MORAL HAZARD
PAPER 8: CREDIT AND MICROFINANCE

LECTURE 3

DR. KUMAR ANIKET

Abstract. Ex ante moral hazard emanates from broadly two types of borrower's actions, project choice and effort choice. In loan contracts, groups with inter-linked contracts make better project choices and effort choices than individuals. Further, the choice for the lender remains between encouraging the borrowers to behave co-operatively or strategically through the terms of the contract. The borrowers could be induced to interact strategically by asking them to queue for loans. The lending efficiency gains made from strategic interaction between the borrowers increases as the information environment becomes more permissive.

1. Introduction

Any lack of information that the lender has about borrower's action between the time the loan has been disbursed and the borrower's project outcome has been realised is classified as ex ante moral hazard.[1] In this lecture we examine the two approaches to the moral hazard problem taken in the literature. Further, we also explore how co-operation or lack of it could affect the lending mechanism.

The literature has explored two types of borrower's actions in the moral hazard context. The first type of models are the *project choice* models. Stiglitz (1990) is an excellent example of this type. The borrower chooses between a risky project that requires a lumpsum initial investment and safe project which is perfectly divisible. The second kind of models are the *effort choice* models. In these models the borrower chooses the diligence with which she would pursue the project, that is, whether she would exert high or low effort on the project. The risk of project failure decreases in the borrower's effort level.

There are two distinct ways in which the lender could the influence the borrower's behaviour and in the process alleviate the moral hazard problem. The first way is to influence the borrower's behaviour directly through payoffs. The second way is for the lender to monitor the borrower either directly or delegate the task of doing so to someone who can influence the borrower. Often, this entails lending to borrowers in a group and inducing an borrower to influence her peer (and vice-versa) through the joint liability clause.[2]

In the moral hazard part of the larger credit contracts literature, monitoring has been the way the lender solves the problem of not being able to observe the borrower's action. Group lending naturally lends itself to the monitoring mechanism by the virtue of having a peer who may have information on the borrower's action. The lender could use the group lending mechanism to extract this information through the borrower's peer(s) in the group in the most inexpensive way possible.

Depending on the cost of monitoring, the lender can use either direct payoff or monitoring or a combination of the two to influence the borrower's behaviour. Whether the lender chooses to monitor himself or delegate the task is determined by comparing the cost of acquiring this information through the borrowers' peer(s) or directly himself. The standing assumption in the microfinance literature remains

[1] Ex post moral hazard refers to the lack of information lender has about the outcome of the borrower's project once it has been realised.

[2] With the joint liability clause, a borrower's payoff are contingent on her peer's outcome.

that the information is far more permissive amongst the borrowers than it is between the lender and the borrowers.‘’

1.1. **Indivisibility.** Lumpiness of indivisibility of potentially profitable projects bear very heavily in the lives of the poor. The literature has taken two distinct view in regards with this issue. The first one is the issue of indivisible sunk cost. Once the sunk cost has been met, there is a further issue of determining the optimal scale of the project. This is equivalent to assuming that the investment in the project is divisible in the range beyond the indivisible sunk cost.

Most papers in microfinance literature assume that the projects are such that they require indivisible investment and with good reason. The issue of sunk cost is especially important when lending to poor individuals because the poor struggle to find funds to invest in potentially profitable projects which require lumpy investment. This could be one of the causes of poverty. Since it is the easiest of cause of poverty to analyse, a host of papers in the literature have used this as a starting point. Other causes of poverty and how they interact with invisibility remain to be explored in the literature. It is also interesting to note that indivisibility or lumpiness in investment projects have extremely interesting consequence in paper general equilibrium papers like Galor and Zeira (1993) that deal with occupational choice, which are just beginning to get analysed in the context of microfinance in papers like Ahlin and Jiang (2008).

The issue of divisibility or scale has been comprehensively dealt by Stiglitz (1990), one of the papers that started off the literature in microfinance. It analyses the issue of endogenous loan size in the context of individual and group lending to poor individuals who have no collateral. In Stiglitz (1990) the borrowers choose between two different projects, which differ in the range over which they are indivisible and divisible. One project has a sunk cost beyond which it is divisible and the other project is entirely divisible with no sunk cost. The borrowers' project choice is not visible to the lender and the lender uses the size of the loan to influence their choices. The paper determines the size of the optimal loan under both the individual and group lending mechanisms and finds that the lender is ready to give larger loan to groups as compared to the individual borrower. Along from the pros and cons of group lending, Stiglitz (1990) is also able to explore the divisibility assumption quite elegantly in the context of poverty alleviation.

1.1.1. *Indivisible Projects and Poverty.* We know that the poorest of the poor often have very stochastic income streams which come from multiple income sources. Consequently, to smooth consumption, they save and dis-save frequently. The empirical literature in this area is very well summarised in Banerjee and Duflo (2007). The poor are constrained because they cannot invest in projects where the initial sunk-cost is a large multiple of their savings or projects that have long gestation periods and would lock their savings for that gestation project.[3] Even though the poor have savings which may be significant proportion of their income stream, these savings cannot be locked into projects that has a significant gestation period.

