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Group-lending: Sequential financing, lender monitoring and joint liability

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Abstract

We develop a simple model of group-lending based on peer monitoring and moral hazard. We find that, in the absence of sequential financing or lender monitoring, group-lending schemes may involve under-monitoring with the borrowers investing in undesirable projects. Moreover, under certain parameter configurations, group-lending schemes involving either sequential financing, or a combination of lender monitoring and joint liability are feasible. In fact, group-lending schemes with sequential financing may succeed even in the absence of joint liability, though the repayment rate will be lower. In the absence of joint liability, however, group-lending with lender monitoring is unlikely to be feasible.

JEL classification: G2; O2
Keywords: Group-lending; Joint liability; Peer monitoring; Sequential financing; Under-monitoring; Lender monitoring

1. Introduction

Formal sector lending to the poor, especially the rural poor is plagued by severe problems of inadequate coverage, very low rates of repayment and imprecise targeting.

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Most of these problems can be traced to two underlying factors, lack of information and inadequate collateral. Given the linkage between finance and growth,[1] such poor performance of formal sector lending is cause for serious concern. In the last few decades, however, there have been attempts at introducing some innovative forms of formal credit, in particular group-lending schemes.[2] In fact the recent success of the Grameen Bank in Bangladesh has raised hopes that group lending schemes might be used as a conduit for channelling formal sector credit to the rural poor. Grameen Bank has a high rate of repayment compared to other schemes that lend to the poor. In fact Hossein (1998) argues that the Grameen Bank has a repayment rate in excess of 95%.[3] This has prompted other countries and NGOs to try out similar schemes.[4] In fact there are around 8–10 million households under similar lending programs in the world (see Ghatak, 2000).

There have been several important contributions that seek to explain the success of such schemes.[5] Stiglitz (1990) and Varian (1990) provide explanations based on peer monitoring. They argue that since group members have better information compared to the lenders, peer monitoring would be relatively cheaper compared to bank monitoring, leading to greater monitoring and greater rates of repayment. Banerjee et al. (1994), in fact, argue that compared to other explanations, arguments based on peer monitoring are relatively more successful in explaining the success of group lending schemes. Besley and Coate (1995) analyze a strategic repayment game with joint liability and demonstrate that successful group members may have an incentive to repay the loans of the less successful ones. They also highlight the effect of social collateral in ensuring repayment. Ghatak (1999, 2000) argue that with joint liability and self-selection, safe borrowers will club together to form credit cooperatives and risky borrowers will be screened out. Another paper that develops a similar idea is Van Tassel (1999). Ghatak and Guinnane (1999), on the other hand, analyze moral hazard problems in group-lending. In a model with moral hazard and monitoring they find that if the social sanctions are effective enough, or monitoring costs are low enough, joint-liability lending will improve repayment rates through peer-monitoring even when monitoring is costly.

Clearly the existing literature goes a long way towards explaining the success of some of the group lending schemes, in particular the Grameen Bank. There are, however, quite a few features of group lending schemes that have not attracted as much attention as they, perhaps, deserve.

[1] Goldsmith (1969) and Gurley and Shaw (1955) were among the first papers to discuss this linkage. For a recent survey of this literature we refer the readers to Levine (1997).

[2] Group-lending schemes, however, are not a recent phenomenon. See Ghatak and Guinnane (1999) for a discussion of an earlier group-lending scheme in Germany.

[3] Similar figures were obtained by Morduch (1999) and Christen et al. (1994).

[4] Similar schemes have been adopted in various countries, including countries in Latin America, Africa, Asia and even the United States of America (see Morduch, 1999). Besley and Coate (1995), for example, mention the farm credit programme set up by the Goodfaith Fund in rural Arkansas.

[5] We refer the readers to Ghatak and Guinnane (1999) and Morduch (1999) for recent surveys of the literature.

First, there is possibly too much emphasis on the positive aspects of such schemes, and too little on the possible negative ones. This is somewhat surprising in view of the fact that several of these schemes performed poorly.[6]

Second, group-lending schemes sometimes involve sequential lending.[7] In the Grameen Bank, for example, the groups have five members each. Loans are initially given to only two of the members (to be repaid over a period of 1 year). If they manage to pay the initial installments then, after about a month or so, another two borrowers receive loans and so on. While Ray (1999) provides an explanation based on coordination failures in case of voluntary default, the incentive implications of such sequential financing are not very well understood.

Third, group-lending schemes often involve active monitoring by the lenders. In case of the Grameen Bank, for example, group members receive training from Bank employees. There are weekly meetings where Grameen Bank employees participate (see Khandker et al., 1995).[8] Given the argument that group-lending schemes are attractive precisely because they replace costly lender monitoring with peer monitoring, such intensive monitoring by the lenders is somewhat surprising.

Finally, most of the theoretical literature has focussed on joint liability, to the relative neglect of the other features described above, namely sequential financing and bank monitoring (see Aghion and de Morduch, 1998). While empirical studies do suggest the importance of joint liability (see Wenner, 1995; Wydick, 1999), there is nothing to suggest that the other features are any less important.

In this paper we seek to develop a framework capable of explaining all these aspects of group-lending schemes. We build a simple model of group lending based on peer monitoring and moral hazard where we demonstrate that, in the absence of sequential financing or lender monitoring, group-lending schemes involve a severe under-monitoring problem. We then argue that both sequential financing, as well as a combination of lender monitoring and joint liability can help in mitigating this problem. Inter alia, we also discuss the relative contribution of these various factors towards the success of group-lending schemes.

The model comprises two potential borrowers who require one unit of capital (say 1 dollar) each for investing in some project. A bank, which advances these loans, can either make the loans individually, or it can loan the amount to the borrowers as a group. In case of group lending there is joint liability for the repayment of the loan. Thus in case one member of the group does not repay her loan, then the other member has to make up the deficit.

[6] See, for example, Adam and Vogel (1984), Braverman and Guasch (1984), Deschamps (1989), Rochin and Nyborg (1989), and Rochin and Solomon (1983). Some of the papers that do deal with the possible negative aspects of group-lending schemes include Besley and Coate (1995) and Banerjee et al. (1994). It is recognized, of course, that in the presence of involuntary default, joint liability may increase the chances of failure of group-lending schemes.

[7] Group-lending schemes often involve other dynamic elements as well, e.g. the threat of withholding future loans. From the literature on repeated games, however, the incentive implications of such threats are reasonably well understood.

[8] In fact, in their survey, Ghatak and Guinnane (1999) argue that active lender monitoring is one of the two fundamental reasons behind the success of group lending schemes (p. 196).

The essential tension in the model arises because while one of the projects has a large verifiable income and no non-verifiable private benefit, the other one has a large non-verifiable private benefit and no verifiable income. The bank prefers the first project (when it can recoup its initial investment), while the borrowers prefer the second one. Thus in the absence of monitoring the borrowers want to invest in the second project. The bank, knowing this, may be unwilling to lend at all.

While borrower i, say, knows the identity of its own projects, neither the bank, nor borrower j have this knowledge. They can, however, spend some non-verifiable amount in gathering this information. Under individual lending the bank can monitor the borrower when, with some probability, it can get to know the identity of the projects. Under group lending the borrowers can monitor each other. If monitoring is successful, then the successful monitor can enforce which one of the projects is to be implemented. Bank monitoring, however, is relatively costly compared to group lending, where the two borrowers can monitor each other at a lower cost.

We first demonstrate that individual lending is feasible if and only if the costs of bank monitoring are not too large. Under group lending, however, there is zero monitoring in equilibrium and group lending is never feasible. This follows since the monitoring levels of the two borrowers are strategic complements. If borrower j monitors then borrower i has an incentive to monitor herself, since, by doing so, she can increase her expected payoff from the first project. If, however, borrower j does not monitor, then borrower i can always invest in the second project itself and has no incentive to monitor herself. Hence both the borrowers choose the second project and the bank makes a loss. Thus the fact that peer monitoring is cheaper, does not necessarily ensure that it will be undertaken at an appropriate level.

We then demonstrate that group-lending schemes involving either sequential financing, or a combination of joint liability and active monitoring by the bank may solve the under-monitoring problem discussed above.

First consider a sequential financing scheme where initially the bank only lends 1 dollar to the group which then randomly allocates the dollar to one of the borrowers. In case the assigned borrower invests in her first project, the bank gets its money back and also lends the group a further 1 dollar in the next period. However, if the money is invested in the second project, then the bank cannot be repaid and there is no further loan later on. We show that such a sequential financing scheme generates a positive level of monitoring by the borrowers. The result is quite intuitive. If initially borrower 1 does not monitor and borrower 2 receives the loan, then borrower 2 would invest in the second project and borrower 1 would have a payoff of zero. By monitoring, however, she may force borrower 2 to invest in the first project, so that the bank is repaid and borrower 1 receives a loan in the second period. This in turn creates a greater incentive to monitor by borrower 2 herself, etc.

