolved once the lender addresses the problem of strategic default, in a growing population model, such a mechanism will not be adequate.

We incoporate a growing population in this lending game, by assuming that in each period the population grows by a constant proportion of k of the borrower population in the immediately preceding period. Thus, if the initial continuum of borrowers is assumed to be 1, then in the second period the number of new entrants is k , in the third period $k(1+k)$. From the fourth period, the pattern changes since, there will be some non-strategic defaulters in the first two periods (i.e., $t = 0$ and $t = 1$) who will drop out of the market in the third period $(t = 2)$. Hence, the total borrower population in the third period (i.e., $t = 2$) is $[(1+k)^2 - (1-p)^2]$. Given that identification of borrowers according to their history of default cannot be done without implemending the strategic default constraint, given in equation (3), on borrowers, a way out could be the introduction of a mechanism of information sharing about the borrowers' credit history among the lenders. The lenders can share the information about their defaulters among themselves and help in the seggregation of these old borrowers from the new entrants in the market. This will in turn help the lender to charge the appropriate interest rate to each borrower type and earn higher profits. Clearly, if the mechanism also prevents strategic default in equlibrium, the only defaulters will be the ones who have faced a bad state in the preceding period. As in section 2, Proposition 1, with information sharing about default, it does not pay a borrower who has faced a good state in any period to strategically default and switch to the other lender who will now charge him the monopoly interest rate r_M. Further, as is shown in Lemma 2, it does not pay the borrower who has faced a good state in some period to switch lenders *without defaulting* on his current loan as both lenders will charge him the same interest rate r_{ND} since he has no default history. Thus, the information sharing mechanism also helps to resolve the problem of strategic default in the model with growing population.

4. Model with Information Sharing

Suppose that both the lenders enter into an information sharing agreement between themselves to share information about their delinquent borrowers. In this way, both the lenders can help each other to distinguish a new entrant in the market from second period $(t=1)$ onwards. A borrower who has defaulted on his loan from one lender in the first period of borrowing and migrates to the other lender for fresh credit in the following period, can now be identified as a defaulter by the second lender. Once identified as a defaulter, the second lender will act as a monopolist and charge the monopoly interest rate $r_M = \frac{\delta_B pY}{L} - 1$ [15].

Given this framework, let us consider the following credit contract that both the lenders may offer the borrowers. Charge an interest rate $r_A = r_B = r_{ND}$ to all borrowers $t=0$: at any $t>0$ charge $r_A = r_B = r_{ND}$ to all borrowers without a known default history with either lender, and r_M to the delinquent migrants. If in any period t, a lender's competitor deviates from his strategy, then charge interest rate $\tilde{r}$, where $\tilde{r}$ is the interest rate at which the lender breaks even over his lifetime, to borrowers without a known default history, for everafter.

With $r_A = r_B = r_{ND}$, the structure of market sharing between the lenders is as follows. In this case, since both the lenders charge the same interest rate, the borrowers are indifferent between the lenders while applying for credit. We assume that both the lenders get a equal share of the population of borrowers to lend to. Now in the first period of lending, the total population is 1, so both the lenders get to address $\frac{1}{2}$ of the borrowers. Hence, the net payoff for each of the lenders in the first period is,

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[15]Besley and Coate (1995), Morduch (1999a), and Tedeschi (2006) show how dynamic incentive schemes can be used as collateral substitutes in presence of adverse selection to discipline borrowers and reduce their probability of strategic default. Theses literature suggest that maintenance of a good credit history, if rewarded with lower interest rates, or higher credit, in subsequent periods generates incentives for contract compliance in good states of nature. In our case, the incentive is replicated by the higher interest rate in case of strategic default and shift to a new lender.

$$-\frac{1}{2}L + p\frac{1}{2}L(1+r_{ND}) \tag{6}$$

In the second period of lending, the total population is $(1+k)$. Hence, the total number of new entrants in the market are k out of which each lender gets $\frac{k}{2}$. As $(1-p)\frac{1}{2}$ of the borrowers have defaulted because of a bad state of nature, each lender gets $p\frac{1}{2}$ of the first period borrowers who are now old borrowers for him and whose credit history is known to the lender. He charges them the rate of interest r_{ND}. Since, these borrowers have not defaulted, they will continue to be with the first lender in this period and repay their loan in a good state. As with the new applicants approaching each lender, there are now $(1-p)\frac{1}{2}$ defaulters who have involuntary defaulted with the other lender in the preceding period. The number of fresh entrants into the market who approach our lender is $\frac{k}{2}$. Given the information sharing arrangement between the lenders about the default history of the borrowers, each of the lenders can segregate the fresh entrants from the defaulting migrants. However, among them, the migrants who have already defaulted with their first period lender will not get access to either of the credit windows subsequently if they default in this period also. Hence, the migrants, who have involuntarily defaulted on their credit in the earlier period, will repay their loan in a good state as long as the interst rate is r_M even though this is higher than r_{ND} , which is the highest interest rate that can be charged to a borrower who has not defaulted with either lender in any of the earlier periods to ensure he does not default strategically. Thus, the net expected payoff of each of the lenders in the second period stands at,

$$-[p\frac{1}{2}+(1-p)\frac{1}{2}+\frac{k}{2}]L + p^2\frac{1}{2}L(1+r_{ND}) + p\frac{k}{2}L(1+r_{ND}) + p(1-p)\frac{1}{2}L(1+r_M) \tag{7}$$

Proceeding this way the present value of the expected lifetime net profit of the lenders is[16],

$$\frac{L}{2}[p(1+r_{ND})-1][1+\delta(p+k)+\delta^2\{p^2+pk+k(1+k)\}+\delta^3\{p^3+p^2k+pk(1+k)+k(1+k)^2\}+.......]$$

$$\frac{L}{2}(1-p)\delta[p(1+r_M)-1][1+\delta(2p+k)+\delta^2\{3p^2+2pk+k(1+k)\}$$

$$+\delta^3\{4p^3+3p^2k+2pk(1+k)+k(1+k)^2\}+.......]$$

[16] Notice that r_M and r_{ND} are the same as in Section 2.