Stefan Dercon and Pramila Krishnan in their numerous micro-econometric studies in Africa find that in poor village communities, the poorest of the poor take up activities like foraging, collecting dung or work for a wage. These are activities that do not require any sunk cost investment in either physical or human capital. The individuals that are slightly better off are the ones that either run small shops, own livestock (e.g. buffalo) or take up activities that involve some sunk capital. Dercon (2004) is an excellent summary of the literature on this area.

Indivisible projects are ones that have some initial sunk cost associated with them. Once, the sunk cost has been met, the projects may indeed become entirely divisible. The assumption of indivisibility becomes important when the sunk cost is a large multiple of the savings an household possess. In a more dynamic or a longer horizon environment like in the aforementioned Galor and Zeira (1993), one would expect the poorest of the poor are the ones that were not able to gather enough resources over

[3]There is also an argument about riskiness of the project along the same dimension.

generations to invest in physical or human capital and are thus left to pursue activities like foraging, collecting dung or work for a wage.

There is an issue of whether divisibility needs to be addressed with or without sunk cost. Most projects have sunk cost or a initial range over which the project investments are indivisible. The microfinance literature sees the assumption of invisibility in this context. There are number of paper that that assume that the projects just have a sunk cost and do not have a divisible range after that. These are papers like Ghatak and Guinnane (1999), Ghatak (1999), Ghatak (2000), Besley (1995), Banerjee et al. (1994), etc. There are other papers like Stiglitz (1990) and Conning (1999) that have models that have divisible project. Meeting the sunk cost is the challenge for the really poor borrowers. Once the sunk cost has been met, the economics of endogenously determining the scale is relatively easy.

1.2. **Limited Liability.** The problem is complicated due to the borrower's lack of wealth. In the credit contracts literature this is formally know as a *limited liability constraint*. With zero wealth, the lowest payoff that the lender can offer the borrower is zero. Incentivizing the borrowers requires offering them a *state contingent contract*, with a sufficiently lucrative *incentive wedge*.

→ *Limited Liability and Moral Hazard:* Limited liability means that when the output is below a specified liability threshold, the borrowers can declare bankruptcy and are exempt from repayment of either the principal or the interest amount of the loan. There is an effective subsidy from the lender for output realisations that are below the liability threshold. This means that the borrower prefer the projects which have a higher probability weight in the tail.

If the borrower's project choice is unobservable, there is a moral hazard problem where the interest of the borrower and lender are orthogonal. The borrower prefers project with the higher probability in the tails since they entail a bigger subsidy from the lender. Conversely, the lender prefers projects with lower probability in the tails. The borrower just *gambles* with the borrowed funds, creating the moral hazard problem. Similarly, there is a moral hazard problem if the borrower's effort choice is unobservable and affects the project's probability distribution. We assume that the liability threshold is zero, unless specified otherwise.

→ *State Contingent Contract:* The state or the state of nature is the outcome of the project. The payoff in this kind of a contract is contingent on the state of nature. Thus, this is contract where the borrowers' payoff are dependent on the outcome of the project.

→ *Incentive Wedge:* The incentive wedge is the variation in the state contingent payoffs, i.e., the way in which borrower's payoff varies with the outcome of the project. If the state of nature is binary, the incentive wedge is just the difference between the payoff when the outcome is successful and not successful.

The liability of the borrower is constrained to the amount of wealth she can offer to the lender as collateral. We will keep it simple by assuming the borrowers have no collateralizable wealth. If the borrowers had sufficient wealth, the lender would be able to influence the borrowers' action by either requiring them to *acquire a sufficient stake* in their own project or by putting up the wealth as a *collateral*. The borrowers would thus lose their stake in the project or lose their collateral if the project fails, which in turn, gives them the requisite incentive to choose the project preferred by the lender and/or exert the requisite effort on the project. Essentially, both acquiring a sufficient sufficient stake or putting up a collateral is a way of aligning the borrower's and the lender's interest.

The incentive wedge thus gives the borrower incentive to take action that results in increasing the probability of the project succeeding. Of course, given a required incentive wedge, the more you can punish the borrower if the project fails, the lower the payoff associated with project success. Thus, limited liability increases the payoff associated with success by putting a lower bound on the payoff associated with failure. This in turn leads to higher expected rent for the borrower.

The key concept here is that both the collateral and acquiring the stake in the project is a means of punishing the borrower for her failure, which in turn ultimately serves the purpose of reducing that economic rents left to the borrower to induce diligence. Group lending, through its inter-linked contracts[4], finds a way of punishing the borrowers, not for their own failure, but for the failure of their peers. This punishment reduces the rents that the lender has to leave the borrowers to induce diligence in them.