We then demonstrate that sequential financing may succeed even if there is no joint liability. However, the repayment rates are higher if sequential financing schemes also involve joint liability. Given that joint liability generates an additional incentive for monitoring this is quite intuitive. This shows that while joint liability by itself is not sufficient to solve the moral hazard problem, in the presence of sequential financing it leads to an increased rate of monitoring.

Finally we consider schemes where there is active monitoring by the lender, both with and without joint liability. With joint liability we find that there is a positive level of monitoring by the borrowers. In this case bank monitoring has a pump-priming effect, so that the bank by indulging in relatively costly monitoring itself, induces relatively less costly monitoring by the borrowers. In the absence of joint liability, however, bank monitoring is not very effective (in a sense made precise later).

The rest of the paper is organized as follows. Section 2 describes the basic model in case of individual, as well as group lending. In Section 3, we examine group lending with sequential financing, both with and without joint liability. While in Section 4 we examine group lending with active lender monitoring, again both with and without joint liability. Section 5 discusses some robustness issues. Finally, Section 6 concludes.

2. Basic model

There are two borrowers, borrower 1 and borrower 2 (denoted B_1 and B_2 respectively). Borrower 1 can invest in one of two projects, P_1^1 or P_2^1, and borrower 2 can invest in one of two projects, P_1^2 or P_2^2.[9] The project income can be of two kinds, verifiable and non-verifiable. Both P_1^1 and P_1^2 have a verifiable income of H, and no non-verifiable income, whereas both P_2^1 and P_2^2 have no verifiable income, and a non-verifiable income of b, where $b<H$. Note, however, that the sets of projects are different for the two borrowers. While the borrowers know the identity of their own projects, they do not know the identity of the other borrower's projects. All projects require an initial investment of 1 dollar. The borrowers do not have any fund of their own and must borrow the required 1 dollar from a bank. This can be done on an individual basis, or as a group. The amount to be repaid is r (≥ 1) in case of individual lending, and $2r$ in case of group lending. We assume that r is exogenously fixed by the government.[10] For the project to be profitable for the borrowers it must be that $r<H$. For simplicity we assume that $H\leq 2r$, so that $r<H\leq 2r$. (We shall discuss the implications of this assumption later).

Let us now describe the monitoring process. Borrower i, by spending an amount $m_i^2/2$ in non-verifiable monitoring costs, can obtain information regarding the identity of the projects of the jth borrower with probability min $\{m_i, 1\}$. The bank can also acquire this information with probability min $\{m, 1\}$ by spending an amount $(\lambda m^2/2)$. This information can be used to ensure that borrower i chooses the contracted upon project. In order to capture the idea that peer monitoring is cheaper compared to bank monitoring, we assume that $\lambda\geq 1$. For simplicity we also assume that $r\leq\lambda$.

This information acquired by the borrowers about each other's projects may be hard, when the borrower may either pass on the information to the bank officials to act on, or may act upon it herself. Alternatively, the evidence may be soft. In that case implementing

[9] In general the subscript refers to the borrower, while the superscript refers to the project.

[10] While some authors assume that the rate of interest is a choice variable for the bank (e.g. Ghatak, 2000), others assume that it is exogenously given (e.g. Besley and Coate, 1995). In this paper we follow Besley and Coate (1995) in assuming that the rate of interest is exogenous. Such an assumption makes sense when the government determines the rate of interest on non-economic, e.g. on political grounds.

the first project may involve various kinds of social sanctions, including those imposed by bank officials.[11]

For ease of exposition though, from now on we assume that the information is hard, and the borrowers simply pass on their information to the bank officials. Note that we do not allow for renegotiation among the borrowers regarding whether to pass on the information gathered through monitoring to the bank official or not. (Later, in Remark 1, we discuss the implications of this assumption.)

We assume that the moral hazard problem is not too small. This is formalized in Assumption 1 below.

Assumption 1. $H-r<b$.

2.1. Individual lending

We first describe the sequence of events under individual lending. There are three stages.

Stage 1. The bank decides whether to lend 1 dollar to an individual borrower.[12] If the loan is made then the game goes to the next stage.
Stage 2. The bank decides on its level of monitoring m.
Stage 3. The borrower then invests the 1 dollar loaned earlier into one of the two projects.

We solve for the subgame perfect Nash equilibrium of this game.

Stage 3: The first project is chosen if the bank is informed regarding the identity of the projects. In that case the bank gets back r, and the borrower obtains $H-r$. Otherwise the borrower chooses the second project. In that case the borrower gets b, but the bank does not obtain any repayment.
Stage 2: Consider the case where the bank has already lent 1 dollar to the borrower. Now the bank decides on the optimal level of monitoring. Note that the objective function of the bank is

$$mr - \frac{\lambda m^2}{2} - 1. \tag{1}$$

Clearly, the optimal level of bank monitoring $\hat{m}=(r/\lambda)$, the expected return of the bank is $(r^2/2\lambda)-1$ and that of the borrower is $(r/\lambda)\,(H-r)+(1-(r/\lambda))b$.
Stage 1: Given that $H>r$, the expected profit of the borrower is strictly positive. Depending on the monitoring cost parameter, λ, the expected profit of the bank may, or may not be positive.

Summarizing the above discussion we can write down our first proposition.

[11] In Section 5 we shall briefly discuss some forms of social sanctions.
[12] In our framework the borrowers are always willing to accept a loan.

Proposition 1. *Individual lending is feasible if and only if* $2\lambda < r^2$.

Thus individual lending is feasible provided monitoring costs are not too large. [13] Otherwise the bank does not have a sufficient incentive to monitor.

2.2. Group lending

We then describe the sequence of events under group lending.

Stage 1. The bank decides whether to lend 2 dollars to the group, which is divided equally among the two borrowers. There is joint liability, i.e. in case one of the borrowers fails to meet her obligation, then the other borrower has to repay for both of them (provided she has the capacity and the bank can make her).

Stage 2. The borrowers simultaneously decide on their level of monitoring. Let m_i denote the level of monitoring by the ith borrower. In case borrower i is successful in her monitoring effort, she uses this information to make the other borrower invests in her first project. Recall that we assume that this information is hard, and there is no renegotiation among the borrowers regarding whether to pass on the information to the bank official or not.

Stage 3. Both the borrowers then invest 1 dollar into one of the two projects. Joint liability implies that if the ith borrower invests in P_1^i and the jth borrower invests in P_2^j, then the jth borrower obtains b, the other borrower obtains nothing and the bank obtains H. In case both the borrowers invest in the first project then they both obtain $H-r$ and the bank is repaid $2r$. Whereas if both the borrowers invest in the second project, then they both obtain b and the bank does not get anything.

Note that in our formulation the moral hazard problem takes the form of project choice itself, rather than shirking following a project choice. Once made, the project choice is irreversible and further monitoring serves no purpose. Thus monitoring must precede project choice itself.

To begin with we solve for the first best level of monitoring when the monitoring level can be verified, but not the project choice. The aggregate welfare level is given by

$$\begin{aligned} &2m_1m_2H + m_1(1-m_2)(H+b) + m_2(1-m_1)(H+b) + (1-m_1)(1-m_2)2b \\ &\quad -\frac{m_1^2}{2} - \frac{m_2^2}{2} - 2\tilde{r}, \end{aligned} \tag{2}$$

where $\tilde{r}$ (≥ 1) represents the per unit opportunity cost of capital. Letting $\hat{m}$ denote the common optimal level of monitoring by the borrowers we have that

$$\hat{m} = \min\{1, H-b\}. \tag{3}$$

[13] A similar argument goes through if we assume that the bank first monitors a potential borrower and then decides whether to provide loan to this applicant or not.

It is clear that the marginal gain to the society from monitoring involves the borrowers choosing project 1 rather than project 2. Hence the above condition simply says that the marginal cost of monitoring equals the marginal social gain.

We then solve for the subgame perfect Nash equilibrium of this game.

Stage 3: If both the borrowers are successful in monitoring then they mutually ensure that they both invest in the first project. Then the bank gets back $2r$, and both the borrowers get $H-r$. If, however, both the borrowers fail in their monitoring efforts then they both invest in the second project. In that case both the borrowers obtain b, while the bank obtains nothing. Whereas if one of the borrowers is successful, while the other borrower fails, then the successful borrower invests in the second project, while the other one is made to invest in the first project. In that case the successful borrower obtains b, the unsuccessful one obtains nothing and the bank obtains H.