which on algebraic manipulation yields[17],

$$\frac{L}{2}\left[\frac{1-\delta}{(1-\delta p)^2\{1-\delta(1+k)\}}\right][(1-\delta p)\{p(1+r_{ND})-1\}+\delta(1-p)\{p(1+r_M)-1\}] \tag{8}$$

We prove next that the strategy profile where each lender's strategy is the one described above, constitutes an SPNE of the game. Define the strategy profile $s^* = (s_A^*, s_B^*)$, with

$s_i^* \equiv$ *{In period zero charge* $r_{ND} = \frac{\delta_B{}^2 pY}{L} - 1$*. For any* $t > 0$ *, charge* $r_{ND} = \frac{\delta_B{}^2 pY}{L} - 1$ *if the borrower has not defaulted on a loan from him in period* $(t-1)$*, and do not lend to the borrower otherwise; charge* $r_M = \frac{Y}{L} p\delta_B - 1$*, to any borrower who has not borrowed from him at* $t = 0$*; if at* $(t-1)$*,* $(r_i^*, r_j^*) \neq (r_{ND}, r_{ND})$*, then charge* $\tilde{r}$ *to all the borrowers forever}, where* $i.j = A, B$*, and* $\tilde{r}$ *is the interest rate at which the present value of the lifetime expected profits with a growing population of borrowers is zero.*

Proposition 4: The strategy profile $s^* = (s_A^*, s_B^*)$ ***is an SPNE of infinitely repeated lending game with a growing population of borrowers if and only if*** $r_{ND} \geq \frac{\delta(1-p)\{1-p(1+r_M)\}+(1-\delta p)}{p(1-\delta p)} - 1$**.**

Proof: In order to prove the above proposition, we first show that the strategy profile s^* is a Nash Equilibrium and then analyze the off-equilibrium paths to prove for the SPNE.

1. We first prove that s^* is a Nash Equilibrium.

Suppose lender A deviates from s^* in period t while lender B sticks to s^*.

(i) Deviation upwards by charging an interest rate above $r_{ND} = \frac{\delta_B{}^2 pY}{L} - 1$, to borrowers without a default record will lead to a migration of all the borrowers who have no default history to the other lender and a consequent loss in profit for lender A.

(ii) Reduction of the interest rate charged to borrowers with no default history by a $\varepsilon > 0$, will attract all borrowers with no default history in the market to lender A. If ε, is sufficiently small then lender A will approximately double his interest earnings from lending to such borrowers in the current period. From the next period onward both lenders will charge $\tilde{r}$ and so lender A will

[17]See Appendix A5 for algebraic derivation of present value of expected lifetime profit.

earn a zero present value of lifetime expected profit staring at period $(t+1)$. If he had not deviated, his present value of expected lifetime profit would be $\frac{L}{2}[\frac{1-\delta}{(1-\delta p)^2\{1-\delta(1+k)\}}][(1-\delta p)\{p(1+r_{ND})-1\}+\delta(1-p)\{p(1+r_M)-1\}]$ which on comparison with the break-even zero profit yeilds that unilateral deviation from $r_{ND}=\frac{\delta_B{}^2 pY}{L}-1$ does not pay if, $r_{ND}\geq\frac{\delta(1-p)\{1-p(1+r_M)\}+(1-\delta p)}{p(1-\delta p)}-1$[18].

(iii) In any period t, deviation from interest rate $r_M=\frac{Y}{L}p\delta_B-1$ charged to borrowers with a default history does not pay.

2. We prove next that s^* is SPNE.

Suppose lender A deviates from $r_{ND}=\frac{\delta_B{}^2 pY}{L}-1$ by some $\varepsilon>0$ in period $(t-1)$. Both the lender's strategies restricted to the off-equlibrium path Sub-game beginning in period t is to charge $\tilde{r}$ from period t onwards. We show that for lender B unilateral deviation from $\tilde{r}$ in period t does not pay. To see this, suppose lender B charges an interest rate $r<\tilde{r}$. Then, his present value of expected lifetime profit, evaluated at period t, will be negative. Suppose, on the other hand, that lender B charges an interest rate $r>\tilde{r}$. Since, all non-defaulting borrowers have migrated to lender A in the preceding period, the only borrowers he will get are the non-strategic defaulters who have defaulted on their loans from lender A. But, he would have gotten these borrowers even if he had not raised the interest rate. So deviation upwards does not pay.

(i) Deviation from $r_M=\frac{Y}{L}p\delta_B-1$ in either direction by lender B will not pay since these borrowers who defaulted on their loan from lender A will default if the interest rate $r>r_M$ and the lender loses if he chrges any interest rate $r<r_M$. So unilateral deviation from $r_M=\frac{Y}{L}p\delta_B-1$ does not pay.

[18]See Appendix A6.

Notice, that as in Section 2, tacit collusion among lenders keeps the interest rate charged to borrowers with no default history at r_{ND} , which is above the interest rate that would have been charged in a one-shot Bertrand game. However, the interest rate at which the present value of lifetime expected profit is zero, which we can obtain by solving equation (9) below,

$$\frac{L}{2}\left[\frac{1-\delta}{(1-\delta p)^2\{1-\delta(1+k)\}}\right][(1-\delta p)\{p(1+r)-1\}+\delta(1-p)\{p(1+r_M)-1\}]=0 \qquad (9)$$

is lower than r_{ND}. It is easy to check that this interest rate can be supported in an SPNE of the game. Tacit collusion allows the lenders to earn positive present value of expected lifetime profits and in that sense, information sharing is a mechanism for tacit collusion.

Model with Incorrect Information Sharing

In the last section, we introduced information sharing among lenders about borrowers' default histories. We assumed that lenders reveal information truthfully and showed that this allows tacit collusion among the lenders. The question then is: What incentive does a lender have to truthfully reveal such information to his competitor? In what follows we assume that the proportion of new entrants into the market k is equal to the proportion of the existing population who have defaulted in the last period because they faced a bad state of the world, i.e., $k=(1-p)$ [19]. In any period $t>0$, the number of borrowers who approach a lender are either those who are new entrants in the market or those migrating from the other lender after defaulting one the loans to him. Notice that, only those who have not defaulted on their loan to this lender will migrate from the other lender. The restriction ensures that the number of fresh borrowers applying for a loan from this borrower is equal to the number of migrants[20].