[4]where the group members are inter-linked, i.e., a borrower's payoff is depends on not just her own outcome but also the outcome of her peer

The borrower's ability to influence each other ultimately determines how effective this joint liability punishment mechanism would be. If the borrower can influence each other perfectly, then effectively, the lender is lending to one composite individual who undertakes two distinct projects. As the information partition between the borrowers becomes increasingly more opaque, joint liability as a punishment mechanism becomes less and less effective in reducing economic rents left to the borrowers.

Stiglitz (1990) assumes that the borrowers are perfectly informed about each other' actions and their ability to influence each is unbounded and costless. Consequently, the lender can induce the borrowers to share information and influence each other costlessly in group lending. The model shows us that joint liability decreases the group's incentive to gamble with the borrowed funds by giving each borrower a stake in her peer's success. Aniket (2006) varies the information permissiveness between the borrowers and pins down the cost of inducing the borrowers to influence each other in group lending. Further, it suggests a new innovative mechanism that the lender can use to reduce the cost making the borrowers influence each other's actions.

2. Project Choice Model

In this section we explore the moral hazard problem associated with choosing the right kind of project. Stiglitz (1990) made seminal early contribution to the literature with a project choice model. We will explore this idea through a simpler version of the Stiglitz (1990) model in this section.

In the model, the borrower's choice is between a risky project that requires lumpsum investment and a safe project that is perfect divisible. The lender can control the borrower's project choice through the size of the loan. We will find that the borrowers are able to get larger loans in groups as compared to the ones they can obtain individually.

The borrowers are wealthless and aspire to borrow funds from the lender to invest into the projects. The projects produce positive output when it succeeds and 0 output when it fails. The borrower has the option of undertaking a project i that is either a risky or a safe project, i.e., $i = \{s, f\}$. The respective projects succeed with the probability p_r and p_s with $p_r < p_s$ and $\Delta p = p_s - p_r$.

2.1. Individual Lending.

The lender cannot observe the project undertaken and thus has to influence the project choice through the contract he offers the borrower. The lender specifies the terms of the contract, that is the loan size L and rate of interest r due on the loan. The lender's own opportunity cost of capital is ρ and the loan market is competitive, which ensures that the lender makes zero profits. Lender's zero profit condition is given below.

$$r = \frac{\rho}{p_i}, \qquad \forall\ i = s, f. \tag{L-ZPC}$$

The lender charges the borrower's the risk adjusted interest rates on the loan.

2.1.1. *Projects.* Even though the risky project requires a fixed initial sunk-cost investment of α, it compensates by giving a higher marginal return to scale β_r than the safe project β_s. Conversely, the safe project has no initial fixed cost of investment and has a lower marginal return to scale. Let V_i be the borrower's payoff from project type i.

$$V_r = p_r(\beta_r L - rL) - \alpha$$
$$V_s = p_s(\beta_s L - rL)$$

Project	Successful		Failure		Investment		Interest
	Prob.	Output	Prob.	Output	Sunk-Cost	Scale	Payment
Risky	p_r	$\beta_r L$	$1 - p_r$	0	α	L	rL
Safe	p_s	$\beta_s L$	$1 - p_s$	0	0	L	rL

The types of projects are summarised in table 2.1. We assume that that the risky project has a higher expected marginal return to scale than safe project.

Assumption 1. $p_r\beta_r - p_s\beta_s = k$

That is the expected marginal return on scale is higher by amount k for the risky project as compared to the safe project. The borrower compares the higher expected marginal return (net of the interest rate

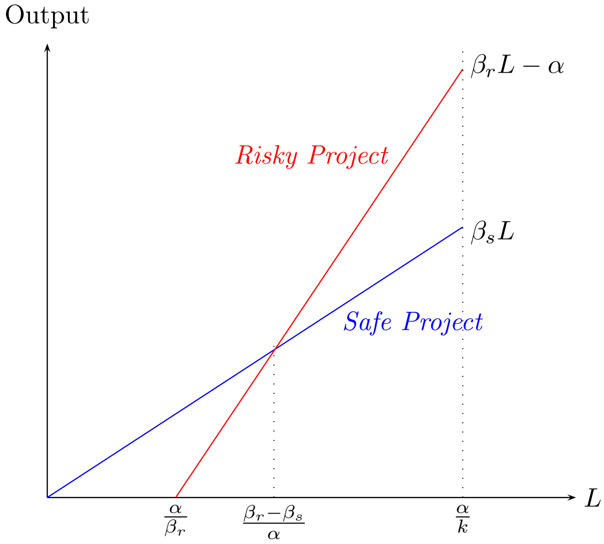

FIGURE 1. Safe and Risky Project Outcome under Success

payments) with the sunk cost when she decide between the risky and the safe project.

$$V_r > V_s$$
$$p_r(\beta_r L - rL) - \alpha > p_s(\beta_s L - rL)$$
$$L > \frac{\alpha}{\Delta pr + k} \tag{1}$$

At a given interest rate, if the borrower gets a loan beyond the scale threshold defined by (1), the borrower prefers undertaking a risky project over a safe one. This scale threshold is reached when the higher expected marginal return[5] of the risky project overwhelms the initial fixed cost investment associated with it.[6] With a higher interest rate, the difference between the two projects types' expected marginal return to scale decreases and leading to decrease in the value of the threshold[7].

