Queuing for Credit: Increasing the Reach of Microfinance Through Sequential Group Lending

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Abstract

We examine a group-lending microfinance institution's ability to lend to wealth-less individuals. The project productivity maybe the source of economic rents, which the lender leaves the borrowers to solve the hidden action problem. Consequently, wealth-less borrowers with low productivity project would be denied access to these loans. We examine the mechanism of sequential group lending used by some practitioners. We show that within the class of wealth-less borrowers, sequential lending reduces the minimum project productivity threshold, thus widening the access to the credit.

Keywords: Group–lending, Collusion, Peer-monitoring, Sequential finance, Microfinance
JEL Classification: O12, O2, D82, G20.

1 Introduction

The recurrent theme in the microfinance literature has been that individuals with negligible wealth, who are too poor to borrow individually may become credit-worthy if they borrow collectively in a group under contracts where they are made jointly-liable for each other's outcomes. It was the simple, catchy poverty alleviation mantra that caught the imagination of both the academics and the practitioners in the post Washington Consensus world in the 1990s. After two decades, there are signs of discomfort in both these communities with this idea of group lending. This discomfort with group lending has been captured comprehensively by Karlan and Morduch (2009). In light of this, our objective here is to reexamine the design of group lending institutions very carefully with the aim of highlighting issues that may constrain a group lending institution's ability to reach the poor. In doing so, we challenge the prevalent notion that a simple group lending mechanism could potentially allow the microfinance institutions to lend to all individuals who do not possess collateralisable wealth. We examine whether an innovative mechanism currently being used by some practitioners could widen the reach of group lending microfinance institutions. The hope is that incorporating this innovative design element may enrich the idea of group lending and enhance its ability to alleviate poverty.

In a usual lending contract, the lender aligns the borrower's incentives with his own by asking the borrower to post collateral. Consequently, poor individuals who do not possess any collateralisable wealth get left out of the credit market. The literature in microfinance has shown that with group lending, the lender is able to use joint-liability to align the borrowers' incentive with his own and incentivize them to *screen* (Armendáriz de Aghion and Gollier (2000), Ghatak (1999), Ghatak (2000), Van Tassel (1999), Sadoulet (2000)), *monitor* (Conning (2005), Roy Chowdhury (2005), Ghatak and Guinnane (1999), Jain and Mansuri (2003) Laffont and Rey (2003)) and *audit* (Besley and Coate (1995), Che (2002), Rai and Sjöström (2004)) their peers. This allows the lender to lend to groups of borrowers even if they do not posses any collateralisable wealth. For a comprehensive survey of group lending, see Ahlin and Townsend (2007), Ghatak and Guinnane (1999), Morduch (1999) and Armendáriz de Aghion and Morduch (2005).

When lending to an individual borrower who does not posses collateral, the lender can only incentivize effort if he leaves her sufficient economic rents. In group lending, the lender can use joint-liability to punish the borrowers for their peer's failure. Consequently, through joint-liability the lender can give borrowers an incentive to influence their peer's decisions and reduce the economic rents left to the borrowers in the group. Of course, with an imperfect information environment, economic rents may be reduced with group lending but they do not go away entirely. The pertinent question is whether these economic rents constrain group lending institutions' ability to reach a certain section of poor.

The paper suggests that a important source of economic rents maybe the value of the project output or more specifically the productivity of the project. Consequently, the wealth-less borrower's projects would be financed only if it is above a productivity threshold. In a cohort of poor individuals, the ones with projects productivity below the threshold would get left out of group lending.[1] This may severely curtail the reach of the microfinance institutions. The ability of microfinance organisations to reach the poor has been a worry in practice (Conning (1999), Morduch (1999) and Morduch (2000)). Thus, if a mechanism could reduce the economic rents retained by the borrowers in group lending, it would also reduce the threshold level of project productivity that is financed by group lending institution and enhance their coverage of the poor.

By default, it is presumed that in group lending, every individual gets their loans simultaneously. This is indeed the case in many group lending microfinance organisations across the world like the ACCION affiliated ones in Latin America and North America. Conversely, Grameen Bank in Bangladesh and the NABARD inspired Self-Help Group (SHG) Linkage Programme[2] in India disburse the loan sequentially within the group. In sequential group lending the borrowers in a group queue for credit and a particular borrower does not obtain a loan unless the previous borrower has repaid her loan.

In this paper, we examine conditions under which sequential group lending reduces the economic rents as compared to simultaneous group lending. We also find conditions under which sequential group lending is able to finance lower productivity projects as compared with simultaneous group lending.

[1]There is an analogy here with the financing of the venture capital firms. Venture capital firms may get financing without any collateral if the lender expect their output to be sufficiently lucrative. Conversely, venture capital firms with low productivity projects do not end up getting financed.

[2]See Aniket (2006) for a detailed description of the mechanism used by the SHG Linkage Programme.

The theme in the moral hazard literature in microfinance has been that when lending to a group of jointly-liable wealth-less borrowers, it is more efficient for the lender to incentivize effort collectively for the group rather than individually. In analysing an effort choice model in a group composed of two borrowers, Ghatak and Guinnane (1999) show that group lending with joint liability is more efficient than individual lending if the borrowers can influence each other's actions. Thus, in a single-task environment, incentivizing the group to exert high effort collectively is less expensive than incentivizing each group member individually. In a similar vein, Stiglitz (1990) shows that the group makes more prudent project choices when given the incentive to do so collectively.