In any period, in equilibrium, a lender knows that he will get half of the new entrants and half of the non-strategic defaulters of the preceding period who have not defaulted twice. He also knows that if information is correct then he should be able to collect the monopoly rent from the migrants and the non-defaulting interest rate from the new entrants in the market. Any deviation from this will indicate that the information given to him was false. Consider the case where lender A passes false information about default histories of the list of borrowers sent to him by lender B. This list consists of all the new borrowers who have applied for loans from him in the current period. If lender A were to provide correct information then charging the borrowers who have been identified as defaulters by him would be charged interest rate r_M and the rest the

[19]See Appendix A7 for the analysis of the restrictive assumption.
[20]Changing this assumption leads to very intricate problems that we shall deal with in a subsequent paper, which is not included here.

interest rate r_{ND}. By assumption, proportion $(1-p)$ of each types of borrowers will default non-strategically due to a bad state. The rest will not default. Hence, the anticipated profit level in this period from the new borrowers is known to lender B ex ante. Any deviation in actual profits fully reveals that false information has been provided by lender A. Using a simple trigger strategy argument one can show that for sufficiently high discount factors, co-operation in the sense of providing correct information can be supported as an SPNE in the information exchange game. We provide the formal proof of this argument below.

To prove the above, we assume that any one of the lenders (say lender B) passes wrong information to the other one (say lender A), while lender A sticks to sharing correct and true information about his borrower type. Now this wrong information sharing can be considered as one where, lender B tries to present his defaulters as some of the new entrants while, some among the new entrants are identified as defaulters of the earlier period. In this case, lender A will charge a normal competitive rate to the migrating defaulters whom he could have charged a higher monopoly rate and made a higher profit. Apart from this, wrong information from lender B to lender A claims lender A's profit from another angle. Since, lender A now considers some of the new entrants as defaulting migrants of the earlier period (assuming lender B's information to be correct), he charges them monopoly rate. However, these new entrants facing a higher rate in their first period of borrowing surely defaults (given that they can get alternative credit from another source at the same interest rate) and migrates to lender B in the next period. Thus wrong identification of borrower type by lender A costs him in double-edged loss. First, he earns a less than deserved return from the actual migrating defaulters and then he looses some of his new entrants by identifying them as defaulters of the earlier period and thereby charging them a monopoly rate. Lender B here gains by booking some of the fresh applicants of lender A who under normal (correct information sharing) situation would have been loyal to lender A and continued their borrowing contract with him. Unfortunately for lender B, all these benefits can only be accrued in one period. When lender A will earn a less than expected return in the next period, he will automatically figure out this informational manipulaion of his partner and retaliate by behaving in the same coin. So we can see that informational asymmetry between the lenders can only continue for one period after which the cheated lender will become aware of this. Since lender B, by our assumption, is the gainer out of signalling a wrong information, his profit will always outweigh that of lender A. Hence, we will focus on the payoffs of lender B only to find out the advantage of such an act. Thus given the framework of this model, the net gain of the lender B by passing wrong information are as follows.

In the first period none of the lenders know about the true nature of the borrowers hence there is no possibility of information sharing. Given this the net gain of lender B in the first period is,

$$-\frac{1}{2}L + p\frac{1}{2}L(1+r_{ND}) \tag{10}$$

After the first period with $(1-p)$ fraction of borrowers default involuntarily, and the remaining p fraction repay the loan to their respective lenders, each lender share their private information about their respective defaulters to their cohort. To incorporate false information sharing here we assume that lender A signals the correct information while lender B chooses to share wrong information. Not only that, lender B identifies all the new second period entrants as the delinquent migrants and claims his own first period defaulters as the fresh entrants. We know that $(1-p)$ fraction of the fresh borrowers in every period are the non-strategic defaulters. Hence, the entire group new entrants whom lender B has falsely spoted as defaulters, are assumed for simplicity to be equal to the number of non-strategic defaulters of the earlier period, i.e., $k=(1-p)$. Here both the lenders will charge their identified defaulters the monopoly interest rate r_M. However, since all the new entrants in the second period who apply for credit to lender A (who are marked falsely as defaulters by lender B) face the monopoly rate, they will not repay their loan (since it violates the instrument of dynamic incentive scheme) and rather default and shift to lender B in the third period. However, since lender A sticks to his strategy of sharing correct information, lender B gets his expected share of profit. Thus, given this set of information the net gain of lender B in the second period is,

$$-[p\frac{1}{2}+(1-p)\frac{1}{2}+\frac{k}{2}]L + p^2\frac{1}{2}L(1+r_{ND}) + p(1-p)\frac{1}{2}(1+r_M) + pk\frac{1}{2}(1+r_{ND}) \tag{11}$$

In the third period, apart from the non-strategic defaulters of the second period i.e. $(1-p)\frac{k}{2}$, the remaining set of borrowers also default strategically i.e., fraction $p\frac{k}{2}$, and migrate from lender A to lender B owning due to high monopoly rate charged by lender A. Besides, lender B also gets his share of new entrants of the third period i.e. $\frac{k(1+k)}{2}$. Being a rational lender, as lender A realises less than expected return at the end of the second period, he finds out that the information shared by lender B in the earlier period was incorrect. Henceforth, lender A will apply trigger strategy of complete break-down of information sharing between themselves. Hence, from third period onwards none of the lenders will have any mechanism to distinguish a non-strategic defaulter of the preceding period from a new entrant in the market. The lenders in turn have to charge the same interest rate r_{ND} to all the fresh borrowers (old non-strategic defaulters and new entrants alike). Given common knowledge, the borrowers will identify this handicap of the lenders knowing that the they have to face the same interest rate r_{ND} with both the lenders under any state of nature. Facing an identical interest rate with or without strategic default from both the lenders provide incentives to the borrowers to always strategically default their first lender (Proposition 1). Hence, any borrower will always default strategically in their first period of borrowing and continue maintaining a faithful tenure with the second lender. Thus, given the above structure, the net gain of lender B in the third period is,

$$-[p^2\frac{1}{2}+p(1-p)\frac{1}{2}+p\frac{k}{2}+p(1-p)\frac{1}{2}+\frac{k}{2}+\frac{k(1+k)}{2}]L+p^2(1-p)\frac{1}{2}L(1+r_M)$$
$$+p^2(1-p)\frac{1}{2}L(1+r_{ND})+p\frac{k}{2}L(1+r_{ND}) \qquad (12)$$