In the $L - r$ space, we can draw the locus of r and L, where the borrower is indifferent between undertaking a risky or a safe project. This downward sloping line is the threshold level of scale beyond which the borrower prefers undertaking a risky project. The line has a negative slope to reflect the fact that higher interest rate lowers the threshold scale.[8] The borrower prefers risky projects to the right of

[5] net of interest rate

[6] By choosing the risky project, the borrower's gains are an increase in expected marginal return of kL and lower expected interest rate payment ΔprL. She also loses the sunk cost investment of α. The threshold scale is the one which balances the two and makes the borrower indifferent between the two types of projects.

[7] $\Delta prL = (p_s - p_r)rL$ is the difference between the expected total interest payment from the safe and the risky project. Lets say the borrower is indifferent between the risky and the safe loan at a given r and L. If r increases, for this particular loan size, the repayment for safe project increase more than the risky project because the safe project succeeds more often $p_s > p_s$. Consequently, the risky project becomes more lucrative and the the borrower would be indifferent again with a smaller loan.

[8] The switch line can also be written as $r = \frac{1}{\Delta p}\left(\frac{\alpha}{L} - k\right)$, which could be interpreted as the highest interest rate the lender can charge on a loan of size L before the borrower switches to the risky projects.

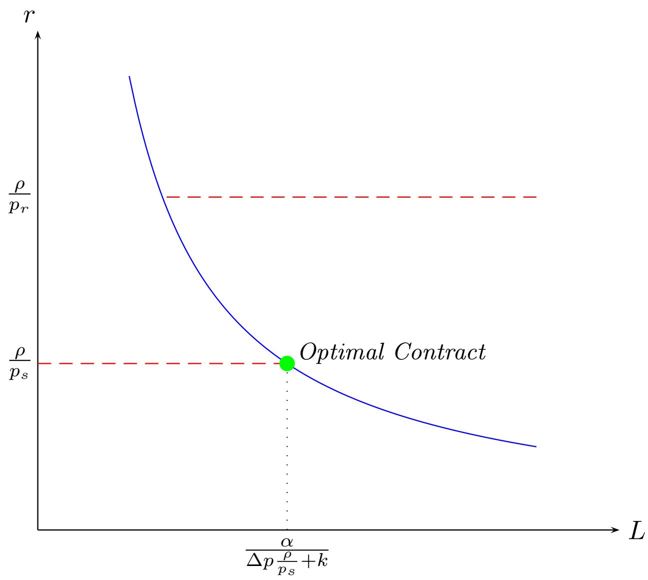

FIGURE 2. Switch Line and Optimal Contract under Individual Lending

this negative sloping line and safe projects to the left of the line.

$$L = \frac{\alpha}{\Delta pr + k} \tag{2}$$

The lender's zero profit condition (L-ZPC) implies that the lender would offer contracts in which he is sets the interest rate at the respective risk adjusted interest rates. The borrower that undertakes a risky and safe project gets loans at $r_r = \frac{\rho}{p_r}$ and $r_s = \frac{\rho}{p_s}$ respectively. Using lender's zero profit condition (L-ZPC) for safe projects and (2), we can find the range of contracts which are able to induce the borrower to choose a safe project over a risky one.

For the safe projects, the lender should be charging $\frac{\rho}{p_s}$, the risk-adjusted interest rate using (L-ZPC). At interest rate $\frac{\rho}{p_s}$, the maximum loan size[9] is given by L^*.

$$L^* = \frac{\alpha}{\Delta p \frac{\rho}{p_s} + k}. \tag{3}$$

If he lender lends more than that, the borrower would automatically switch to a risky project.

Loans larger than L^* would be obtained at interest rate r_r. When giving such large loans, the lender would presume that the borrower would choose the riskier project and the thus would charge a higher interest rate associated with the risky project. The interest rate increase with loan size in this case to compensate for the increased risk associated with the loans.

2.1.2. *Group Lending.* In group lending the lender lends to groups of two. The additional repayment requirement in group lending is the joint liability payment c. This is incurred if the borrower succeeds but her peer fails. Thus, for a group undertaking identical projects of the type i the probability with which a particular lender incurs the joint liability payment is given by $p_i(1 - p_i)$.[10]

Assumption 2. $p_s(1 - p_s) \leqslant p_r(1 - p_r)$

[9] We find this using the (L-ZPC) and (2)

[10] We assume that the borrowers in a group make their decision cooperatively and after full communication. They also have perfect information about each other. This allows us to restrict our analysis to the symmetric choices where either both the borrowers undertake risky projects or both undertake safe projects. If the borrowers had imperfect information about each other, they interact strategically with each other and the analysis can no longer be restricted to symmetric decisions.