Conning (2000) extends the Ghatak and Guinnane (1999) single-task environment to a two-task environment. In Ghatak and Guinnane (1999), borrowers could costlessly influence each other's effort choices. Conning (2000) looks at a two-task environment, where both the tasks of exerting effort and monitoring their peers is costly. The assumption is that borrowers can no longer observe each other's effort choices. They can only influence each other's effort choices through monitoring. Specifically, the task of monitoring reduces the peer's (opportunity) cost of exerting effort. Since the tasks are complementary in nature, the lender would find it optimal to induce monitoring and effort through a group lending joint-liability contract (Itoh, 1991).

Conning (2000) shows that if the borrowers influence each other's effort choice through costly monitoring, then there are two possible equilibria. The "*good equilibrium*" where both borrowers monitor each other and exert high effort and a "*bad equilibrium*" where both borrower don't monitor each other and exert low effort. The lender allocates the borrowers sufficient rents to make the good equilibrium more lucrative.

When the lending is simultaneous, the group is viewed by the lender as an composite entity and borrowers are treated symmetrically. Since the lender prefer to incentivize the effort collectively, the borrowers retain rents they would have retained if they had an ability to collude perfectly. This is irrespective of whether they actually have an ability to collude or not. On reflection we find that the default mechanism of simultaneous group lending analysed by Conning (2000) is only feasible when collusion is beneficial for the lender and the lender has no option but to leave the borrowers collusion rents.[3] It is useful to note that the borrowers do not need any side contracting ability to be able to retain collusion rents.

This paper extends the Conning (2000) two-task framework to analyse sequential group lending where a randomly chosen borrower borrows in the first period with the proviso that the second borrower does not get the loan if the first borrower's project fails. In Conning's simultaneous lending framework, the borrowers make their monitoring and effort choices simultaneously, whereas in sequential lending, the borrowers' effort and monitoring choices are temporally separated. This forces the borrower to interact strategically amongst themselves. We show that separating the effort and monitoring choices temporally lowers borrower's economic rents in sequential group lend-

[3]In a principal multi-agent environment, Mookherjee (1984) suggests that the problem of collusion could have two sources. With multiplicity of Nash Equilibria, there may exist another Nash equilibrium that the agents prefer to the one the principal is trying to implement. Conversely, the agents may choose their task co-operatively, leading to an Nash equilibrium that is different from the one the principal is trying to implement.

ing. The borrowers no longer retain collusion rents by default. They will obtain collusion rents only if they have an explicit ability to side-contract on effort and monitoring choices.

Further, we vary the information environment by varying the efficiency of the monitoring technology. This does not change the information problem between the lender and borrower. It only lowers the cost of borrowers' influencing each other's effort choices. We find that as monitoring becomes cheaper for the borrowers, the borrowers' rents decreases in both sequential and simultaneous group lending, though borrowers always retain lower rents in sequential group lending. Taking the limit, as the borrower's cost of influencing their peer's decision tends to zero, the sequential group lending tends to the first best as the borrower's information rent tends to zero. Conversely, in simultaneous group lending the borrowers' still retains significant economic rents as this happens.

As the borrower's cost of influencing their peer's decision tends to zero, we move from the two-task framework to the single task framework and it is not surprising the economic rents in simultaneous group lending are exactly the ones that the borrower retains in single-task group lending model in Ghatak and Guinnane (1999). Consequently, if borrowers are not able to monitor each other costlessly, lending sequentially is able to reduce the economic rents associated with group lending.

In sequential group lending, the second borrower's punishment for the first borrower's failure is denial of credit. Consequently, from the lender's perspective, not lending to the second borrower if the first borrower's project fails is expensive and may lower the lender's expected payoff in sequential lending as compared to simultaneous lending. This has to be weighed up against the lower rents in sequential lending. We show that if the monitoring technology is sufficiently efficient, a greater range of low productivity projects are financed in sequential as compared to simultaneous lending and vice versa.

Early on in the literature, Varian (1990) explored the benefits of sequential lending in a setup with high and low productivity borrowers. Varian (1990) showed that, if the high and the low type are grouped together, sequential lending gives the high type the incentive to school the low type, thus raising the overall productivity of the group. Ray (1998), in a footnote, has suggested that sequential lending is able to minimises the possibility of group members defaulting in expectation that other group members would default.

In an important recent contribution, Roy Chowdhury (2005) has analyses the sequential lending mechanism in a moral hazard environment. The paper compares the borrower's repayment rate in simultaneous and sequential group lending. It shows that simultaneous group lending results in the no-monitoring low-effort (bad) equilibrium and then proceeds to show that sequential group lending can attain the positive monitoring high effort equilibrium by enhancing the incentives for peer monitoring. As Cason et al. (2008) have pointed out, the Roy Chowdhury (2005) only compares the bad equilibrium in simultaneous lending to the sequential lending equilibrium. Roy Chowdhury (2005) does not take into account the result in Conning (2000), which shows that there would always be two equilibria, the good and the bad one. This paper contributes to the literature by comparing the lender's cost of inducing the positive-monitoring high-effort (good) equilibrium in simultaneous group lending to the sequential group lending. Further, we find conditions under which sequential group lending would allow microfinance institutions to reach a great proportion of the poor.

2 Model

There are two agents, borrowers 1 and 2, who have have access to identical projects, each requiring a lump-sum investment of 1 unit of capital. The project produces an uncertain and observable outcome x, valued at $\bar{x}$ when it succeeds (s) and 0 when it fails (f).

The borrowers are risk neutral, with zero reservation wage and no wealth. Agent i may choose to pursue the aforementioned project with a high (H) or low (L) effort e_i, which is unobservable to everyone. With a high (low) effort, $\bar{x}$ is realised with a probability π^h (π^l) and 0 with $1-\pi^h$ ($1-\pi^l$). ($\pi^h > \pi^l$) We assume that the project outcomes are statistically independent.