In a similar way the net gain of lender B in the fourth period is,

$$-[p^2(1-p)\frac{1}{2}+p^2(1-p)\frac{1}{2}+p\frac{k}{2}+\frac{k(1+k)}{2}+p^2\frac{1}{2}+\frac{k(1+k)^2}{2}]L$$
$$+p^3(1-p)\frac{1}{2}L(1+r_M)+p^3(1-p)\frac{1}{2}L(1+r_{ND})+p^2\frac{k}{2}L(1+r_{ND})$$
$$+p\frac{k(1+k)}{2}L(1+r_{ND})+p^3\frac{1}{2}L(1+r_{ND}) \qquad (13)$$

Proceeding this way, the lifetime profit of lender B by passing incorrect/wrong information will be[21],

$$\frac{L}{2}[p(1+r_{ND})-1][1+\delta(p+k)+\delta^2\{k+p(1-p)\}+\frac{2\delta^3p^2-\delta^3p^3+\delta^3pk}{(1-\delta p)}+\frac{\delta^3k(1+k)}{(1-\delta p)\{1-\delta(1+k)\}}]$$
$$+\frac{L}{2}\delta(1-p)\frac{[p(1+r_M)-1]}{(1-\delta p)}-\frac{L}{2}\delta^2p(p+k)-\frac{L\delta^2k(1+k)}{2\{1-\delta(1+k)\}} \qquad (14)$$

Let us denote lender B's profit with correct information sharing througout the lifetime in equation (8) as π^C and that with sharing wrong (incorrect) information in equation (14) as π^{IC}.

[21]See Appendix A8 for the mathematical derivation.

Then we can compare both the profit levels to find out if staying faithful and sharing correct information with his competitor is wiser for lender B. Therefore,

$$\pi_C \geq \pi_{IC}$$

$$\Rightarrow \frac{L}{2}[\frac{1-\delta}{(1-\delta p)^2\{1-\delta(1+k)\}}][(1-\delta p)\{p(1+r_{ND})-1\}+\delta(1-p)\{p(1+r_M)-1\}] \geq$$

$$\frac{L}{2}[p(1+r_{ND})-1][1+\delta(p+k)+\delta^2\{k+p(1-p)\}+\frac{2\delta^3 p^2-\delta^3 p^3+\delta^3 pk}{(1-\delta p)}+\frac{\delta^3 k(1+k)}{(1-\delta p)\{1-\delta(1+k)\}}]$$

$$+\frac{L}{2}\delta(1-p)\frac{[p(1+r_M)-1]}{(1-\delta p)}-\frac{L}{2}\delta^2 p(p+k)-\frac{L\delta^2 k(1+k)}{2\{1-\delta(1+k)\}} \qquad (15)$$

Hence, if we find the above equation (15) to be positive, then we can infer that for both the lenders, staying mutually faithful between themselves by sharing correct and true information will be profitable as against signalling wrong information.

This is feasible iff[22],

$$r_M \geq \frac{1}{p}-\frac{(1-\delta p)^2\{1-\delta(1+k)}{\delta^2(1-p)\{k(1-\delta p)+p(1-\delta)\}}[\delta^2 p(p+k)+\frac{\delta^2 k(1+k)}{1-\delta(1+k)}+$$

$$\{p(1+r_{ND})-1\}\{\frac{1-\delta-\delta^2 k(1+k)}{(1-\delta p)\{1-\delta(1+k)\}}-\frac{(1+\delta k-2\delta^2 p^2-\delta^2 pk+\delta^2 p+\delta^3 p^2+\delta^2 k}{1-\delta p}\}]-1$$

(16)

Since, the game is an infinitely repeated one, hence, the condition in equation (16) is independent of whichever period any lender decides to deviate.

Hence, it can be concluded that with $r_M > r_{ND}$ by a considerable margin, any correct information sharing contract between the lenders will be profitable for both of them without any of the lenders having any incentive to deviate from such a contract and cheat. In this dynamic model with growth of size of borrower pool, participating in any information shaing contract is thus a dominating SPNE over any other startegy.

Proposition 5: With two competing lenders under growing population of borrowers, sharing correct and true information about the history of borrowers' default among themselves will be profitable over sharing incorrect information as long as

$$r_M \geq \frac{1}{p}-\frac{(1-\delta p)^2\{1-\delta(1+k)}{\delta^2(1-p)\{k(1-\delta p)+p(1-\delta)\}}[\delta^2 p(p+k)+\frac{\delta^2 k(1+k)}{1-\delta(1+k)}+$$

[22]See Appendix A9.

$$\{p(1+r_{ND})-1\}\{\frac{1-\delta-\delta^2 k(1+k)}{(1-\delta p)\{1-\delta(1+k)\}}-\frac{(1+\delta k-2\delta^2 p^2-\delta^2 pk+\delta^2 p+\delta^3 p^2+\delta^2 k}{1-\delta p}\}]-1 .$$

Proof: Follows trivially from equation (16).

5. Conclusion

In this paper, the principal results are that if there is no entry of new borrowers in the market, then with two lenders, information sharing mechanisms are inessential. This result directly contradicts the result in [Padilla and Pagano (1997)]. Any rational lender can infer that a new borrower who asks for a loan from him in any period $t > 0$, must be one who has defaulted in the last period on his loan with the other lender. Further, in equilibrium, such a default was non-strategic. Such borrowers will be charged the monopoly interest rate while the others who have been borrowing from the lender from period $t = 0$ will be charged the non-defaulting interest rate. There is no need for a formal information sharing mechanism in this case.