This assumption ensures that joint liability payment is made less frequently when the group chooses the safe project. Assumption 2 simplifies to $p_s + p_r \geqslant 1$. Borrower's payoffs under group lending with joint liability payment is given by.

$$V_{ss} = p_s(\beta_s L - rL) - p_s(1 - p_s)cL$$
$$V_{rr} = p_r(\beta_r L - rL) - \alpha - p_r(1 - p_r)cL$$

where V_{ss} and V_{rr} are the borrower's payoffs respectively when the groups symmetrically undertake either risky or safe projects.

Even though this looks like a matching process similar to Ghatak (2000), it is actually not a matching process. Matching can only describe the situation when individual borrowers have inherent characteristics. In this context, the individuals are homogenous with both borrowers having access to the technology that would allow them to undertake the risky and the safe project. Hence, the borrowers take the decision cooperatively, once they have seen the terms of the loan contract. Of course, the question is whether cooperative decision making is feasible. Turns out, there is no information partition between the borrowers. Consequently, for the borrowers there is no cost associated with acquiring information of enforcement. The borrowers can fully observe each other's project while it is going on and fully enforce and side contract or any arrangement they make amongst themselves. The group can thus act like a composite individual who takes on two stochastic projects of type i and pays r_i if both of these stochastic projects succeeds and pays $r_i + c$ when only one of the project succeeds. As we would see ahead, due to the lender's zero profit condition, the expected repayment to the lender remains the same in the group lending, though the variance of the repayment goes up in group lending. As an exercise, show that the variance of the repayment increases in c.

Even though at first glance it may seem that the borrower's payoffs are lowered due to the joint liability payment, it turns out the group lending allows the borrowers to get larger loans which in turn increases their payoffs.

The new switch like gives us the locus of the contracts where the group is indifferent between undertaking the risky or the safe projects. The group would undertake a risky project if the following condition is met.

$$V_{rr} > V_{ss}$$
$$p_r(\beta_r L - rL) - \alpha - p_r(1 - p_r)cL > p_s(\beta_s L - rL) - p_s(1 - p_s)cL$$

This gives us the threshold loan size beyond which the borrower would undertake a risky projet.

$$L > \frac{\alpha}{\Delta pr + k - \Delta p(p_s + p_r - 1)c} \tag{4}$$

At a given interest rate r and joint liability payment c, the borrower prefers undertaking a risky project beyond the threshold loan size defined by (4) if Assumption 2 ($p_s + p_r > 1$) holds.

We now need to incorporate the joint liability payment c in the lender's zero profit condition. For a group undertaking project of the type i, the lender receives c with the probability $p_i(1 - p_i)$, when a member of the group succeeds and her peer fails. As the lender shifts the repayment burden to the peer by increasing c, the interest rate falls concomitantly. We have to be careful here because the repayment has two components, the interest rate and the joint liability payment. Falling interest rate does not mean that the total expected repayment by the borrower falls as well. The lender has to meet his zero profit condition and this condition would ensure that the expected total repayment of the borrowers are always equal to ρ. Even though the expected repayment in individual and group lending remain identical, the variance of the repayment in the group lending increases due to the joint liability component of the repayment.

If the lender is lending to group that undertakes a safe projects, his zero profit condition would be as follows.

$$p_s r + p_s(1-p_s)c = \rho$$
$$r = \left(\frac{\rho}{p_s}\right) - (1-p_s)\,c \tag{L-ZPC(G)}$$

Thus, due to joint liability payment c, the interest rate component of the repayment by the groups is lowered by amount $(1-p_s)\,c$ when compared to the interest rate individual in lending. This would help us in finding the optimal contract on the switch line. Using the interest rate and the threshold level defined by (4), we can find the maximum loan size the lender would be willing to give to the borrowers in group lending. Given the opportunity cost of capital ρ, the maximum loan size is given by the following expression.

$$L_G^* = \frac{\alpha}{\Delta p\left(\frac{\rho}{p_s}\right) + k - \varphi c} \tag{5}$$

where $\varphi = \Delta p\big[(1-p_s) + (p_s + p_r - 1)\big]$. We should also not that $\varphi > 0$ if $p_s + p_r > 1$ holds due to Assumption 2.

It should be clear from (5) that for $c > 0$, the borrower obtains a larger loan in group lending than in individual lending if Assumption 2 holds. With this assumption, for a given ρ, the loan size is increasing in c. Undertaking some burden of repayment in case of the peer's failure through joint liability component thus allows the borrowers to get larger loans in group lending. This of course comes at the cost of variance of the repayment increasing in group lending.