By exerting low effort, agents obtain non-pecuniary and non-transferable private benefits of value B from the project. These private benefits could be curtailed by monitoring by the borrower's peer j undertaken at cost c_j. c is observable amongst the borrowers but unobservable to the lender. We assume that the monitoring function $B(c)$ is continuous, $B(0) > 0$ and for all $c, \epsilon \geqslant 0$, $B(c) \geqslant B(c+\epsilon) \geqslant 0$.

The lender is risk-neutral. He is unable to monitor the agents and can only incentivize them through their payoffs. He can observe the initial capital invested and the project output and enforce the contracts. The lender operates in a competitive market and makes zero profits on funds loaned. He has access to capital at ρ, the opportunity cost of capital.

In group lending, the lender offers a group-contract to a group consisting of borrower 1 and 2. The borrowers are jointly-liable such that each borrower's pecuniary payoff b_{ij} is contingent on the state of the world $i, j = \{s, f\}$ defined by the respective outcomes of borrower 1 and 2's project. The borrowers get a symmetric non-negative (limited-liability) pecuniary payoffs, i.e., $b_{fs} = b_{sf}$. Borrower 1's final payoff (and symmetrically for borrower 2) is given by $\Pi_1[(e_1, c_1), (e_2, c_2)] = E[b_{ij}|e_1, e_2] - c_1 + \left[\frac{\pi^h - \pi_1}{\Delta\pi}\right] B(c_2)$.

3 Individual Lending

In individual lending, the lender offers a contract (b_s, b_f) that satisfies the participation constraint $E[b_i|H] \geqslant 0$, the incentive-compatibility constraint $E[b_i \mid H] \geqslant E[b_i \mid L] + B(0)$, and the limited-liability constraint $b_i \geqslant 0$; $i = s, f$. Lender's optimal contract $\left(b_s = \frac{B(0}{\Delta\pi},\ b_f = 0\right)$ ensures that limited-liability constraint binds for state f only allowing the borrower to retain strictly positive limited-liability rents.

Using the lender's feasibility condition $E[x \mid H] \geqslant E[b_i \mid H] + \rho$, we find that the set of feasible projects is $\bar{x} \geqslant \frac{\rho}{\pi^h} + \frac{B(0)}{\Delta\pi} = \bar{x}_{ind}$. Of course, in a perfect information environment, the incentive-compatibility constraint would be irrelevant and all socially viable projects, $\bar{x} \geqslant \frac{\rho}{\pi^h}$, would be financed by the lender.

4 Group lending

Limited liability restricts the lender's ability to use payoffs to punish a borrower if her project fails. Conversely, joint-liability allows the lender the use of payoffs to punish a successful borrower if her peer's project fails. Consequently, a lender can use a joint-liability group-contract to give each borrower an explicit incentive to influence her peer's effort decision by monitoring her and thus reducing the likelihood of the peer's project failing.

4.1 Simultaneous Group Lending

If the borrowers accept the group contract offered by the lender, they obtain loans for their respective projects simultaneously. We show below that with costly monitoring, the lender has to leave sufficient rents to satisfy the following two conditions. (1) The individual borrower's incentive compatibility condition associated with effort and (2) the group's collective incentive compatibility condition.

The game is played in two stages. The agents simultaneously choose their monitoring intensities (c_1, c_2) in the first stage and their effort choices (e_1, e_2) in the second stage. A given pair of monitoring intensities (c_1, c_2) determines the payoff structure of the subgame $\xi(c_1, c_2)$ in effort decisions in the second stage.

Timing: At *t=0*, the lender offers the two borrowers identical contracts $(b_{ss}, b_{sf}, b_{fs}, b_{ff})$ and the game continues if they accept. At *t=1*, the two borrowers simultaneously choose c_1 and c_2. At *t=2*, the two borrowers simultaneously choose e_1 and e_2. Project outcomes are realised at *t=3* and the borrowers get symmetric payoffs b_{ij}.

If ss occurs, the two agents are most *likely* to have undertaken the requisite monitoring to induce high effort from their respective peer and vice versa if ff occurs. Consequently, the lender should reward ss and punish ff to the maximum extent possible. With limited liability $b_{ff} \geqslant 0$. Increasing b_{ss} sharpens the incentive for the borrowers to exert high effort and make ss more likely. With risk-neutral borrowers, there is no point in rewarding intermediate outcomes sf and fs. Consequently the lender offers contract $(b_{ss}, 0, 0, 0)$.

We show in Appendix A that if the following two conditions are met, a pure strategy Subgame Perfect Nash Equilibrium (SPNE) of the game is the one where both borrower exert high effort on the their respective projects.

The first condition is each borrower's incentive compatibility constraint for effort level in the subgame $\xi(c, c)$ where $c > 0$.

$$b_{ss} \geqslant \frac{B(c)}{\pi^h \Delta\pi} \qquad \text{(Condition 1)}$$

As monitoring increases, inducing high effort becomes cheaper for the lender. The second condition is the group's collective incentive compatibility condition which ensures that the borrowers prefer the *good equilibrium* where both monitor with intensity $c > 0$ and exert high effort over the *bad equilibrium* where both borrowers don't monitor and exert low effort.

$$b_{ss} \geqslant \frac{B(0) + c}{{\pi^h}^2 - {\pi^l}^2} \qquad \text{(Condition 2)}$$

Rents required to satisfy Condition 2 are increasing in c. Simultaneous group lending was infeasible in Roy Chowdhury (2005, Proposition 2,page 423) because condition 2 remained unsatisfied. Although, within a group, monitoring makes incentivizing the individual effort cheaper at the margin (Condition 1), it makes satisfying both tasks collectively more expensive (Condition 2). We summarise with the following proposition.