The need for information sharing emerges when such an inference cannot be made. This requires that there exist other borrowers who do not have a default history but cannot signal this credibly. The only way that a lender can separate the two types, i.e., those without a default history and those with one, would be by checking with the other lender. In equilibrium, an existing borrower who has not defaulted has no interest in migrating away from his lender, so we introduce new borrowers in the market in each period. We find that information sharing is also a collusive device that allows lenders to charge collusive interest rates from borrowers without default histories. What is less surprising perhaps is that the equilibrium rate of interest r_{ND}, is the same with a growing population of borrowers as in the case of a non-growing population. The reason behind this is that truthful information sharing removes the adverse selection problem completely and, therefore, the problem caused by the growing population is completely removed. This is precisely the idea behind setting up institutions for information sharing among lenders.

The question we ask finally is: What incentive does a lender have to provide correct information about borrowers' default histories in equilibrium? We construct a repeated game in information exchange where the lenders share information about default and show that if they are sufficiently patient then there is an SPNE of the game where truthful revelation of information takes place. To get this result we had to make a restrictive assumption that we shall relax in future work.

Appendices

A1: Condition to Avoid Non-Strategic Default with Competing Lenders

In a good state, the borrower will strategically default if the present value of expected lifetime gain from defaulting on his loan and borrowing from another lender at the monopoly rate of interest from the next period onwards exceeds the gain from not defaulting on his current period loan, i.e.,

$$[Y - L(1+r)] + \delta_B[p\{Y - L(1+r)\} + (1-p)\{0 + \delta_B pA\}]$$

$$+ \delta_B{}^2 p[p\{Y - L(1+r)\} + (1-p)\{0 + \delta_B pA\}].... \geq Y + \delta_B pA$$

where, $A = [Y - L(1+r_M)] + \delta_B p[Y - L(1+r_M)] + ... = \dfrac{[Y - L(1+r_M)]}{(1-\delta_B p)} = \dfrac{Y(1-\delta_B p)}{(1-\delta_B p)} = Y$

$$\Rightarrow \{Y - L(1+r)\}[1 + \delta_B p + \delta_B{}^2 p^2 + ...] + \delta_B{}^2 p(1-p)A[1 + \delta_B p + \delta_B{}^2 p^2 + ...] \geq Y + \delta_B pA$$

$$\Rightarrow \frac{\{Y - L(1+r)\}}{(1-\delta_B p)} + \frac{\delta_B{}^2 p(1-p)A}{(1-\delta_B p)} \geq Y + \delta_B pA$$

$$\Rightarrow \{Y - L(1+r)\} + \delta_B{}^2 p(1-p)A \geq (1-\delta_B p)Y + \delta_B p(1-\delta_B p)A$$

$$\Rightarrow Y[1-(1-\delta_B p)] - L(1+r) \geq \delta_B pA[(1-\delta_B p) - \delta_B(1-p)]$$

$$\Rightarrow \delta_B pY - L(1+r) \geq \delta_B pY(1-\delta_B)$$

$$\Rightarrow \delta_B pY[1-(1-\delta_B)] \geq L(1+r)$$

$$\Rightarrow \delta_B{}^2 pY \geq L(1+r)$$

Hence, solving for r we get,

$$r \leq \frac{\delta_B{}^2 pY}{L} - 1$$

(A1.1)

A2: Non-negativity Condition of $r_{ND} = \frac{\delta_B{}^2 pY}{L} - 1$

For non-negativity condition of the interest rate $r_{ND} = \frac{\delta_B{}^2 pY}{L} - 1 < \frac{\delta_B pY}{L} - 1 = r_M$, we need to ensure the following.

$$r_{ND} = \frac{\delta_B{}^2 pY}{L} - 1 \geq 0$$

$$\Rightarrow \delta_B{}^2 pY \geq L$$

(A2.1)

A3: Sufficient Condition for SPNE under Constant Population of Borrowers

Let us consider that the lender sticks to his given strategy profile $s^* = (s_A^*, s_B^*)$. Given this if the lender charges the old non-defaulting borrowers the interest rate and the migrating defaulters the monopoly interest rate , then the net expected profit of the lender in the first period is,

$$-\frac{1}{2}L + p\frac{1}{2}L(1 + r_{ND})$$

(A3.1)

Following the same strategy the net expected profit of the lender in the second period is,

$$-\frac{L}{2}[p+(1-p)]+p^{2}\frac{1}{2}L(1+r_{ND})+p(1-p)\frac{1}{2}L(1+r_{M})$$

(A3.2)

Proceeding this way the present value of the lifetime expected profit of the lender is given by,

$$\frac{L}{2}[p(1+r_{ND})-1]+\delta\frac{L}{2}[p\{p(1+r_{ND})-1\}+(1-p)\{p(1+r_{M})-1\}]$$

$$\delta^{2}p\frac{L}{2}[p\{p(1+r_{ND})-1\}+2(1-p)\{p(1+r_{M})-1\}]+..........$$

$$\Rightarrow\frac{1}{2}L\frac{\{p(1+r_{ND})-1\}}{(1-\delta p)}+\delta(1-p)\frac{1}{2}L\{p(1+r_{M})-1\}[1+2\delta p+3\delta^{2}p^{2}+........]$$

$$\Rightarrow\frac{1}{2}L\frac{\{p(1+r_{ND})-1\}}{(1-\delta p)}+\delta(1-p)\frac{1}{2}L\{p(1+r_{M})-1\}[\frac{1}{(1-\delta p)^{2}}]$$

$$\frac{1}{2}L[\frac{\{p(1+r_{ND})-1\}}{(1-\delta p)}+\delta(1-p)\frac{\{p(1+r_{M})-1\}}{(1-\delta p)^{2}}]$$

(A3.3)