Stage 2: Next we solve for the Nash equilibrium of the game where the borrowers simultaneously decide on their level of monitoring. Clearly, the net payoff of the ith borrower is

$$m_i m_j (H-r) + m_i(1-m_j)b + (1-m_i)(1-m_j)b - \frac{m_i^2}{2}. \tag{4}$$

Hence the reaction function of the ith borrower is given by

$$m_i = m_j(H-r). \tag{5}$$

It is easy to see that the unique Nash equilibrium $(\tilde{m}_1, \tilde{m}_2)$ involves no monitoring, i.e. $\tilde{m}_i=\tilde{m}_j=0$.[14] Thus there is a problem of under-monitoring in the sense that the equilibrium level of monitoring is lower compared to the optimal level $\hat{m}$. In this case both the borrowers opt for the second project and has a net payoff of b, whereas the bank has a net payoff of -2.

The intuition behind the under-monitoring result relies on the fact that there is strategic complementarity between the monitoring levels of the two borrowers. A borrower monitors only because if the other borrower monitors, and she does not, then she is in trouble. Not only does she loose the private benefits from the second project, but she also has to pay out the whole of her income from the first project. By monitoring herself, she can at least increase her expected income from the first project. If, however, the other borrower does not monitor, then both these threats vanish and she has no incentive to monitor herself.

This result is clearly similar to that in Ghatak and Guinnane (1999). In a model where the borrowers choose effort levels, they also find that mere joint liability does not solve the moral hazard problem, for efficiency to increase one also requires that group-members choose their effort levels cooperatively. The similarity in the results is driven by the fact that in both the models the key strategic variables are strategic complements, namely effort levels in Ghatak and Guinnane (1999), and monitoring levels in the present paper.

[14] Strictly speaking, we have a unique Nash equilibrium provided $H-r$ is not equal to 1.

Stage 1: It is clear that the expected payoff of the bank is strictly negative. Thus in case of a loan the bank always makes a loss and group lending is not feasible.

Summarizing the above discussion we obtain our next proposition.

Proposition 2. *Group lending is not feasible.*

Proposition 2 identifies one potential problem with group lending, that of under-monitoring. Thus though peer monitoring is cheaper, the borrowers do not monitor at all. Given the somewhat surprising nature of the above result we now perform some robustness checks.

Remark 1. Note that under our formulation the borrowers necessarily report the results of the monitoring process to the bank. What happens if the borrowers could renegotiate among themselves regarding whether to report their findings to the bank or not?

Suppose that both the borrowers are successful in monitoring. If they renegotiate, i.e. agree not to report each other to the bank, then they both obtain b, rather than $H-r$, which is their payoff when they report each other. Given Assumption 1, there is clearly an incentive to renegotiate. Similarly, if only one of the borrowers is successful, then the payoff of the successful borrower is b irrespective of the report she makes to the bank. Thus the successful borrower gains nothing by reporting and may as well renegotiate.[15] Clearly, given that they are going to renegotiate, it is optimal for the borrowers not to monitor at all. The bank, knowing this, will not find it feasible to lend. Thus Proposition 2 goes through even if we allow for borrower renegotiation.

Remark 2. Consider the case where the lending scheme does not involve joint liability. Thus in case B_i invests in P_1^i and B_j invests in P_2^j, then the bank obtains r and B_i obtains $H-r$. Would the under-monitoring problem be resolved in this case? Clearly the net payoff of the ith borrower is

$$m_j(H-r) + \left(1-m_j\right)b - \frac{m_i^2}{2}. \tag{6}$$

Thus the payoff of the ith borrower is decreasing in m_i. Hence the equilibrium involves zero monitoring, and group-lending is not feasible.

Remark 3. Next consider a more general cost of monitoring function $f(m_i)$, where $f(m_i)$ is strictly increasing and convex in m_i, $\forall 0<m_i\leq 1$. Moreover, $f'(0)=0$. Clearly, the net payoff of the ith borrower is

$$m_im_j(H-r) + m_i\left(1-m_j\right)b + (1-m_i)\left(1-m_j\right)b - f(m_i). \tag{7}$$

Hence the reaction function of the ith borrower is given by

$$f'(m_i) = m_j(H-r). \tag{8}$$

Given the Inada condition it is easy to see that there is an equilibrium that involves no monitoring, i.e. $\tilde{m}_i=\tilde{m}_j=0$. While, there could be other equilibria involving positive levels

[15] Though note that the successful borrower gains nothing by renegotiating either.

of monitoring,[16] the payoff of the borrowers under such an equilibrium would be lower compared to the zero monitoring equilibrium.[17] Hence, if the borrowers could coordinate on the equilibrium with the greatest payoff, then the zero monitoring equilibrium will be selected. Next note that the first best level of monitoring involves min $\{1, f'^{-1}(H-b)\}>0$. Thus under the Inada condition we find that the payoff dominant equilibrium involves under-monitoring in the sense that the equilibrium level of monitoring is lower compared to the first best one.[18]

Remark 4. Next recall our assumption that $H\leq 2r$. We then examine what happens if we relax this assumption, i.e. if $H>2r$. For generality we still consider the cost of monitoring function $f(m_i)$, where $f'(0)=0$ and $f'(m_i), f''(m_i)>0$, $\forall 0<m_i\leq 1$. In that case the net payoff of the ith borrower is

$$m_i m_j(H-r)+m_i(1-m_j)b+(1-m_i)(1-m_j)b+(1-m_i)m_j(H-2r)-f(m_i). \tag{9}$$

Hence the reaction function of the ith borrower is given by

$$f'(m_i)=rm_j. \tag{10}$$

Given that $f'(0)=0$, it is easy to see that there is an under-monitoring equilibrium which involves no monitoring. Moreover, the zero monitoring equilibrium payoff dominates any other equilibria involving a positive level of monitoring.

3. Group-lending with sequential financing

In this section we consider a group-lending scheme with sequential financing where initially only one of the group members receive a loan. Depending on whether this loan is repaid or not, the bank decides on whether to make further advances.

[16] Such an equilibrium exists if and only if there is some $m\leq 1$, such that $f'(m)>m(H-r)$. In addition, if $f'''(m)>0$, then there is exactly one equilibrium with a positive level of monitoring. For example, if $f(m_i)=(m_i^3/3)$ then, apart from the zero monitoring equilibrium, there is another equilibrium with a positive level of monitoring min $\{H-r, 1\}$.

[17] Consider a positive monitoring equilibrium with a common level of monitoring m^*. The payoff of the borrowers in this equilibrium is given by

$$m^{*2}(H-r)+(1-m^*)b-f(m^*)\leq m^*(H-r)+(1-m^*)b-f(m^*)<m^*b+(1-m^*)b<b,$$

the payoff of the borrowers under the zero monitoring equilibrium.

[18] What happens if the monitoring cost does not satisfy the Inada condition that $f'(0)=0$? One interesting case is when $f(m)=(m^2/2)-am$, where $0<a\leq 1$ and $m\in[a, 1]$. In that case the equilibrium level of monitoring $\tilde{m}_i=\min\{1, a/(1-H+r)\}$, whereas the optimal level of monitoring $\tilde{m}=\min\{1, H-b+a\}$. Note that the equilibrium level of monitoring is strictly greater than a, the minimum possible level of monitoring. Next note that for a small, there is under-monitoring in the sense that $\tilde{m}>\tilde{m}_i$. For a large, however, there could be over-monitoring. For example if $H=3$, $b=2.5$, $r=2.25$ and $a=0.45$, then there is over-monitoring in the sense that $\tilde{m}=0.95<1=\tilde{m}_i$. I am indebted to an anonymous referee for this point, as well as encouraging me to examine the general monitoring function.

3.1. With joint liability

In this subsection we examine the case where the group-lending scheme involves both sequential financing and joint liability. Consider a two-period model where the sequence of actions can be described as follows.

Period 1:

Stage 1: The bank decides on whether to lend 1 dollar to the group or not. The bank puts another dollar to its alternative use, which yields $\tilde{r}$ dollars in the next period.

Stage 2: The borrowers simultaneously decide on their level of monitoring m_1 and m_2. They then report their findings to the bank.

Stage 3: One of the borrowers is randomly selected (with probability half) by the group as the recipient of the 1 dollar lent by the bank. This borrower, say B_i, then decides whether to invest in P_i^1 or P_i^2.