Proposition 1. *Simultaneous group lending is feasible if the borrowers are allocated rents which satisfy conditions 1 and 2.*

To minimise the rents, the lender induces c_{sim} defined by $B(c_{sim}) = \alpha(B(0) + c_{sim})$ where $\alpha = \frac{\pi^h}{\pi^h+\pi^l}$. Borrower's expected payoff is given by $E(b_{ij} \mid HH) = \frac{\pi^h}{\Delta\pi}B(c_{sim})$. The lender's feasibility condition, $E[x_i \mid HH] \geqslant \rho + E[b_{ij} \mid HH]$, gives us $\bar{x} \geqslant \frac{\rho}{\pi^h} + \frac{\alpha}{\Delta\pi}\left[B(0)+c_{sim}\right] = \bar{x}_{sim}$, the set of projects that can be financed under simultaneous group lending. Since $\bar{x}_{sim} < \bar{x}_{ind}$, simultaneous lending is an improvement over individual lending.

4.2 Sequential Group Lending

If the lender allocates credit sequentially, only one borrower gets the loan per period with the proviso that the second borrower obtains the loan only if the first one succeeds. A randomly chosen borrower borrows first, whom we call B_1. Her peer B_2 can only borrow if B_1's project succeeds.

Timing: At *t=0*, the lender offers B_1 and B_2 an identical group contract (b_{ss}, b_{sf}, b_f) and the game continues if they accept. At *t=1*, B_2 chooses c_2 and at *t=2*, B_1 chooses e_1. B_1's project outcome is realised at *t=3*. If B_1's project fails, both agents get b_f and the game terminates. Conversely, if B_1's project succeeds, the game continues. At *t=4*, B_1 chooses c_1 and at *t=5* B_2

chooses e_2. At t=6, B_2's project outcome is realised. If B_2's project succeeds, both agents get b_{ss}, otherwise they get b_{sf}.

In Appendix B, we show that both borrowers exerting high effort is the SPNE of the game if the following condition is met.

$$b_{ss} \geqslant \frac{1}{\pi^h \Delta\pi} \max \left[B(c), c\right] \qquad \text{(Condition 3)}$$

Proposition 2. *Sequential group lending is feasible if the borrowers are allocated rents which satisfy condition 3.*

In sequential lending, the lender only needs to satisfy the individual's incentive compatibility condition associated with monitoring and effort. Unlike simultaneous lending, the group's collective incentive compatibility condition doesn't need to be satisfied. In simultaneous group lending, allowing the group to decide on the tasks simultaneously meant that both tasks had to be incentivized simultaneously. By separating the decision temporally, the lender only has to incentivize the tasks individually at each stage.

To minimise the rents that the borrowers retain, the lender would like to induce monitoring intensity c_{seq} defined by $B(c_{seq}) = c_{seq}$ and the borrower's expected payoff is given by $E[b_{ij} \mid HH] = \frac{\pi^h}{\Delta\pi} B(c_{seq})$.

Lender's feasibility condition gives us, $\bar{x} \geqslant \frac{\rho}{\pi^h} + \frac{2}{(1+\pi^h)\Delta\pi} c_{seq} = \bar{x}_{seq}$, the set of feasible projects under sequential lending.

Punishing the group if the first borrower's project fails is expensive for the lender. The lender expects to pay the borrower more frequently per unit capital lent in sequential as opposed to simultaneous group lending.[4]

[4]In simultaneous lending, the lender expects to lend 2 units of capital, obtain output

Conversely, the borrower's payoffs depend on the monitoring function and are comparatively lower in sequential lending. Comparing the least productive project is thus non-trivial for a general monitoring function. Section 5.3 has some comparative statics for the general monitoring function. Assuming a linear functional form allows us to get a definite result in Section 5.4.

5 Discussion

In simultaneous lending, Conditions 1 and 2 are satisfied above segments ED and AB respectively in Figure 1. In sequential lending, Condition 3 is satisfied above segments ED and OC. Lender's problem gets solved at H in simultaneous and at G in sequential group lending. Consequently, the borrower's payoff is higher in simultaneous as compared to sequential lending with condition 2 remaining slack.

In simultaneous lending, the borrowers take their monitoring and effort decisions simultaneously and thus earn *collusion rents* by default as Condition 2 gets satisfied. No ability to side-contract is not required to earn collusion rents. Conversely, colluding in sequential lending requires explicit side-contracting ability as decisions on actions are separated temporally.

5.1 Delegated Monitoring

Group lending is plagued with the possibility of collusion between the borrowers in the group. Understanding how collusion is prevented in the delegated

$2\pi^h$ and pay borrowers with the probability $(\pi^h)^2$. In sequential lending, the lender expects to lend $(1 + \pi^h)$ units of capital, obtain output $\pi^h(1 + \pi^h)x$ and pay borrowers with the probability $(\pi^h)^2$.