Let us consider the off-equilibrium strategy profile for lender A where he decides to deviate from the equlibrium interest rate r_{ND} and charge an interest rate $r=r_{ND}-\varepsilon$, where $\varepsilon>0$. Now in the first period, when none of the borrowers have any history of default let us assume that both the lenders charge a uniform interest rate profile i.e., r_{ND}. Given this the net gain of the lender in the first period is,

$$-\frac{1}{2}L+p\frac{1}{2}L(1+r_{ND})$$

(A3.4)

Let us assume that in the second period also such an interest rate profile persists in the market, as a result only the non-strategic defaulters switch their lenders while the remaing borrowers stick to their first lender. Given this, the net gain of lender A in the second period is given by,

$$-\frac{L}{2}[p+(1-p)]+p^2\frac{1}{2}L(1+r_{ND})+p(1-p)\frac{1}{2}L(1+r_M)$$

(A3.5)

However, let us assume that before the commencement of the third period lender A announces his interest rate profile for the next period to be r^*. As a result given Lemma 2, all the borrowers default their loans to lender B apart from the ones who have already defaulted lender A in either of the last two period. Given this the net expected profit of Lender A is,

$$-\frac{L}{2}[p^2+p(1-p)+p^2+p(1-p)]+p^3\frac{1}{2}L(1+r_{ND})+p^2(1-p)\frac{1}{2}L(1+r_M)$$

$$+\{p^3+p^2(1-p)\}\frac{1}{2}L(1+r^*)$$

(A3.6)

Proceeding this way the present value of the lifetime expected profit of the deviator is given by,

$$[-\frac{L}{2}+p\frac{1}{2}L(1+r_{ND})]+\delta[-\frac{L}{2}+p^2\frac{1}{2}L(1+r_{ND})+p(1-p)\frac{1}{2}L(1+r_M)]$$

$$\delta^2[-\frac{L}{2}2p+p^3\frac{1}{2}L(1+r_{ND})+p^2(1-p)\frac{1}{2}L(1+r_M)+p^2\frac{1}{2}L(1+r^*)]+.....$$

$$\Rightarrow -\frac{L}{2}[1+\delta+2\delta^2p+2\delta^3p^2+........]+p\frac{1}{2}L(1+r_{ND})[1+\delta p+\delta^2p^2+........]$$

$$\delta p(1-p)\frac{1}{2}L(1+r_M)[1+\delta p+\delta^2p^2+.......]+\delta^2p^2\frac{1}{2}L(1+r^*)[1+\delta p+\delta^2p^2+.......]$$

$$\Rightarrow \frac{L}{2(1-\delta p)}[-(1-\delta)(1-\delta p)+p(1+r_{ND})+\delta p(1-p)(1+r_M)+\delta^2 p^2(1+r^*)]$$

(A3.7)

From the above equation (A3.4), the break-even interest rate r^* can be given by setting the profit level equal to zero.

$$\frac{L}{2(1-\delta p)}[-(1-\delta)(1-\delta p)+p(1+r_{ND})+\delta p(1-p)(1+r_M)+\delta^2 p^2(1+r^*)]$$

$$\Rightarrow [-(1-\delta)(1-\delta p)+p(1+r_{ND})+\delta p(1-p)(1+r_M)+\delta^2 p^2(1+r^*)]=0$$

$$\Rightarrow \delta^2 p^2(1+r^*)=(1-\delta)(1-\delta p)-p(1+r_{ND})-\delta p(1-p)(1+r_M)$$

$$\Rightarrow r^*=\frac{1}{\delta^2 p^2}[(1-\delta)(1-\delta p)-p(1+r_{ND})-\delta p(1-p)(1+r_M)]-1$$

(A3.8)

Comparing the profit levels with and without deviation from r_{ND} we find that for any lender deviation from pays if and only if, the level of profit by charging the interest rate r_{ND} as is given in equation (A3.3) is more than the break-even profit level zero, i.e.,

$$\frac{1}{2}L[\frac{\{p(1+r_{ND})-1\}}{(1-\delta p)}+\delta(1-p)\frac{\{p(1+r_M)-1\}}{(1-\delta p)^2}]\geq 0$$

$$\Rightarrow \{p(1+r_{ND})-1\}(1-\delta p)+\delta(1-p)\{p(1+r_M)-1\}\geq 0$$

$$\Rightarrow \{p(1+r_{ND})-1\}(1-\delta p)\geq \delta(1-p)\{1-p(1+r_M)\}$$

$$\Rightarrow p(1+r_{ND})\geq \frac{\delta(1-p)\{1-p(1+r_M)\}}{(1-\delta p)}+1$$

$$\Rightarrow r_{ND} \geq \frac{\delta(1-p)\{1-p(1+r_M)\}+(1-\delta p)}{p(1-\delta p)}-1$$

(A3.9)

A4: Condition for Defaulting the First lender by a Borrower

We want to check whether a borrower will repay his loan to the lender whom he has borrowed from in period $(t-1)$ and reapply for fresh credit at reduced interest rate $r = r_{ND} - \varepsilon$ with the other lender, or stategically default on his loan in period $(t-1)$ and apply for fresh credit in period t. To check this we need to compare the present value of the lifetime expected payoff of a borrower by either strategically defaulting the lender in period $(t-1)$ and then switching lender or repaying the previous credit of period $(t-1)$ and then reapplying for fresh credit in period t. Strategic default is a better outcome if,

$$[Y - L(1+r_{ND})] + \delta_B [p\{Y - L(1+r)\} + (1-p)\{0 + \delta_B pA\}]$$

$$+\delta_B{}^2 p[p\{Y - L(1+r)\} + (1-p)\{0 + \delta_B pA\}] .... \leq Y + \delta_B p\,[Y - L(1+r)] + ...$$

where, $A = [Y - L(1+r_M)] + \delta_B p[Y - L(1+r_M)] + ... = \dfrac{[Y - L(1+r_M)]}{(1-\delta_B p)} = \dfrac{Y(1-\delta_B p)}{(1-\delta_B p)} = Y$

$$\Rightarrow [Y - L(1+r_{ND})] + \delta_B p\{Y - L(1+r)\}[1 + \delta_B p + \delta_B^2 p^2 + ...]$$