If B_i invests in P_i^2 then B_i obtains b, and this is the end of the game. Neither B_j nor the bank receives anything and there is no further lending in period 2.

Whereas if B_i invests in P_i^1 then there is a verifiable return of H, out of which the bank is repaid r, and the remaining $H-r$ yields $(H-r)\tilde{r}$ in period 2. We assume that $(H-r)\tilde{r}<1$, so that this amount is not sufficient to finance the investment in the next period. Without this assumption the group would be self-financing in period 2, thus taking away the need for sequential financing itself. Since we are interested in analyzing the implications of sequential financing, this assumption is a natural one to make.[19]

Period 2:

Stage 1: This stage arises only if B_i had invested in P_i^1 in stage 3 earlier. The bank lends a further 1 dollar to the group which is allocated to B_j who decides whether to invest it in P_j^1 or P_j^2. (Of course, if B_i had been successful in its monitoring efforts in period 1, then B_j will have to invest in P_j^1). If its invested in P_j^2 then B_j obtains b and the bank obtains $(H-r)\tilde{r}$. If its invested in P_j^1 then the bank obtains r, and the surplus $(H-r)(1+\tilde{r})$ is distributed between the two borrowers, so that B_j obtains $(H-r)(1+\tilde{r})$ and B_i obtains $(1-\alpha)(H-r)(1+\tilde{r})$.[20]

One can think of the α as being set by the bank itself. In the Grameen Bank, for example, in case all the borrowers manage to repay successfully, they get to keep the surplus. In our framework this implies that if both the borrowers invest in their first project, then, in the second period, the first recipient of the loan, i.e. B_i, obtains $(H-r)\tilde{r}$, whereas B_j obtains $H-r$. This corresponds to an allocation rule where $\alpha=(1/1+\tilde{r})$. Alternatively, the allocation rule can be interpreted as being set by the borrowers themselves through some form of side-contracting. In that case it would depend, among other things, on the

[19] Note that if $H>2r$, then the condition that $(H-r)\tilde{r}<1$ cannot hold. Thus the assumption that $H\leq 2r$ does play a role in this case.

[20] I am indebted to an anonymous referee for encouraging me to work with a general α.

relative bargaining power of the two borrowers. For simplicity, however, we take α to be exogenously given.

We then solve for the subgame perfect Nash equilibrium of this game. There are three cases to consider.

Case A: $\alpha(H-r)(1+\tilde{r})\geq b>((H-r)(1+\tilde{r})(1-\alpha)/\tilde{r})$.
Case B: $((H-r)(1+\tilde{r})(1-\alpha)/\tilde{r})\geq b>\alpha(H-r)(1+\tilde{r})$. In cases A and B we can say that the moral hazard problem is not too severe.
Case C: $b>\alpha(H-r)(1+\tilde{r})$, $((H-r)(1+\tilde{r})(1-\alpha))/\tilde{r}$.[21] In this case we can say that the moral hazard problem is very severe.

Recall that the allocation rule under the Grameen Bank is that $\alpha=(1/1+\tilde{r})$, so that $\alpha(H-r)(1+\tilde{r})=((H-r)(1+\tilde{r})(1-\alpha)/\tilde{r})=H-r$. Hence the allocation rule under the Grameen Bank corresponds to Case C.

Case A. As usual we solve the game through backwards induction. Let m denote the equilibrium level of monitoring for both the borrowers in this case. Straightforward calculations show that[22]

$$\bar{\mathrm{m}}=\min\left\{1,\frac{\alpha(H-r)(1+\tilde{r})}{2\tilde{r}}\right\}. \tag{11}$$

In case of an interior solution $\bar{\mathrm{m}}$ is increasing in H and decreasing in both r and $\tilde{r}$. Moreover, the equilibrium payoff of both the borrowers is

$$\frac{b}{2}(1-\bar{\mathrm{m}})+\bar{\mathrm{m}}\left[\frac{\alpha(H-r)(1+\tilde{r})}{4\tilde{r}}-\frac{\bar{\mathrm{m}}}{2}\right]\geq 0, \tag{12}$$

and that of the bank is

$$\bar{\mathrm{m}}\left(r+\frac{r+\tilde{r}-1}{\tilde{r}}-1\right)-1. \tag{13}$$

Note that in this case the payoff of the borrowers is increasing in b, whereas the payoff of the bank is independent of b. Clearly, in this case group-lending is feasible if and only if $\bar{\mathrm{m}}(r+(r+\tilde{r}-1/\tilde{r})-1)-1>0$.
Thus we find that the monitoring level is strictly positive and moreover, for some parameter values, group-lending is feasible.

The equilibrium outcomes in cases B and C are qualitatively similar.
Interestingly we find that there is a positive level of monitoring irrespective of the value of α, i.e. irrespective of the nature of side-contracting between the two borrowers. The intuition is as follows. Consider the problem facing, say, borrower 1. Even if borrower 2 does not monitor, borrower 1 has a positive incentive to monitor. Suppose that borrower 2

[21] Given that $b>H-r$ we can rule out the case where $((1-\alpha)(H-r)(1+\tilde{r}))/\tilde{r}$, $\alpha(H-r)(1+\tilde{r})\geq b$.
[22] The detailed derivation of this case, along with that of cases B and C has been relegated to Appendix A.

receives the loan in period 1. If borrower 1 does not monitor, then borrower 2 would invest in P_2^2 and borrower 1 would have a payoff of zero. By monitoring, however, she may force borrower 2 to invest in P_2^1 when the group gets an additional loan in the second period which comes to borrower 1. Moreover, given that borrower 1 is going to monitor, borrower 2 now has a greater incentive to monitor herself, and so on. All this constitutes an additional motivation for monitoring that is being generated by the sequential nature of the financing scheme. Under some parameter values this may be sufficient to ensure that group lending is feasible.

We are now in a position to write down our next proposition.

Proposition 3. *Consider group-lending with sequential financing and joint liability.*

- ***(i)*** *If $\alpha(H-r)(1+\tilde{r})\geq b>((H-r)(1+\tilde{r})(1-\alpha)/\tilde{r})$, then the common equilibrium level of monitoring $\bar{m}=\min\{1, (\alpha(H-r)(1+\tilde{r})/2\tilde{r})\}$. Moreover, such a scheme is feasible if and only if $\bar{m}(r+(r+\tilde{r}-1/\tilde{r})-1)-1>0$.*
- ***(ii)*** *If $((H-r)(1+\tilde{r})(1-\alpha)/\tilde{r})\geq b>\alpha(H-r)(1+\tilde{r})$, then the common equilibrium level of monitoring $m'=\min\{1, ((1-\alpha)(H-r)(1+\tilde{r}))/2\tilde{r}\}$. Moreover, such a scheme is feasible if and only if $m'(r+(r+\tilde{r}-1/\tilde{r})-1)>0$.*
- ***(iii)*** *If $b>\alpha(H-r)(1+\tilde{r})$, $((H-r)(1+\tilde{r})(1-\alpha)/\tilde{r})$, then the common equilibrium level of monitoring $m''=\min\{1, (b/b+2\tilde{r}-(H-r)(1+\tilde{r}))$. Moreover, such a scheme is feasible if and only if $m''^2(r/\tilde{r})+m''(r+(\tilde{r}-1/\tilde{r})-1)-1>0$.*

The following example shows that Proposition 3 is not vacuous.

Example 1.

- **(i)** Suppose that $H=4$, $b=2.5$, $r=2$, $\tilde{r}=2$ and $\lambda=10$. Note that this example satisfies the conditions that $H>b$, $r<H\leq 2r$, $r\leq\lambda$ and $H-r<b$. Moreover, neither individual, nor group lending is feasible.
  - **(a)** Suppose that $\alpha=(1/2)$. Then $\alpha(H-r)(1+\tilde{r})\geq b>((1-\alpha)(H-r)(1+\tilde{r}))/\tilde{r}$. Therefore, from Proposition 3(i), $\bar{m}=0.75$ and $\bar{m}(r+(r+\tilde{r}-1/\tilde{r})-1)-1=7/8$, so that sequential financing with joint liability is feasible.
  - **(b)** Next suppose that $\alpha=0$. Thus $((1-\alpha)(H-r)(1+\tilde{r})/\tilde{r})\geq b>\alpha(H-r)(1+\tilde{r})$. Therefore, from Proposition 3(ii), $m'=1$ and $m'(r+(r+\tilde{r}-1/\tilde{r})-1)-1=3/2$. Hence sequential financing with joint liability is feasible.
- **(ii)** Suppose that $H=4$, $b=3$, $r=2$, $\tilde{r}=2$, $\lambda=10$ and $\alpha=1/(1+\tilde{r})=(1/3)$. Again neither individual, nor group lending is feasible. Next note that $b>\alpha(H-r)(1+\tilde{r}),((H-r)(1+\tilde{r})(1-\alpha))/\tilde{r}$. Therefore, from Proposition 3(iii), $m''=1$ and $m''^2(r/\tilde{r})+m''(r+((\tilde{r}-1)/\tilde{r})-1)-1=1.5$. Thus there are parameter values such that sequential financing with joint liability and the Grameen allocation rule is feasible.