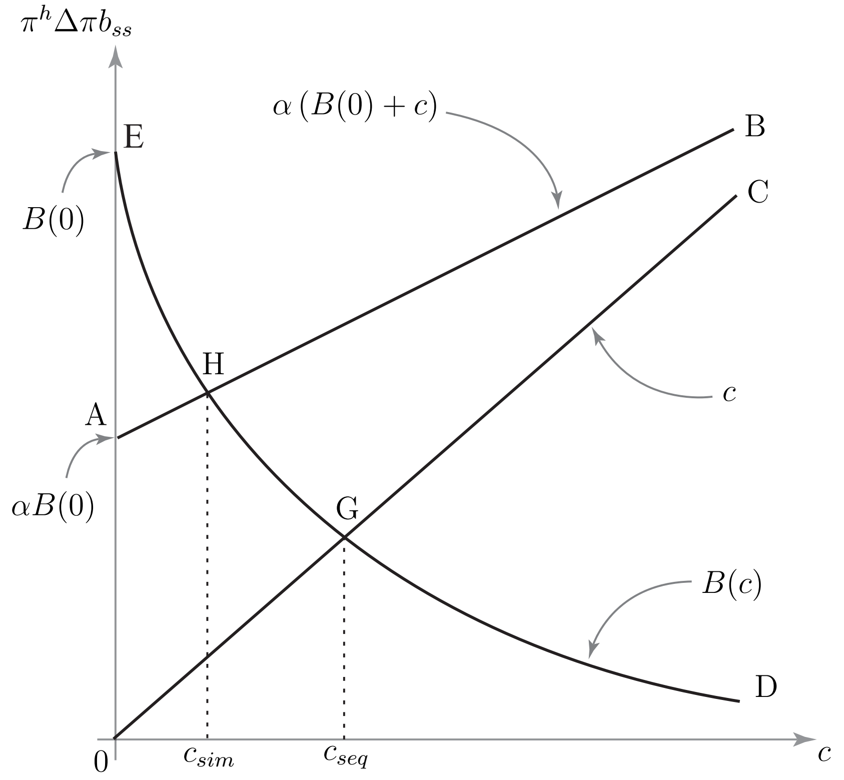

Figure 1: Monitoring Intensities in Group lending

monitoring helps us better understand how it can be prevented in group lending.

Like the effort level, the lender cannot observe the task of monitoring. If the lender delegates the task of monitoring, he makes the monitor's payoff contingent on the borrower's project outcome. This gives the monitor the requisite incentive to influence the borrower's effort choice by monitoring her and curtailing her private benefits B. This particular lending mechanism is partially akin to joint liability in group lending, where the two borrowers' project outcomes affect each other's payoffs.

The borrower's and monitor's contracts work in conjunction with each other. The borrower's contract aims to influence her effort choice directly through her payoff. The lender is also able to influence the borrower's effort choice indirectly through the monitor's contract.

The lender's problem is set out in Appendix C. We find that the borrower's and monitor's incentive compatibility constraints bind in the optimal contract. Their respective participation constraints remain slack and their limited liability constraints bind only in state f. The lender induces monitoring of intensity c_{dm} by offering the borrower a state contingent contract $\left(\frac{B(c_{dm})}{\Delta\pi}, 0\right)$ and the monitor a contract $\left(\frac{c_{dm}}{\Delta\pi}, 0\right)$, where $c_{dm} = {B_c}^{-1}(-1)$.[5]

The lender delegates the task of monitoring only if $B_c(0) < -1$, that is, the benefit of curtailing the borrower's private benefit initially is not overwhelmed by the payoff allocated to the monitor. The lender induces monitoring till the marginal benefit from additional monitoring is matched by its marginal cost.

5.2 Collusion

Earning collusion rents does not require any side-contracting ability in simultaneous group lending. The borrowers take their monitoring and effort decisions simultaneously and consequently incur the cost of monitoring and obtain private benefits, simultaneously.

Conversely, colluding in sequential group lending is not trivial given that the decision on actions are separated temporally. The borrowers incur their monitoring costs and obtain private benefits at different points in time. Thus, to collude, they need to be able to sign and enforce contracts across time.

[5]For only the delegated monitoring case, we need an additional assumption on the monitoring function: $B(c)$ is continuous and at least twice differentiable.

For instance, by not monitoring, B_1 (B_2) saves on monitoring costs at $t = 4$ ($t = 1$) and B_2 (B_1) obtains the private benefits from low effort at $t = 5$ ($t = 2$). The subgame(s) of the sequential group lending game is (are) almost identical to the delegated monitoring case we analysed above.

In group lending, the group's incentive compatibility condition (Condition 2) can also be interpreted as the no-collusion condition. This condition tells us when the group members would have an incentive to collude if they have an ability to side contract on effort and monitoring choices.

Given that in simultaneous group lending, the borrowers do not need any ability to side contract to be able to retain collusion rents, the lender has to ensure that Condition 2 is always satisfied. Otherwise, simultaneous group lending is not feasible. Conversely, Condition 2 remains slack in sequential group lending and the borrowers could potentially benefit from colluding, that is, by coordinating on the no-monitoring low-effort equilibrium.

Given that monitoring costs and private benefits are non-pecuniary, the borrowers would collude through side-contracting if either (a) the non-pecuniary costs and benefits were transferable amongst them or (b) if they had the ability to sign and enforce side contracts on actions across time. We summarise with the following proposition.

Proposition 3. *The lender is able to exploit the group's inability to fully side-contract on actions over time in sequential group lending to lower the borrower's rents.*

5.3 Varying Peer Monitoring Technology

In this section we examine the effect of varying the efficiency of the peer monitoring technology. We introduce a parameter β which measures the efficiency of the peer monitoring technology. Higher values of β are associated with greater efficiency of the peer monitoring technology. We impose the following additional assumption on the monitoring function $B(c, \beta)$.

Assumption 1 (Monitoring function $B(c, \beta)$)**.**

i. $B(0, \beta) = B_0 > 0 \ \forall \beta \geqslant 0$

ii. $B(c, \beta)$ *is continuous and at least once differentiable* $\forall \beta, c \geqslant 0$

iii. $B_c(c, \beta) < 0, \ \ B_\beta(c, \beta) < 0 \ \forall \beta, c \geqslant 0$

For any given β, $\bar{x}_{sim}$ and $\bar{x}_{seq}$, the least productive projects financed under simultaneous and sequential group lending respectively, are given by $\bar{x}_{sim} = \frac{\rho}{\pi^h} + \frac{1}{\Delta\pi}\left[B(c_{sim}, \beta)\right]$ and $\bar{x}_{seq} = \frac{\rho}{\pi^h} + \frac{2}{(1+\pi^h)\Delta\pi}\left[B(c_{seq}, \beta)\right]$, where c_{seq} and c_{sim} are defined by for a given β by $B(c_{seq}, \beta) = c_{seq}$ and $B(c_{sim}, \beta) = \alpha(B_0 + c_{sim})$.