$$+\delta_B^2 p(1-p)A[1 + \delta_B p + \delta_B^2 p^2 + ...] \leq Y + \delta_B p\{Y - L(1+r)\}[1 + \delta_B p + \delta_B^2 p^2 + ...]$$

$$\Rightarrow -L(1+r_{ND}) + \frac{\delta_B p\{Y - L(1+r)\}}{(1-\delta_B p)} + \frac{\delta_B^2 p(1-p)A}{(1-\delta_B p)} \leq \frac{\delta_B p\{Y - L(1+r)\}}{(1-\delta_B p)}$$

$$\Rightarrow \frac{\delta_B^2 p(1-p)Y}{(1-\delta_B p)} \leq L(1+r_{ND})$$

where, $A = Y$ from equation (3). Substituting $r_{ND} = \frac{\delta_B{}^2 pY}{L} - 1$.

$$\Rightarrow \frac{\delta_B^2 p(1-p)Y}{(1-\delta_B p)} \le L(1 + \frac{\delta_B^2 pY}{L} - 1)$$

$$\Rightarrow \frac{\delta_B^2 p(1-p)Y}{(1-\delta_B p)} \le \delta_B^2 pY$$

$$\Rightarrow \frac{(1-p)}{(1-\delta_B p)} \le 1$$

$$\Rightarrow (1-p) \le (1-\delta_B p)$$

$$\Rightarrow \delta_B \le 1$$

(A4.1)

A5: Present Value of Expected Lifetime Profit of a Lender under Growing Population of Borrowers by Sharing Correct Information

In a infinitely repeated game with growing population of borrowers, the present value of the expected lifetime net profit of the lenders is,

$$\frac{L}{2}[p(1+r_{ND})-1][1+\delta(p+k)+\delta^2\{p^2+pk+k(1+k)\}+\delta^3\{p^3+p^2k+pk(1+k)+k(1+k)^2\}+.......]$$

$$+\frac{L}{2}(1-p)\delta[p(1+r_M)-1][1+\delta(2p+k)+\delta^2\{3p^2+2pk+k(1+k)\}$$

$$+\delta^3\{4p^3+3p^2k+2pk(1+k)+k(1+k)^2\}+.......]$$

$$\Rightarrow \frac{L}{2}[p(1+r_{ND})-1][(1+\delta p+\delta^2 p^2+...)+\delta k(1+\delta p+\delta^2 p^2+...)+\delta^2 k(1+k)(1+\delta p+\delta^2 p^2+...)+...]$$

$$\frac{L}{2}(1-p)\delta[p(1+r_M)-1][(1+2\delta p+3\delta^2 p^2+...)$$

$$+\delta k(1+2\delta p+3\delta^2 p^2+...)+\delta^2 k(1+k)(1+2\delta p+3\delta^2 p^2+...)+...]$$

$$\Rightarrow \frac{L}{2}[p(1+r_{ND})-1][\frac{1}{(1-\delta p)}\{1+\delta k+\delta^2 k(1+k)+.........\}]$$

$$\frac{L}{2}(1-p)\delta[p(1+r_M)-1][\frac{1}{(1-\delta p)^2}\{1+\delta k+\delta^2 k(1+k)+.........\}]$$

$$\Rightarrow \frac{L}{2}[\frac{1-\delta}{(1-\delta p)^2\{1-\delta(1+k)\}}][(1-\delta p)\{p(1+r_{ND})-1\}+\delta(1-p)\{p(1+r_M)-1\}]$$

(A5.1)

A6: Sufficient Condition for SPNE under Growing Population of Borrowers

Any lender will stick to the equilibrium strategy profile $s^*=(s_A^*,s_B^*)$ in an infinitely repeated lending game with growing population and not deviate by charging the break-even interest rate $\tilde{r}$, if his present value of expected lifetime profit by deviation is less than that under non-deviation from equilibrium strategy profile, i.e

$$\frac{L}{2}[\frac{1-\delta}{(1-\delta p)^2\{1-\delta(1+k)\}}][(1-\delta p)\{p(1+r_{ND})-1\}+\delta(1-p)\{p(1+r_M)-1\}]\geq 0$$

$$\Rightarrow (1-\delta p)\{p(1+r_{ND})-1\}+\delta(1-p)\{p(1+r_M)-1\}\geq 0$$

$$\Rightarrow p(1+r_{ND})\geq \frac{\delta(1-p)\{1-p(1+r_M)\}}{(1-\delta p)}+1$$

$$\Rightarrow r_{ND}\geq \frac{\delta(1-p)\{1-p(1+r_M)\}+(1-\delta p)}{p(1-\delta p)}-1$$

(A6.1)

A7: Logical Analysis of the Restriction $k=(1-p)$

We need to check the logical consistency of the restrictive assumption that the proportion of new entrants into the market k is equal to the proportion of the existing population who have defaulted in the last period because they faced a bad state of the world, i.e., $k = (1-p)$.

In the first period all the borrowers are new entrants and so this restrictive asumption is not applicable. It is from the second period onwards that this assumption is required. In the second period the number of new entrants are k, and the number of non-startegic defaulter migrants are $(1-p)$. For simplicity we assume $k = (1-p)$. In the third period, the number of new entants are $k(1+k)$, and the number of nonstrategic defaulter migrants are $p(1-p)$. Notice, $k(1+k) = (1-p)p$. Hence, in this case, by making this restrictive assumtion, the number of new entrants in the market will always be equal to the number of non-strategic defaulter migrants.