From (5) it follows that loan size is decreasing in interest rate or opportunity cost of capital $\frac{\partial L_G^*}{d\rho} < 0$ and increasing in the joint liability payment $\frac{\partial L_G^*}{dc} > 0$. We also find that for any give interest rate or opportunity cost of capital, the slope of the switch line is steeper[11] for group loans. An increase in c makes the group loan switch line steeper and more sensitive to change in interest rates.

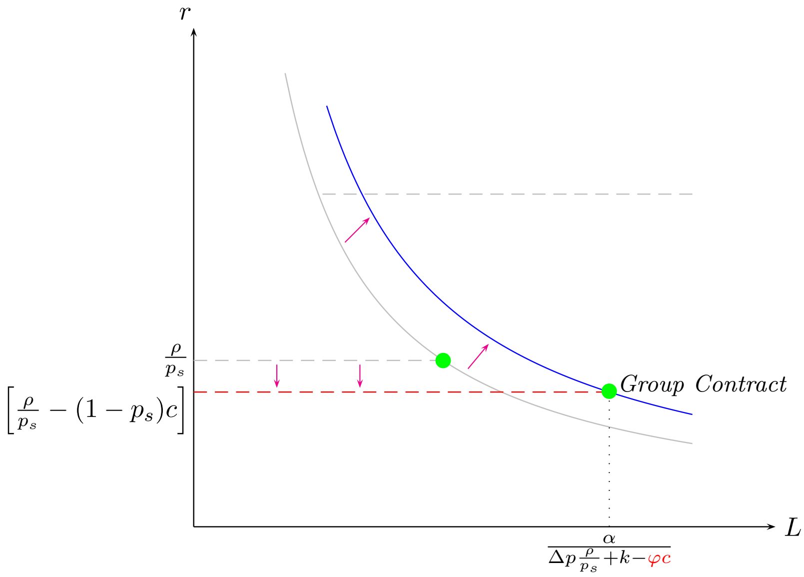

FIGURE 3. Switch Line and Optimal Contract under Group Lending

[11]From (3) we have $\frac{\partial L^*}{\partial \rho} = \frac{-\alpha}{(\Delta pr+k)^2}\frac{\Delta p}{p_s}$. From (5) we have $\frac{\partial L_G^*}{\partial \rho} = \frac{-\alpha}{\left(\Delta p\frac{\rho}{p_s}+k-\varphi c\right)^2}\frac{\Delta p}{p_s}$ and $\frac{\partial^2 L_G^*}{\partial\rho\partial c} = \frac{-2\alpha\varphi}{\left(\Delta p\frac{\rho}{p_s}+k-\varphi c\right)^2}\frac{\Delta p}{p_s}$. This gives us $\frac{\partial L^*}{d\rho} < \frac{\partial L_G^*}{d\rho}$ and $\frac{\partial^2 L_G^*}{\partial\rho\partial c} < 0$

3. Effort Choice Model

This section is based on a simple versions of the models in Aniket (2006) and Conning (2000). We are back in the world where there is potentially profitable project that requires an initial lumpy investment. The borrowers have no collateralisable wealth and thus would like to borrow this lumpy from the lender.

3.1. **Environment.** A project requires an investment of 1 unit of capital and produces output x with probability π^i and and 0 with probability $1 - \pi^i$, where i is the effort level exerted by the borrower.[12] If the borrower is diligent and exerts $h$igh effort level ($i = h$) the project succeeds with probability π^h. Conversely, if the borrower exerts $l$ow effort ($i = l$) the project succeeds with probability π^l and the borrower enjoys private benefits B.[13] These private benefits are are only visible to her and not to other borrowers or lenders.[14] We assume that the borrower's reservation utility is 0.

3.2. **Perfect Information Benchmark.** In the perfect information world the lender can observe the borrower's effort level and ensure that she exerts an high effort level. He can thus offer her a contract contingent on her effort level. The constraints the optimal contract needs to satisfy are the borrower's participation and limited liability constraint and the lender's break even condition. We will discuss each constraint below.

We assume that the borrower are wealth-less and thus the limited liability constraint applies. The limited liability constraint just says that the borrower cannot pay more than the output of the project. This just implies that borrower's interest rate should be greater than x and she should not be allowed to default in case the project fails.

The borrower's participation constraint is satisfied if the borrower has sufficient incentive to accept the contract. If the project succeeds, the borrower's pays an interest rate of r on the loan. If it fails, the borrower declares default and pays nothing. Given borrower's effort level $i \in \{h, l\}$, her expected payoff is given by $\pi^i(x - r)$. The borrower's participation constraint that the lender would like to satishy would be given by

$$\pi^h(x - r) \geqslant 0. \tag{PC-I}$$

The participation constraint would be satisfied if $x \geqslant r$. Turns out that the limited liability constraint and the participation constraint are identical in this case. In the perfect information world, the lender is able to ensure that the borrower exerts high effort. The lender's break even constraint that requires that his profits are non-negative is as follows.

$$\pi^h r \geqslant \rho \tag{L-ZPC-I}$$

Lender's break even constraint is satisfied if $r \geqslant \frac{\rho}{\pi^h}$, or the interest rate is greater than risk adjusted interest rate. We are moving away from the lender's zero profit condition, which ensured that the lender made zero profit and not more. The lender's break even condition puts a lower bound on his profit but does not put an upper bound. Consequently, we are allowing the lender to make positive profits and explore its implication.