Proposition 4.

i. As the peer monitoring technology becomes more efficient, a greater range of projects are feasible under both simultaneous and sequential group lending mechanisms.

ii. With an extremely efficient peer monitoring technology ($\beta \to \infty$)*, some socially viable projects are not feasible with simultaneous group lending,* *whereas all socially viable projects are feasible under sequential group lending.*

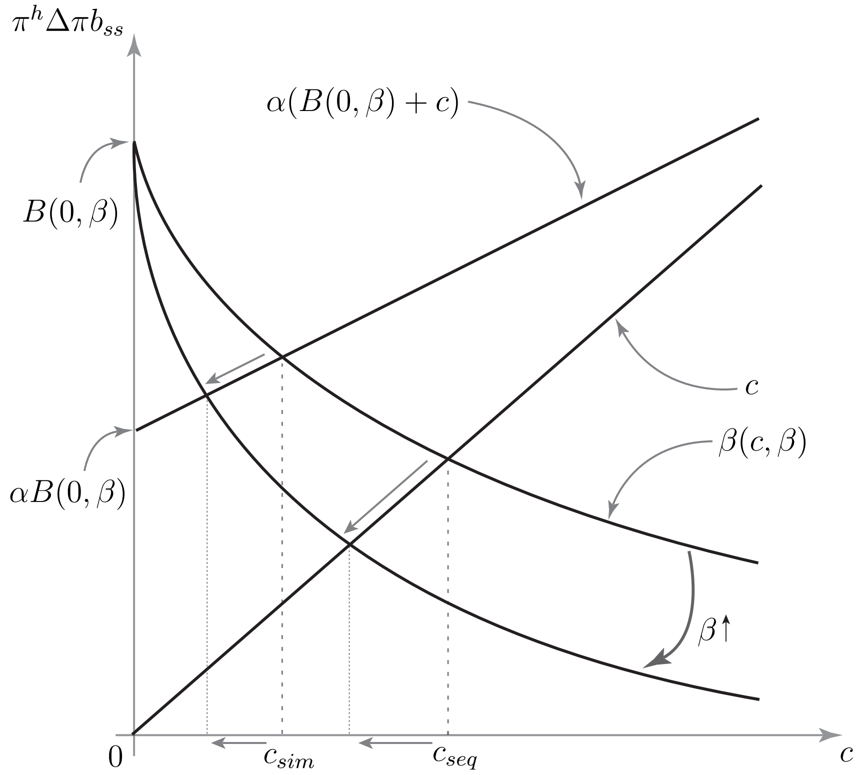

Figure 2: c_{sim} and c_{seq} as Monitoring Efficiency Varies

We see the effects of a more efficient peer monitoring technology on the borrower's payoff in Figure 2. In Appendix D, we show that as the peer monitoring technology becomes more efficient (β increases), the borrowers in both group lending mechanism get lower rents. $\bar{x}_{sim}$ and $\bar{x}_{seq}$ decrease as the lender is able to finance lower productivity projects.

Further, as $\beta \to \infty$, $c_{sim} \to 0 \Rightarrow \bar{x}_{sim} \to \frac{\rho}{\pi^h} + \frac{\alpha B(0)}{\Delta\pi}$ and $c_{seq} \to 0 \Rightarrow \bar{x}_{seq} \to \frac{\rho}{\pi^h}$. Sequential lending approaches the first best and $\bar{x} \in \left[\frac{\rho}{\pi^h}\,,\, \frac{\rho}{\pi^h} + \frac{\alpha B(0)}{\Delta\pi}\right)$ is the set of socially viable projects that are feasible under sequential but not under simultaneous lending.

5.4 Linear Monitoring Function

We use a linear monitoring function $B(c, \beta) = \max[(B(0) - \beta \cdot c), 0]$ to determine conditions under which sequential lending finances a greater range of projects. The effectiveness of the peer monitoring technology is increasing in β.

$\bar{x}_{seq} \geqslant \bar{x}_{sim}$ if $\beta \geqslant -\left(2 - \frac{k}{\alpha}\right) + \sqrt{\left(2 - \frac{k}{\alpha}\right)^2 + 4(k-1)} > 0$ (where $k = \frac{2}{1+\pi^h}$), that is sequential lending finances a greater range of projects if the monitoring technology is sufficiently efficient. See Appendix E for details. This is because the difference in the borrower's rents increase with β. Conversely, the lender payoffs of the borrowers more frequently per unit of capital lent. If β sufficiently high, a comparatively greater range of projects get financed with sequential group lending.

6 Conclusion

The contribution of this paper is to show that in microfinance the rhetoric of lending to wealth-less individuals may obfuscate the truth. Within the cohort of wealth-less individuals, the ones with low productivity projects may get left out due to economic rents. This may explain why microfinance institutions are often criticised for not being able to reach the poorest of the poor. If the borrower's ability to influence each other's decisions is sufficiently cheap, by adopting sequential group lending mechanism, the microfinance institutions could potentially lend to wealth-less individuals who do not have access to high productivity projects.

Appendix

A Simultaneous Group lending

$\frac{B(c)}{\pi^h \Delta\pi} \leqslant b_{ss} \leqslant \frac{B(c)}{\pi^l \Delta\pi}$ ensures that the $\{(c,H),(c,H)\}$ and $\{(c,L),(c,L)\}$ are the two Nash equilibria of a subgame $\xi(c,c)$, with former preferred[6] over the latter by the borrowers.