Remark 5. We then examine the implications of allowing for post-monitoring renegotiation by the borrowers in this case.

First consider the case where only one of the borrowers, say borrower j is successful in monitoring. Suppose she renegotiates i.e. chooses not to report her findings to the bank. If borrower i receives the bank loan in period 1, then she will invest in the second project, and borrower j will have a payoff of zero. Whereas by reporting her findings to the bank, she can ensure that borrower i will invest in her first project, thus ensuring a positive payoff for herself. Thus borrower j has no incentive to renegotiate.

Next consider the case where both the borrowers are successful in monitoring. In case there is no renegotiation the expected payoff of the borrowers is $(H-r)(1+\tilde{r})/2\tilde{r}$, whereas in case of renegotiation the expected payoff of the borrowers is $b/2$.[23] Thus under the additional assumption that $((H-r)(1+\tilde{r})/\tilde{r})\geq b$, the borrowers have no incentive to renegotiate and our results go through.[24]

3.2. Without joint liability

In this subsection we consider the case of sequential lending without joint liability. The objective is to examine if sequential financing alone (i.e. in the absence of joint liability) can solve the moral hazard problem.

The sequence of actions is the same as in case of sequential lending with joint liability, except for the following difference: If, in stage 3 of period 1, the borrower who obtains the 1 dollar invests this amount in the first project, then the bank obtains r and this borrower obtains $H-r$, irrespective of what the other borrower does in period 2. This borrower does not obtain any further payoff from the group in period 2.

In this case it is straightforward to show that there is a unique equilibrium level of monitoring[25]

$$\tilde{m} = \min\left\{1, \frac{b}{2\tilde{r}+b-H+r}\right\}. \tag{14}$$

Thus the equilibrium level of payoff of the borrowers involves

$$\frac{b}{2} + \tilde{m}^2\frac{H-r-b-\tilde{r}}{2\tilde{r}} + \tilde{m}\frac{\tilde{r}(H-r-b)+b}{2\tilde{r}}, \tag{15}$$

and that of the bank involves

$$\tilde{m}^2\frac{r}{\tilde{r}} + \tilde{m}\left(r+\frac{\tilde{r}-1}{\tilde{r}}-1\right) - 1. \tag{16}$$

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[23] It is straightforward to check that in case of renegotiation the first recipient will invest in the second project under all possible parameter values.

[24] Note that all three cases in Example 1 satisfy the condition that $((H-r)(1+\tilde{r}))/\tilde{r}\geq b$. In fact our analysis, not reported here, suggests that similar results go through even if $((H-r)(1+\tilde{r}))/\tilde{r}<b$.

[25] The expected payoff of the kth borrower in the second stage of period 1 can be written as follows:

$$m_k m_l\left(\frac{H-r}{2}+\frac{H-r}{2\tilde{r}}\right)+m_k(1-m_l)\left(\frac{b}{2}+\frac{b}{2\tilde{r}}\right)+(1-m_k)m_l\frac{H-r}{2}+(1-m_k)(1-m_l)\frac{b}{2}-\frac{m_k^2}{2}, k\neq l.$$

Thus the first order condition for the kth borrower is given by

$$\frac{m_l(H-r)}{2\tilde{r}}+\frac{b(1-m_l)}{2\tilde{r}}-m_k=0, k\neq l.$$

Given that the reaction functions are linear in m_k and m_l, a unique equilibrium exists.

Thus even in this case we find that there is a positive level of monitoring in equilibrium. The intuition is very similar to that in the previous subsection and is generated by the sequential nature of the financing scheme. Note, however, that the rate of monitoring is lower compared to that for the case when there is both sequential financing, as well as joint liability (see Proposition 4(ii) below). This is quite intuitive. With joint liability there is an additional incentive for monitoring. While this is not sufficient to solve the moral hazard problem by itself, in the presence of sequential financing it leads to an increased rate of monitoring.

Summarizing the above discussion we obtain our next proposition.

Proposition 4. *Consider group-lending with sequential financing but without joint liability.*

(i) *The common equilibrium level of monitoring* $\tilde{m}=\min\{1, (b/(2\tilde{r}+b-H+r))\}$*. Moreover, such a scheme is feasible if and only if* $\tilde{m}^2(r/\tilde{r})+\tilde{m}(r+((\tilde{r}-1)/\tilde{r})-1)-1>0$*.*

(ii) *The rate of monitoring under sequential financing with joint liability is greater (strictly greater if* $\tilde{m}<1$*) than that under sequential financing without joint liability.*

Remark 6. We can again examine the implications of allowing for renegotiation in this case. It is straightforward to see that the analysis in Remark 5 goes through in this case as well.

We then provide an example to show that there could be parameter values where sequential group-lending without joint liability dominates both individual lending and ordinary group-lending.

Example 2. Suppose $H=4$, $r=2$, $b=3$, $\tilde{r}=1$ and $\lambda=4$. Clearly, neither individual, nor group lending is feasible. It is easy to check that $\tilde{m}=1$ and $\tilde{m}^2(r/\tilde{r})+\tilde{m}(r+((\tilde{r}-1)/\tilde{r})-1)-1=2$. From Proposition 4(i) sequential financing without joint liability is feasible. Finally, it is easy to see that this Example satisfies the condition that $((H-r)(1-\tilde{r}))/\tilde{r}\geq b$.

Our analysis in this subsection demonstrates that there is a justification for sequential financing even in the absence of joint liability lending. In contrast, Ray (1999) views sequential financing as a device for avoiding the coordination problems arising out of joint liability lending. Given that in the presence of involuntary default joint liability lending has some problems, this is a finding of some importance. However, in the presence of joint liability the rate of monitoring is higher, thus leading to a greater rate of repayment.

4. Group-lending with bank monitoring

We now consider group-lending schemes with active bank monitoring. For simplicity, in this section we assume that $H-r<1$.[26]

[26] Note that $H-r<1$ implies that $H\leq 2r$. The assumption that $H-r<1$, is, however, for ease of exposition alone. Thus we can relax the assumption that $H-r<1$, and hence the assumption that $H\leq 2r$ without affecting the results qualitatively.

4.1. With joint liability

In this subsection we consider the case where there is both bank monitoring, as well as joint liability lending.

The sequence of events in this case is as follows.

Stage 1. The bank decides whether to lend 2 dollars to the group, which is divided equally among the two borrowers.

Stage 2. The bank decides on its level of monitoring. Let M_i denote the level at which the bank monitors the ith borrower. In case the bank gets to know the identity of the ith borrower's project, it passes on this knowledge to both the borrowers.

Stage 3. The borrowers simultaneously decide on their level of monitoring m_1 and m_2. They then report their findings to the bank.

Stage 4. Both the borrowers then invest 1 dollar into one of the two projects. There is joint liability. Thus if borrower 1 invests in P_1^1 and borrower 2 invests in P_2^2, then borrower 1 obtains 0, the bank obtains H and borrower 2 obtains b.

We can again solve for the subgame perfect Nash equilibrium of this game. In Appendix A we show that the equilibrium involves a positive level of monitoring by the banks. The intuition is as follows. Consider the subgame where the bank succeeds in its monitoring regarding, say, borrower B_i alone and it is the borrowers turn to monitor. Clearly, B_j has no incentive to monitor. Whereas given that B_i's payoff from monitoring is given by $m_i(H-r)-m_i^2/2$, B_i will monitor at a strictly positive level (i.e. $H-r$). Otherwise B_j would invest in the second project and B_i, who would have to invest in the first project, would have a payoff of zero. Thus the bank, by monitoring itself, can induce further monitoring by the borrowers themselves.