A8: Present Value of Expected Lifetime Profit of a Lender under Growing Population of Borrowers by Passing Incorrect Information

The net gain of lender B in the first period is,

$$-\frac{1}{2}L + p\frac{1}{2}L(1+r_{ND})$$

(A8.1)

The net gain of lender B in the second period is,

$$-[p\frac{1}{2} + (1-p)\frac{1}{2} + \frac{k}{2}]L + p^2\frac{1}{2}L(1+r_{ND}) + p(1-p)\frac{1}{2}(1+r_M) + pk\frac{1}{2}(1+r_{ND})$$

(A8.2)

The net gain of lender B in the third period is,

$$-[p^2\frac{1}{2} + p(1-p)\frac{1}{2} + p\frac{k}{2} + p(1-p)\frac{1}{2} + \frac{k}{2} + \frac{k(1+k)}{2}]L + p^2(1-p)\frac{1}{2}L(1+r_M)$$

$$+ p^2(1-p)\frac{1}{2}L(1+r_{ND}) + p\frac{k}{2}L(1+r_{ND})$$

(A8.3)

In a similar way the net gain of lender B in the fourth period is,

$$-[p^2(1-p)\frac{1}{2}+p^2(1-p)\frac{1}{2}+p\frac{k}{2}+\frac{k(1+k)}{2}+p^2\frac{1}{2}+\frac{k(1+k)^2}{2}]L$$

$$+p^3(1-p)\frac{1}{2}L(1+r_M)+p^3(1-p)\frac{1}{2}L(1+r_{ND})+p^2\frac{k}{2}L(1+r_{ND})$$

$$+p\frac{k(1+k)}{2}L(1+r_{ND})+p^3\frac{1}{2}L(1+r_{ND})$$

(A8.4)

Proceeding this way, the lifetime profit of lender B by passing incorrect/wrong information will be,

$$\frac{L}{2}\{p\frac{1}{2}L(1+r_{ND})-1\}+\delta\frac{L}{2}[\{p\frac{1}{2}L(1+r_{ND})-1\}(p+k)+(1-p)\{p(1+r_M)-1\}]$$

$$\delta^2\frac{L}{2}[\{p(1+r_{ND})-1\}p\{(1-p)+k\}+p(1-p)\{p(1+r_M)-1\}-\{p^2+pk+k(1+k)\}]+....$$

$$\Rightarrow\frac{L}{2}[p(1+r_{ND})-1][1+\delta(p+k)+\delta^2\{k+p(1-p)\}+\frac{2\delta^3p^2-\delta^3p^3+\delta^3pk}{(1-\delta p)}+\frac{\delta^3k(1+k)}{(1-\delta p)\{1-\delta(1+k)\}}]$$

$$+\frac{L}{2}\delta(1-p)\frac{[p(1+r_M)-1]}{(1-\delta p)}-\frac{L}{2}\delta^2p(p+k)-\frac{L\delta^2k(1+k)}{2\{1-\delta(1+k)\}}$$

(A8.5)

A9: Comparison of Profits by Sharing Correct Information and Sharing Wrong Information

Denoting lender B's profit with correct information sharing througout the lifetime in equation (8) in Section 4 as π^C and that with sharing wrong (incorrect) information in equation (14) in

Section 5 as π^{IC} , we can compare both the profit levels to find out if staying faithful and sharing correct information with his competitor is wiser for lender B. Therefore,

$\pi_C \geq \pi_{IC}$

$$\Rightarrow \frac{L}{2}[\frac{1-\delta}{(1-\delta p)^2\{1-\delta(1+k)\}}][(1-\delta p)\{p(1+r_{ND})-1\}+\delta(1-p)\{p(1+r_M)-1\}] \geq$$

$$\frac{L}{2}[p(1+r_{ND})-1][1+\delta(p+k)+\delta^2\{k+p(1-p)\}+\frac{2\delta^3p^2-\delta^3p^3+\delta^3pk}{(1-\delta p)}+\frac{\delta^3k(1+k)}{(1-\delta p)\{1-\delta(1+k)\}}]$$

$$+\frac{L}{2}\delta(1-p)\frac{[p(1+r_M)-1]}{(1-\delta p)}-\frac{L}{2}\delta^2p(p+k)-\frac{L\delta^2k(1+k)}{2\{1-\delta(1+k)\}}$$

$$\Rightarrow \{p(1+r_{ND})-1\}[\frac{(1-\delta)}{(1-\delta p)\{1-\delta(1+k)\}}-1+\delta(p+k)+\delta^2\{k+p(1-p)\}$$

$$+\frac{2\delta^3p^2-\delta^3p^3+\delta^3pk}{(1-\delta p)}+\frac{\delta^3k(1+k)}{(1-\delta p)\{1-\delta(1+k)\}}] \geq -\delta^2p(p+k)-\frac{\delta^2k(1+k)}{\{1-\delta(1+k)\}}$$

$$+\delta(1-p)\{p(1+r_M)-1\}[\frac{1}{(1-\delta p)}-\frac{1-\delta}{(1-\delta p)^2\{1-\delta(1+k)\}}]$$

$$\Rightarrow \frac{\delta(1-p)\{p(1+r_M)-1\}}{(1-\delta p)^2\{1-\delta(1+k)\}}[(1-\delta p)\{1-\delta(1+k)\}-(1-\delta)] \geq -\delta^2p(p+k)-\frac{\delta^2k(1+k)}{\{1-\delta(1+k)\}}$$

$$-\{p(1+r_M)-1\}[\frac{1-\delta-\delta^2k(1+k)}{(1-\delta p)\{1-\delta(1+k)\}}$$

$$-\frac{\{1-\delta(p+k)-\delta^2\{k+p(1-p)\}(1-\delta p)+2\delta^3 p^2-\delta^3 p^3+\delta^3 pk}{(1-\delta p)}]$$

$$\Rightarrow r_M \geq \frac{1}{p}-\frac{(1-\delta p)^2\{1-\delta(1+k)}{\delta^2(1-p)\{k(1-\delta p)+p(1-\delta)\}}[\delta^2 p(p+k)+\frac{\delta^2 k(1+k)}{1-\delta(1+k)}+$$

$$\frac{\{p(1+r_{ND})-1\}}{(1-\delta p)}\{\frac{1-\delta-\delta^2 k(1+k)}{\{1-\delta(1+k)\}}-(1+\delta k-2\delta^2 p^2-\delta^2 pk+\delta^2 p+\delta^3 p^2+\delta^2 k)]-1$$

(A9.1)

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