The participation constraint puts an upper bound on the interest rate and the break even constraint puts a lower bound on the interest rate. In an optimal contract that satisfies the borrower's participation and limited liability and lender's break even constraint, the interest rate has to be in the range given below.

[12] Note that we have choosen to use p to represent probability associated with the inherent characteristics of either the project or a borrower and π with effort which the borrower may choose explicitly.

[13] An alternative way of looking at this would have been to assume that exerting high effort is more costly for the borrower as compared to the low effort.

[14] We assume in latter sections that a borrowers' private benefits may be curtailed if her peer monitors her. Monitoring may not be costless and the peer may have to bear the cost of monitoring. The assumption would be that the lender is not able to curtail these private benefits.

$$\frac{\rho}{\pi^h} \leqslant r \leqslant x \tag{6}$$

The first thing to notice about (6) is that an optimal contract and thus a feasible interest rate would exist only if the $x \geqslant \frac{\rho}{\pi_h}$. That is, if the project is not more productive than the opportunity cost of capital, it would not be finanaced even in the first best world. Put another way, the project should be socially viable.

Now lets assume that the project is strictly socially viable, i.e., $x > \frac{\rho}{\pi^h}$. Then r can take any value in the range $(\frac{\rho}{\pi^h}, x)$. If $r = \frac{\rho}{\pi^h}$, then the borrower's expected payoff is $\pi^h(x - \frac{\rho}{\pi^h})$ and the lender makes zero profit.[15] Conversely, if $r = x$, then the borrower's expected payoff is 0 and the lender makes expected profits of $\pi^h x - \rho$.[16]

What this shows us is that financing a socially viable project creates a positive social surplus of $\pi^h x - \rho$. This social surplus can either be allocated entirely to the borrower or entirely to the lender or shared between the two.

3.2.1. *Lender's Break Even versus Zero Profit Condition.* Who gets what proportion of the profit depends entirely on the relative bargaining position of the borrower and the lender. If the lender has all the bargaining position, he would keep the entire surplus. This is the case if the lender was a monopolist.[17] Conversely, if there is a competitive loan market, the lender would be undercut by his competitors till he makes zero profit. In this case the lender has no relative bargaining strength and all the bargaining power lies in the hand of the borrower. We have been referring to this case as the *zero profit condition.*

Now lets deviate for a moment and think of how a higher borrower's reservation utility[18] would change the analysis. If the borrower reservation utility u increases, the surplus created is decreased. Who gets the surplus still gets determined by the relative bargaining strength.

Solving any optimal contract problem entails finding the contract space or the region which satisfies all the constraints and then using the objective function to find the optimal contract(s). With perfect information, the contract space is $r \in (\frac{\rho}{\pi^h}, \; x)$ and the objective function tells us whether we are maximising or minimising r. We maximise r if the lender is a monopolist and minimise it if the loan market is competitive.

3.3. **Second Best World: Individual Lending.** Lets analyse how the imperfect information changes the contract space. In the imperfect information world, the lender does not observe the borrower's effort level and has to induce the borrower to exert his proffered effort level (high in this case) through the contract he offers her. The incentive compatibility constraint below ensures that the borrower has sufficient incentive to exert high effort.

$$\pi^h(x - r) \geqslant \pi^l(x - r) + B \tag{ICC-I}$$
$$r \leqslant x - \frac{B}{\Delta\pi}$$

The participation constraint puts a upper bound on r. If the interest rate is too high, it interferes with the borrower's incentive to exert high effort. The *contract space* in the second best world is the range of r which satisfies the borrower's participation and incentive compatibility constraint and the lender's break even condition. The borrower's participation constraint and the lender's break even constraint is identical to the ones given by (PC-I) and (L-ZPC-I). The lender's break-even constraint puts a lower bound on the interest rate and the borrower's participation constraint puts an upper bound on the

[15] The lender's break even condition *binds* and the borrower's participation constraint is *slack.*
[16] which is positive because we assumed that $\frac{\rho}{\pi^h} < x$ as the beginning of this analysis.
[17] In this case, we maximise the lender's profit subject to his *break even condition.*
[18] We have assumed that his 0 till now.

interest rate.[19] All three constraints above can be satisfied if the following conditions are met.

$$\frac{\rho}{\pi^h} \leqslant r \leqslant \left(x - \frac{B}{\Delta\pi}\right) \tag{7}$$

Comparing the (7) to the (6), we find that the range is curtailed in the second best world due to the incentive compatibility constraint. If the interest rate is set in the range $\left(\frac{\rho}{\pi^h},\, x - \frac{B}{\Delta\pi}\right)$, then the borrower would definitely exert high effort.