In fact there is an unique equilibrium where the bank monitors both the borrowers at the level $\widehat{\mathrm{M}}$. Clearly,

$$\widehat{\mathrm{M}} = \min\left\{1, \frac{(H-r)2r + (1-H+r)H}{2[\lambda - r + (H-r)2r + (1-H+r)H]}\right\}, \tag{17}$$

and the equilibrium payoff of the bank $\hat{\mathrm{B}}(\widehat{\mathrm{M}},\widehat{\mathrm{M}})$ is given by

$$\widehat{\mathrm{M}}^2 2r + 2\widehat{\mathrm{M}}(1-\widehat{\mathrm{M}})[(H-r)2r + (1-H+r)H] - 2 - 2\lambda\widehat{\mathrm{M}}^2. \tag{18}$$

Thus whether this scheme is feasible or not depends on $\hat{\mathrm{B}}(\widehat{\mathrm{M}},\widehat{\mathrm{M}})$.

We are now in a position to write down our next proposition (see Appendix A for the proof).

Proposition 5. *Consider group-lending with bank monitoring and joint liability. Such a scheme is feasible if and only if* $\hat{B}(\widehat{M},\widehat{M})>0$.

The intuition behind Proposition 5 is as follows. As we argued earlier, bank monitoring has a pump-priming effect, so that by undertaking relatively costly monitoring itself, the bank induces more efficient monitoring by the borrowers themselves. Under certain conditions this might be sufficient to make it feasible. Example 3 below shows that Proposition 5 is not empty.

Example 3. Suppose H=3.5, r=2.5, b=2 and λ=2.5. Clearly neither individual, nor group lending is not feasible. Moreover, $\widehat{\mathrm{M}} = 0.5$ and $\widehat{\mathrm{B}}(\widehat{\mathrm{M}}, \widehat{\mathrm{M}}) = 0.5>0$, so that group-lending with active bank monitoring and joint liability is feasible.

Remark 7. We then examine the implications of allowing for post-monitoring renegotiation in this case. Clearly, the interesting case is when the bank has been successful regarding say, B_i, and subsequently B_i has also been successful in her monitoring regarding B_j. In case B_i reports her findings to the bank she obtains a payoff of $H-r$, whereas if she renegotiates then she obtains a payoff of zero (since in that case B_j will invest in the second project). Thus in this case there is no incentive to renegotiate.

4.2. Without joint liability

In this subsection we examine if bank monitoring alone (i.e. even in the absence of joint liability) can solve the moral hazard problem.

The sequence of events in this case is the same as in the previous subsection. However, there is no joint liability. Thus, in stage 4, if borrower i invests in P_i^1 and borrower j invests in P_j^2, then borrower i obtains $H-r$, the bank obtains r and borrower j obtains b.

Notice that in the absence of joint liability there is no incentive for peer monitoring. Utilizing this fact it is straightforward to show that in equilibrium the aggregate level of monitoring by the bank $\widetilde{\mathrm{M}} = \frac{r}{\lambda}$, and the equilibrium payoff of the bank is given by

$$r\,\widetilde{\mathrm{M}} - 2 - \lambda\frac{\widetilde{\mathrm{M}}^2}{2} = \frac{r^2}{2\lambda} - 2. \tag{19}$$

Thus whether this scheme is feasible or not depends on $(r^2/2\lambda)-2$.

We are now in a position to write down our next proposition (see Appendix A for the proof).

Proposition 6. *Consider group-lending with bank monitoring but without jointliability.*

(i) *Such a lending scheme is feasible if and only if* $(r^2/2\lambda)-2>0$.
(ii) *If individual lending is not feasible, then group lending with bank monitoring but without joint lending is also not feasible.*
(iii) $\widehat{M} > \frac{\tilde{M}}{2}$.

The intuition behind Proposition 6(ii) is as follows. Recall that the advantage of bank monitoring is that, by creating an informational asymmetry among the borrowers, it induces a positive level of monitoring by the borrowers themselves. This effect, however, depends on the interdependence between the borrowers' payoffs created through joint liability. In the absence of joint liability this linkage is broken and the scheme effectively reduces to one of individual monitoring. Hence the result.

Remark 8. We then observe that since there is no peer monitoring in this case anyway, allowing for borrower renegotiation will not affect our results.

Thus a group-lending scheme involving both bank monitoring and joint liability may solve the under-monitoring problem associated with group-lending schemes. However, if individual lending is not feasible then bank monitoring without joint liability is not feasible either. Moreover, in the absence of joint liability the rate of monitoring by the bank is lower.

5. Discussion

In this section we discuss the robustness of our analysis to renegotiation and side-contracting.[27]

Recall that in this paper we do not allow for post-monitoring renegotiation by the borrowers. However, we have earlier argued (in particular in Remarks 1, 5–8) that the results are not affected to any great extent even if we do allow for such renegotiation. Even so it may be interesting to think of situations where the no renegotiation assumption makes sense.

One such scenario is when the bank can costlessly observe the monitoring outcomes. In this context it is interesting that there are weekly meetings between Grameen Bank officials and the borrowers, which might facilitate such observations by the bank officials. While such meetings are clearly not costless, the marginal cost of finding out if the borrowers monitored successfully may be quite low if the bank officials are going to hold such meetings for other reasons anyway.

Social sanctions may, perhaps, provide an alternative and more interesting justification for our modelling approach. Besley and Coate (1995) build a model where there are social sanctions against the group-members if they harm the other group-members.[28] Clearly, in their framework there is an even greater incentive for such renegotiation since reporting to the bank would reduce the payoff of the other group member. One can, however, generalize their notion so that such social sanctions accrue whenever any member of the village community is harmed, and not just the other group members.[29] Next note that the bank's future loans to the other members of that particular village may depend on the repayment record of the current groups. In the Grameen Bank, for example, sometimes loan officers at the center level (a center being a collection of 5 to 8 groups) suspend all loan disbursements by that center until all debts are up-to-date (see Schreiner, 2003). In such a scenario renegotiation might affect the future loan prospects of the other villagers leading to social disapproval.[30] While there is clearly a tension between these two forms of

[27] I am grateful to two anonymous referees for encouraging me to think through the issues discussed in this section, as well as in Remarks 1, 5–8.

[28] See the paper by Besley and Coate (1995) for a succinct introduction to the literature on social sanctions.

[29] In fact social exchange theory suggests that an individual cares about social approval and will face social disapproval whenever his action imposes a cost on another person. See, for example, Homans (1961).

[30] In the Grameen Bank context such social disapproval also arise when the center chiefs scold women defaulters, or detain them in the center longer than necessary (see Rahman, 1999).

social sanctions, under some situations, however, the second effect may be dominant enough to prevent renegotiation.

Another related issue is the possibility of side-contracting by the borrowers. As discussed earlier, such side-contracting may take the form of bargaining over the allocation rule α under sequential financing. As Proposition 3 demonstrates, however, the basic intuition is robust to such side-contracting.

Side-contracts may also take the form where the borrowers agree not to monitor at all (assuming that the no monitoring outcome is contractible). How does such side-contracting affect our results? Clearly, it does not affect Proposition 2 at all, since, under ordinary group-lending, there is zero monitoring in equilibrium anyway. However, in the presence of such side-contracting group-lending without sequential financing is clearly not feasible. Moreover, group-lending with bank monitoring is also not attractive since the raison d'etre behind bank monitoring is to induce further monitoring by the borrowers themselves.

Suppose, however, that while the no monitoring outcome can be contracted upon, the actual project choice cannot be. In that case it is clear that writing such side-contracts is not profitable for the borrowers. Consider the case of sequential financing. Given that the other borrower does not monitor, both the borrowers have an incentive to deviate and monitor at some positive level.[31] Similarly in case of group-lending with bank monitoring, if the bank obtains information regarding exactly one of the borrowers, then this borrower will have an incentive to deviate and monitor at the level $H-r>0$.

Such side contracts may, however, be profitable if the borrowers can also contract upon the actual project choice. Under sequential financing, for example, the borrowers may contract that neither borrower will monitor and that the first recipient will invest in the second project and share the proceeds equally. Under certain parameter conditions this may be profitable for the borrowers.[32]

Finally, given that the borrowers do not know the identity of the other borrower's projects, it may be difficult to implement contracts specifying the no monitoring outcome. Again social sanctions may help to sustain such contracts, though, as discussed earlier, such social sanctions may operate in rather complex fashions.

Clearly, these issues are important for a proper understanding of the problems associated with group-lending. Given their complexity, however, a more detailed investigation of these questions must await future work.

One interesting paper that does allow for side contracting and renegotiation possibilities is by Rai and Sjostrom (2004). They study a mechanism design problem with limited side contracting where the borrowers submit reports about each other to the bank. Rai and

[31] For example, consider the case where $\alpha(H-r)(1+\tilde{r})\geq b>((H-r)(1+\tilde{r})(1-\alpha)/\tilde{r})$. In this case the monitoring level of borrower i, given that borrower j does not monitor, is given by $\min\{1, (\alpha(H-r)(1+\tilde{r})/2\tilde{r})\}>0$. The analyses for the other cases are similar.