$\{(c,L),(0,L)\}$ and $\{(0,L),(c,L)\}$ and $\{(0,L),(0,L)\}$ are the only Nash equilibria in their respective subgames $\xi(c,0)$, $\xi(0,c)$ and $\xi(0,0)$ if $b_{ss} < \frac{B(0)}{\pi^h \Delta\pi}$ holds.

Moving up the game tree, $\{(c,H),(c,H)\}$ is the SPNE if $\Pi_m[(c,H),(c,H)] \geqslant \max\left[\Pi_m[(c,L),(0,L)], \Pi_m[(0,L),(c,L)], \Pi_m[(0,L),(0,L)]\right]$ for $m = \{1,2\}$, which holds if the condition $b_{ss} \geqslant \frac{B(0)+c}{\pi^{h^2} - \pi^{h^2}}$ is met.[7]

Since the lender minimises b_{ss}, we can ignore the upper bounds and summarise the two conditions as $b_{ss} \geqslant \frac{1}{\pi^h \Delta\pi} \max\left[B(c), \alpha(B(0)+c)\right]$.

B Sequential Group Lending

At $t = 5$, B_2 chooses $e_2 = H$ ($e_2 = L$) if B_1 has previously chosen $c_1 = c$ ($c_1 = 0$) at $t = 4$ if $\frac{B(0)}{\Delta\pi} > b_{ss} \geqslant \frac{B(c)}{\Delta\pi}$ holds. At $t = 4$, B_1 chooses $c_1 = c$ if $b_{ss} \geqslant \frac{c}{\Delta\pi}$ holds. To summarise, if $\frac{B(0)}{\Delta\pi} > b_{ss} \geqslant \frac{\max[B(c),c]}{\Delta\pi}$ holds, B_1 would

[6] since this range satisfies $b_{ss} \geqslant \frac{B(c)}{(\pi^h+\pi^l)\Delta\pi}$

[7] Since $\Pi_m[(0,L)(0,L)] \geqslant \max\left[\Pi_m[(c,L),(0,L)], \Pi_m[(0,L),(c,L)]\right]$, this condition ensures that $\Pi_m[(c,H),(c,H)] \geqslant \Pi_m[(0,L),(0,L)]$.

choose $c_1 = c$ at $t = 4$ and B_2 would choose $e_2 = H$ at $t = 5$.

At $t = 3$, the uncertainty about B_1's project outcome is resolved. At $t = 2$, B_1 chooses $e_1 = H$ ($e_1 = L$) if B_2 has chosen $c_2 = c$ ($c_2 = 0$) at $t = 1$ if $\frac{B(0)}{\pi^h \Delta\pi} > b_{ss} \geqslant \frac{B(c)}{\pi^h \Delta\pi}$ hold. At $t = 1$, B_2 chooses $c_2 = c$ if $b_{ss} \geqslant \frac{c}{\pi^h \Delta\pi}$ holds. To summarise, B_2 chooses $c_2 = c$ at $t = 1$, B_1 chooses $e_1 = H$ at $t = 2$, B_1 chooses $c_1 = c$ at $t = 4$ and B_2 chooses $e_2 = H$ at $t = 5$ if the $\frac{B(0)}{\Delta\pi} > b_{ss} \geqslant \frac{\max[B(c),c]}{\pi^h \Delta\pi}$ holds.

C Delegated Monitoring

The lender offers the borrower a contract (b_s, b_f) and the monitor a contract (w_s, w_f) which solves the following problem: $\max_{b_i,w_i,c} \big(E[x_i|H] - E[b_i|H] - E[w_i|H]\big)$ subject to the participation constraints, $E[b_i|H] \geqslant 0$ and $E[w_i|H] - c \geqslant 0$, incentive constraint, $E[b_i|H] \geqslant E[b_i|L] + B(0)$ and $E[w_i|H] - c \geqslant E[w_i|L]$ and limited liability constraints $b_i \geqslant 0$ and $w_i \geqslant 0$ for $i = s, f$.

The lender offers the borrower and the monitor the following contracts: $b_s = \frac{B(c_{dm})}{\Delta\pi}$, $b_f = 0$, $w_s = \frac{c_{dm}}{\Delta\pi}$ and $w_f = 0$ where $c_{dm} = {B_c}^{-1}(-1)$.

D Varying Efficiency of Monitoring

Proposition 4 (*i.*). As β changes, the rates at which c_{sim} and c_{seq} change are given by $\frac{dc_{sim}}{d\beta} = \frac{B_\beta(c_{sim},\beta)}{\alpha - B_c(c_{sim},\beta)} \leqslant 0$ and $\frac{dc_{seq}}{d\beta} = \frac{B_\beta(c_{seq},\beta)}{1 - B_c(c_{seq},\beta)} \leqslant 0$ gives us.

By substituting $\frac{dc_{sim}}{d\beta}$ and $\frac{dc_{seq}}{d\beta}$ from the above expressions, we can find the rate at which $\bar{x}_{sim}$ and $\bar{x}_{seq}$ change as β changes. This is given by $\frac{d\bar{x}_{sim}}{d\beta} = \frac{\alpha}{\Delta\pi}\left[\frac{B_\beta(c_{sim},\beta)}{\alpha - B_c(c_{sim},\beta)}\right] \leqslant 0$ and $\frac{d\bar{x}_{seq}}{d\beta} = \frac{2}{\Delta\pi(\pi^h+1)}\left[\frac{B_\beta(c_{seq},\beta)}{1 - B_c(c_{seq},\beta)}\right] \leqslant 0$

As the peer monitoring technology becomes more efficient (β increases), a greater range of projects is financed under both simultaneous and sequential group lending.