[32] Consider Example 1(i)(a). Note that the equilibrium payoff of the borrowers is given by $(b/2)(1-\bar{m})+\bar{m}[((\alpha(H-r)(1+\tilde{r}))/4\tilde{r})-(\bar{m}/2)]=0.3125$, whereas the payoff under the proposed side-contracting is $b/2=1.25$.

Sjostrom (2004) demonstrate that despite the limited side contracting ability, there is a mechanism that induces mutual insurance, and is, moreover robust to collusion against the bank. The model used is one of strategic default and abstracts from moral hazard and adverse selection. While the model is quite different from ours, one of their main results is similar in flavor: Joint liability by itself is not sufficient to provide mutual insurance, in addition one also requires cross-reporting.

6. Conclusion

The recent success of the Grameen Bank has led to the adoption of group-lending schemes by many NGOs and governments. Given this fact we need to have a clear understanding of the various aspects of such schemes, including possible problems with such schemes. In this paper we focus on one such possible pitfall, that of under-monitoring. Thus under group lending, while monitoring may be relatively cheap (because of peer monitoring), there is too little of it. This makes ordinary group lending infeasible, even when there is joint liability. We then demonstrate that the under-monitoring problem may be resolved if the group-lending schemes involve either sequential financing, or a combination of lender monitoring and joint liability. Given that in reality group-lending schemes often involve either one or both these features, these findings are of some importance. Our analysis also throws some light on the interplay between the various aspects of group-lending. We demonstrate that sequential financing may succeed even if there is no joint liability. Given that in the presence of involuntary default joint liability lending has a serious problem, this is of some interest. The repayment rate is, however, higher if sequential financing schemes also involve joint liability. In the absence of joint liability, however, bank monitoring is likely to fail.

Finally, the analysis in this paper allows one to draw some tentative policy conclusions:

1. Group lending schemes should involve either sequential financing, or a combination of lender monitoring and joint liability. If, as is the case with this model, the under-monitoring problem is very severe, then joint liability by itself may not ensure the feasibility of group lending schemes.
2. If there is a serious problem of involuntary default, making joint-liability-lending infeasible, then group-lending schemes with sequential financing, but without joint liability may be feasible.
3. If, however, involuntary default is not a serious problem, then group-lending schemes should also involve joint liability. Apart from other reasons, well known in the literature, we find that the monitoring rates are higher when joint liability is present.

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Appendix A

Proof of Proposition 3(i). As usual we solve the game through backwards induction.

Period 2:

Stage 1: Consider the case where B_i had invested in P_i^1 earlier. Note that it is optimal for B_j to invest in P_j^1 since his payoff from investing in P_j^1, i.e. $\alpha(H-r)(1+\tilde{r})$ is greater than his payoff from investing in P_j^2, i.e. b. Thus irrespective of whether B_i was successful in monitoring or not, B_j invests in P_j^1.

Period 1:

Stage 3: The outcome is going to depend on what happened in the monitoring subgame earlier. Thus there are several cases to consider.

Suppose both B_1 and B_2 were successful in their monitoring efforts. In that case B_j ensures that B_i invests in P_i^1.

Next consider the case where B_i was successful and B_j failed in its monitoring efforts. In that case B_i's payoff from investing in P_i^2 is b. Whereas if B_i invests in P_i^1, then, in period 2, B_j is also going to invest in P_j^1, when the present discounted value of B_i's payoff is $((H-r)(1+\tilde{r})(1-\alpha))/\tilde{r}$. Given that $b>((H-r)(1+\tilde{r})(1-\alpha))/\tilde{r}$, it is clearly optimal for B_i to invest in P_i^2.

Next suppose that B_j was successful, while B_i had failed in monitoring. In that case B_j ensures that B_i invests in P_i^1.

Finally consider the case where both B_i and B_j had failed in their monitoring efforts. In that case B_i invests in P_i^2.

Stage 2: We then consider the monitoring subgame. Note that the kth borrower's expected payoff in stage 2 is given by

$$\begin{aligned} & m_k m_l\left(\frac{\alpha(H-r)(1+\tilde{r})}{2\tilde{r}}+\frac{(1-\alpha)(H-r)(1+\tilde{r})}{2\tilde{r}}\right) \\ & \quad + m_k(1-m_l)\left(\frac{b}{2}+\frac{\alpha(H-r)(1+\tilde{r})}{2\tilde{r}}\right) \\ & \quad + (1-m_k)m_l\frac{(H-r)(1+\tilde{r})(1-\alpha)}{2\tilde{r}} \\ & \quad + (1-m_k)(1-m_l)\frac{b}{2}-\frac{m_k^2}{2}, k\neq l. \end{aligned} \tag{20}$$

Thus the reaction function of B_k is given by

$$\begin{aligned} & m_l\frac{(H-r)(1+\tilde{r})}{2\tilde{r}}+(1+m_l)\left(\frac{b}{2}+\frac{\alpha(H-r)(1+\tilde{r})}{2\tilde{r}}\right) \\ & \quad - m_l\frac{(H-r)(1+\tilde{r})(1-\alpha)}{2\tilde{r}}-(1-m_l)\frac{b}{2}-m_k=0, k\neq l. \end{aligned} \tag{21}$$

After simplification the above equation yields that $m_k=(\alpha(H-r)(1+\tilde{r})/2\tilde{r})$. Hence letting $\bar{m}$ denote the equilibrium level of monitoring for both the borrowers

$$\bar{m}=\min\left\{1,\frac{\alpha(H-r)(1+\tilde{r})}{2\tilde{r}}\right\}. \tag{22}$$

Thus the equilibrium level of payoff of the borrowers is

$$\frac{b}{2}(1-\bar{m})+\bar{m}\left[\frac{\alpha(H-r)(1+\tilde{r})}{4\tilde{r}}-\frac{\bar{m}}{2}\right]\geq 0, \tag{23}$$

and that of the bank is

$$\begin{aligned}\bar{m}^2\left(r+\frac{r+\tilde{r}-1}{\tilde{r}}-2\right)&+2\bar{m}(1-\bar{m})\left[\frac{1}{2}\left(r+\frac{r+\tilde{r}-1}{\tilde{r}}-2\right)-\frac{1}{2}\right]\\ &-(1-\bar{m})^2=\bar{m}\left(r+\frac{r+\tilde{r}-1}{\tilde{r}}-1\right)-1.\end{aligned} \tag{24}$$

Stage 1: Clearly, in this case group-lending is feasible if and only if $\bar{m}(r+(r+\tilde{r}-1/\tilde{r})-1)-1>0$. □

Proofs of Propositions 3(ii) and 3(iii). Very similar to that of Proposition 3(i) and hence omitted. □

Proof of Proposition 4(ii). First consider the case when $\alpha(H-r)(1+\tilde{r})>b\geq((1-\alpha)(H-r)(1+\tilde{r}))/\tilde{r}$. It is sufficient to show that

$$\frac{\alpha(H-r)(1+\tilde{r})}{2\tilde{r}}>\frac{b}{2\tilde{r}+b-H+r}. \tag{25}$$

Given that $\alpha(H-r)(1+\tilde{r})>b$, it is sufficient to show that $(1/2\tilde{r})>(1/(2\tilde{r}+b-H+r))$. Given Assumption 1 this is always satisfied.

Next suppose that $((1-\alpha)(H-r)(1+\tilde{r})/\tilde{r})>b\geq\alpha(H-r)(1+\tilde{r})$. It is sufficient to show that

$$\frac{(1-\alpha)(H-r)(1+\tilde{r})}{2\tilde{r}}>\frac{b}{2\tilde{r}+b-H+r}. \tag{26}$$

Given that $((1-\alpha)(H-r)(1+\tilde{r})/\tilde{r})>b$, it is sufficient to show that $(1/2)>(1/(2\tilde{r}+b-H+r))$, which is always satisfied.

Finally, consider the case where $b>((1-\alpha)(H-r)(1+\tilde{r}))/\tilde{r}$, $\alpha(H-r)(1+\tilde{r})$. In this case it is sufficient to show that

$$\frac{b}{b+2\tilde{r}-(H-r)(1+\tilde{r})}>\frac{b}{2\tilde{r}+b-H+r}. \tag{27}$$

Given the parameter restrictions this is always satisfied. □

Proof of Proposition 5

Stage 4: First consider the stage 4 subgame. Suppose both the borrowers get to know the identity of each others projects, either through their own monitoring efforts, or through that of the bank. Then the borrowers ensure that they both invest in the first project, the bank gets back $2r$ and both the borrowers get $H-r$.

If, however, neither of the borrowers knows the identity of the other borrower's project then they both invest in the second project. In that case both the borrowers obtain b, while the bank obtains nothing.

Whereas if one of the borrowers is informed, while the other borrower is uninformed, then the informed borrower invests in the second project, while the other one is made to invest in the first project. In that case the informed borrower obtains b, the uninformed borrower obtains nothing and the bank obtains H.

We then consider the stage 3 subgame. There are three cases to consider.

First consider the case where the bank succeeds with both the borrowers. Then there is no need for the borrowers to do any further monitoring.

Next consider the case the case where the bank fails with both the borrowers. As argued before, in equilibrium both the borrowers choose not to monitor.

Finally, consider the case where the bank succeeds regarding, say, borrower B_i alone. Clearly, B_j has no incentive to monitor. B_i's payoff from monitoring is given by

$$m_i(H-r) - \frac{m_i^2}{2}. \tag{28}$$

Hence B_i's level of monitoring is given by $H-r>0$.

Stage 2: We then consider the stage 2 subgame. Note that the expected payoff of the bank $\hat{\mathrm{B}}(M_i, M_j)$ equals

$$M_iM_j2r + \left[M_j(1-M_i) + M_i(1-M_j)\right]\left[(H-r)2r + (1-H+r)H\right] - 2 - \frac{\lambda(M_i+M_j)^2}{2}. \tag{29}$$

Thus the first order conditions are

$$\frac{\partial \hat{B}(M_i, M_j)}{\partial M_i} = M_j2r + [(H-r)2r + (1-H+r)H][1-2M_j] - \lambda(M_i+M_j) = 0, i \neq j. \tag{30}$$

From the first order conditions it is easy to see that the equilibrium is symmetric, with $M_i=M_j$. Given that the equilibrium is symmetric it is easy to see that the second order condition is also satisfied. Let the equilibrium level of M_i and M_j be denoted by $\hat{\mathrm{M}}$. Clearly,

$$\hat{\mathrm{M}} = \min\left\{1, \frac{(H-r)2r + (1-H+r)H}{2[\lambda - r + (H-r)2r + (1-H+r)H]}\right\}. \tag{31}$$

Given that $\lambda \geq r$ and $H-r \leq 1$, it follows that $((H-r)2r+(1-H+r)H)/2[\lambda-r+(H-r)2r+(1-H+r)H])>0$. Thus the equilibrium payoff of the bank is given by

$$\widehat{\mathrm{B}}(\widehat{\mathrm{M}}, \widehat{\mathrm{M}}) = \widehat{\mathrm{M}}^2 2r + 2\widehat{\mathrm{M}}(1-\widehat{\mathrm{M}})[(H-r)2r + (1-H+r)H] - 2 - 2\lambda\widehat{\mathrm{M}}^2. \tag{32}$$

Stage 1: Note that the equilibrium payoff of the both the borrowers is positive. Thus whether this scheme is feasible or not depends on $\widehat{\mathrm{B}}(\widehat{\mathrm{M}}, \widehat{\mathrm{M}})$. □

Proof of Proposition 6

(i) Notice that in the absence of joint liability there is no incentive for peer monitoring. Therefore the bank's payoff function is

$$M_i M_j 2r + r\left[M_j(1-M_i) + M_i\left(1-M_j\right)\right] - 2 - \frac{\lambda\left(M_i+M_j\right)^2}{2}$$

$$= r\left(M_i+M_j\right) - 2 - \frac{\lambda\left(M_i+M_j\right)^2}{2}. \tag{33}$$

Hence the first order condition yields $r-\lambda(M_i+M_j)=0$. Clearly, while the aggregate level of monitoring has a unique solution, the exact values of M_i, M_j are indeterminate. Thus letting $\tilde{\mathrm{M}}$ denote the aggregate level of monitoring in equilibrium, we have that $\tilde{\mathrm{M}}=(r/\lambda)$. For any M_i, M_j such that $M_i+M_j=(r/\lambda)$, the payoff of the bank is the same. Hence the equilibrium payoff of the bank is given by

$$r\tilde{\mathrm{M}} - 2 - \frac{\lambda\tilde{\mathrm{M}}^2}{2} = \frac{r^2}{2\lambda} - 2. \tag{34}$$

It is clear that the equilibrium payoff of the both the borrowers is positive. Thus whether this scheme is feasible or not depends on $(r^2/2\lambda)-2$.

(ii) Recall that the expected payoff of the bank is $(r^2/2\lambda)-2$. Given that individual lending is not feasible, $(r^2/2\lambda)-2<1$. Hence $(r^2/2\lambda)-2<0$.

(iii) This reduces to showing that $2r(H-r)+(1-H+r)H>r$. Given that $2r \geq H > r$, this always holds. □

References

Adam, D.W., Vogel, R., 1984. Rural financial markets in low-income countries: recent contributions and lessons. World Development 14, 477–487.

Aghion, B., de Morduch, J. Armendiariz, 1998. Microfinance Beyond Group-Lending. Working paper, University College, London.

Banerjee, A., Besley, T., Guinnane, T.W., 1994. Thy neighbor's keeper: the design of a credit cooperative with theory and a test. Quarterly Journal of Economics 109, 491–515.

Besley, T., Coate, S., 1995. Group lending, repayment schemes and social collateral. Journal of Development Economics 46, 1–18.

Braverman, A., Guasch, J.-L., 1984. Rural credit markets and institutions in developing countries: lessons for policy analysis from practice and modern theory. World Development 14, 1253–1267.

Christen, R.P., Rhyne, E., Vogel, R., 1994. Maximizing the Outreach of Micro-Enterprise Finance: The Emerging Lessons of Successful Programs. International Management and Communications Corporation Paper, Washington, DC.

Deschamps, J.J., 1989. Credit for the Rural Poor: The Experience in Six African countries: Synthesis Report. Development Alternatives, Washington, DC.

Ghatak, M., 1999. Group lending, local information and peer selection. Journal of Development Economics 60, 27–50.

Ghatak, M., 2000. Screening by the company you keep: joint liability lending and the peer selection effect. Economic Journal 110, 601–631.

Ghatak, M., Guinnane, T.W., 1999. The economics of lending with joint liability: theory and practice. Journal of Development Economics 60, 195–228.

Goldsmith, R., 1969. Financial Structure and Development. Yale University Press, New Haven, CT.

Gurley, J., Shaw, E., 1955. Financial aspects of economic development. American Economic Review 65, 515–538.

Homans, G.H., 1961. Social Behavior: Its Elementary Form. Harcourt, Brace and World, New York.

Hossein, M., 1998. Credit for the Alleviation of Rural Poverty: The Grameen Bank in Bangladesh, Research Report 65, IFPRI, February.

Khandker, S., Khalily, B., Khan, Z., 1995. Grameen bank: performance and sustainability. World Bank Discussion Paper, 306.

Levine, R., 1997. Financial development and economic growth: views and agenda. Journal of Economic Literature 35, 688–726.

Morduch, J., 1999. The micro-finance promise. Journal of Economic Literature 37, 1564–1614.

Rahman, A., 1999. Micro-credit initiatives for equitable and sustainable development: who pays? World Development 27, 67–82.

Rai, A., Sjostrom, T., 2004. Is Grameen lending efficient? Repayment incentives and insurance in village economies, Review of Economic Studies 71, 217–234.

Ray, D., 1999. Development Economics. Oxford University Press, New Delhi.

Rochin, R., Nyborg, I., 1989. Organizing credit cooperatives for small farmers: factors conducive for operational success. Journal of Rural Cooperation 26, 57–87.

Rochin, R., Solomon, J., 1983. Cooperative Credit Programs for Small Farmers in Developing Countries: A Compendium of Recent Studies. University of California Davis, Department of Agricultural Economics.

Schreiner, M., 2003. A cost-effectiveness analysis of the Grameen bank of Bangladesh. Development Policy Review 21, 357–382.

Stiglitz, J., 1990. Peer monitoring and credit markets. World Bank Economic Review 4, 351–366.

Tassel, E.V., 1999. Group-lending under asymmetric information. Journal of Development Economics 60, 3–25.

Varian, H., 1990. Monitoring agents with other agents. Journal of Institutional and Theoretical Economics 146, 153–174.

Wenner, M., 1995. Group credit: a means to improve information transfer and loan repayment performance. Journal of Development Studies 32, 263–281.

Wydick, B., 1999. Can social cohesion be harnessed to repair market failures? Evidence from group-lending in Guatemala. Economic Journal 109, 463–475.