Proposition 4 (*ii.*). As $\beta \to 0$, peer monitoring technology becomes extremely efficient, the lender induces negligible amounts of monitoring in the group members giving us $\lim_{\beta\to\infty} c_{sim} = 0$ and $\lim_{\beta\to\infty} c_{seq} = 0$. It follows that $\lim_{\beta\to\infty} B(c_{sim}, \beta) = \alpha B(0)$ and $\lim_{\beta\to\infty} B(c_{seq}, \beta) = 0$. $\bar{x}_{sim}$ and $\bar{x}_{seq}$ are given by $\lim_{\beta\to\infty} \bar{x}_{sim} = \frac{\rho}{\pi^h} + \frac{\alpha B(0)}{\Delta\pi}$ and $\lim_{\beta\to\infty} \bar{x}_{seq} = \frac{\rho}{\pi^h}$.

With borrowers retaining almost no rents in sequential group lending, all socially viable projects are feasible. In simultaneous group lending, due to the rents that borrowers retain, some projects namely $\bar{x} \in \left[\frac{\rho}{\pi^h}, \frac{\rho}{\pi^h} + \frac{\alpha B(0)}{\Delta\pi}\right)$ are not feasible even as $\beta \to \infty$.

E Linear Monitoring Function

With the linear monitoring function, $B(c, \beta) = B(0) - \beta c$, the values of c_{sim} and c_{sim} are given by $c_{sim} = \left[\frac{1-\alpha}{\beta+\alpha}\right] B(0)$ and $c_{seq} = \left[\frac{1}{1+\beta}\right] B(0)$

$\bar{x}_{sim} \geqslant \bar{x}_{seq}$ gives us $\alpha\big(B(0)+c_{sim}\big) \geqslant k \cdot c_{seq}$ where $k = \frac{2}{1+\pi^h}$. Substituting the values of c_{sim} and c_{seq} gives us the following condition in terms of β: $\beta^2 + (2 - \frac{k}{\alpha})\beta - (k-1) \geqslant 0$. Using the positive root of the quadratic equation, we find that the above condition is met when $\beta \geqslant -\big(2 - \frac{k}{\alpha}\big) + \sqrt{\big(2 - \frac{k}{\alpha}\big)^2 + 4(k-1)} > 0$. The right hand side is always positive since $k > 1$.

References

Ahlin, C. R. and Townsend, R. M. (2007). Using repayment data to test across models of joint liability lending. *Economic Journal*, pages F11–F51.

Aniket, K. (2006). Self Help Group Linkage Programme: A case-study. Mimeo.

Armendáriz de Aghion, B. and Gollier, C. (2000). Peer group formation in an adverse selection model. *The Economic Journal*, 110:632–643.

Armendáriz de Aghion, B. and Morduch, J. (2005). *The Economics of Microfinance*. MIT Press.

Besley, T. J. and Coate, S. (1995). Group lending, repayment incentives and social collateral. *Journal of Development Economics*, 46(1):1–18.

Cason, T. N., Gangadharan, L., and Maitra, P. (2008). Moral hazard and peer monitoring in a laboratory microfinance experiment. Mimeo.

Che, Y. (2002). Joint liability and peer monitoring under group lending. *Contributions to Theoretical Economics*, 2(1):3.

Conning, J. (1999). Outreach, sustainability and leverage in monitored and peer-monitored lending. *Journal of Development Economics*, 60:51–77.

Conning, J. (2000). Monitoring by delegates or by peers? joint liability loans under moral hazard. Mimeo.

Conning, J. (2005). Monitoring by delegates or by peers? joint liability loans under moral hazard.

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. *The Economic Journal*, (110):601–631.

Ghatak, M. and Guinnane, T. W. (1999). The economics of lending with joint liability: theory and practice. *Journal of Development Economics*, 60(1):195–228.

Itoh, H. (1991). Incentives to help in multi-agent situations. *Econometrica*, 59(3):611–636.

Jain, S. and Mansuri, G. (2003). A little at a time: the use of regularly scheduled repayments in microfinance programs. *Journal of Development Economics*, 72(1):253–279.

Karlan, D. and Morduch, J. (2009). Access to Finance. In Rosenzweig, M. and Rodrik, D., editors, *Handbook of Development Economics*, volume 5.

Laffont, J. and Rey, P. (2003). Collusion and group lending with moral hazard. Mimeo, IDEI, Toulouse and University of Southern California.

Mookherjee, D. (1984). Optimal incentive schemes with many agents. *The Review of Economic Studies*, 51(3):433–446.

Morduch, J. (1999). The microfinance promise. *Journal of Economic Literature*, 37(4):1569–1614.

Morduch, J. (2000). The microfinance schism. *World Development*, 28(4):617–629.

Rai, A. S. and Sjöström, T. (2004). Is grameen lending efficient? repayment incentives and insurance in village economies. *Review of Economic Studies*, 71:217–234.

Ray, D. (1998). *Development economics*. Princeton University Press Princeton, NJ.

Roy Chowdhury, P. (2005). Group-lending: Sequential financing, lender monitoring and joint liability. *Journal of Development Economics*, 77:415–439.

Sadoulet, L. (2000). Equilibrium risk-matching in group lending. In *Econometric Society World Congress 2000 Contributed Papers*. Econometric Society.

Stiglitz, J. (1990). Peer monitoring and credit markets. *World Bank Economic Review*, 4(3):351–366.

Van Tassel, E. (1999). Group lending under asymmetric information. *Journal of Development Economics*, 60(1):3–25.

Varian, H. (1990). Monitoring agents with other agents. *Journal of Institutional and Theoretical Economics*, 146(1):153–174.