In the first best world, allocating the borrower 0 expected payoff satisfied her participation constraint. In the second best world, 0 expected payoff does not satisfy the incentive compatibility constraint and thus the lender has to offer her expected payoff of at least $\pi^h\left(\frac{B}{\Delta\pi}\right)$ to ensure that she exerts high effort.[20]

In the first best world, the surplus created by financing the project is $\pi^h x - \rho$. In the first best world, this was shared amongst the borrower and the lender according to the relative bargaining strength. Imperfect information reduces the surplus by $\pi^h \frac{B}{\Delta\pi}$, the rent allocated to the borrower in order to incentivise her to exert high effort. In the second best world, the surplus created by financing the project is $\pi^h\left(x - \frac{B}{\Delta\pi}\right) - \rho$,[21] which is shared between the borrower and the lender according to the relative bargaining strength.

Lending Efficiency: This is connected to the concept of lending efficiency. The first best world surplus of a project is reduced by the rent allocated to agents by the principal to incentivise them to take a particular action. For every institutional mechanism, we can find the associated surplus. The lower the rents allocated to the borrowers, the higher the surplus created by the project. Thus, the lower the rents required to implement a project (in this case, to get it financed) the more efficient the project is considered. Lending efficiency is thus the metric by which all the institutional mechanism are evaluated.

Borrower's Private Benefits: It should be obvious that anything that decreases the borrower's private benefit B should be able to increases the surplus from the project and thus increase the lending efficiency. There are a category of models that look at how efficiently monitoring can reduce the private benefits and increase the lending efficiency.

3.4. **Delegated Monitoring.** The lender has no ability to reduce the borrower's private benefits but he could hire someone who lives in the same area or is socially connected to the borrower to do exactly that. Let assume that this person is able to reduce the private benefits of the borrower by monitoring her. Specifically, the borrower's private benefit B is a function of how intensively she is being monitored. To the monitor, the cost of monitoring is m. As m increases, the monitor monitors more intensely and B, the private benefits fall. Assumption below characterise the monitoring function.

Assumption 3 (Monitoring Function $B(m)$)**.** *$B(m) > 0$; $B'(m) < 0$.*

Of course, the lender has to incentivize the monitor by making her payoffs contingent on the outcome of the project.[22] Incentivizing the monitor would require satisfying her limited liability, participation and

[19] It should be clear that the incentive capability constraint puts puts a smaller upper bound on the r than the participation constraint and thus we can ignore it. If the borrower's incentive compatibility constraint binds, then her participation constraint would automatically be satisfied.
[20] If (ICC-I) holds with equality, it gives us $x - r = \frac{B}{\Delta\pi}$ which implies that the borrower's expected payoff should be $\pi^h \frac{B}{\Delta\pi}$ at the least.
[21] This distance of the green arrow in Figure 3.3 multiplied by the probability of success.
[22] Since that is the only signal the lender gets, he has no option but to make the monitoring payoff contingent on that signal.

incentive compatibility constraint. We assume that like the borrower, the monitor's reservation utility is 0. The limited liability constraint ensures that the monitor's wage w is not less than 0 irrespective of the project outcome.[23]

$$\pi^h w \geqslant 0 \tag{PC-M}$$

$$\pi^h w - m \geqslant \pi^l w \tag{ICC-M}$$

The participation constraint is satisfied for any non-negative w. The incentive compatibility condition is satisfied if $w \geqslant \frac{m}{\Delta\pi}$. So, the cost of getting m amount of monitoring for the lender is offering the monitor a wage of at least $\frac{m}{\Delta\pi}$ if the project succeeds. In expected terms, this cost is at least $\pi^h \frac{m}{\Delta\pi}$. The benefit of hiring a monitor is that it reduces the borrower's rent. The borrower's incentive compatibility condition is now given by

$$\pi^h(x-r) \geqslant \pi^l(x-r) + B(m). \tag{ICC-I'}$$

This can be written as $x - r \geqslant \frac{B(m)}{\Delta\pi}$. The borrower's expected payoff has to be at least $\pi^h \frac{B(m)}{\Delta\pi}$ which is less than payoff the borrower got when there was no monitoring. With monitoring the expected surplus of the project is $\pi^h \left(x - \frac{B(m)}{\Delta\pi} - \frac{m}{\Delta\pi}\right) - \rho$.

The optimal amount of monitoring is the m that maximises the surplus. That is $B'(m) = -1$. Thus, there would be postive amounts of monitoring if $B'(0) < -1$. Further, if this condition holds, it should be clear that the lending efficiency increases in m till the reduction in private benefits at the margin is exactly matched by cost of monitoring ($B'(m) = -1$).

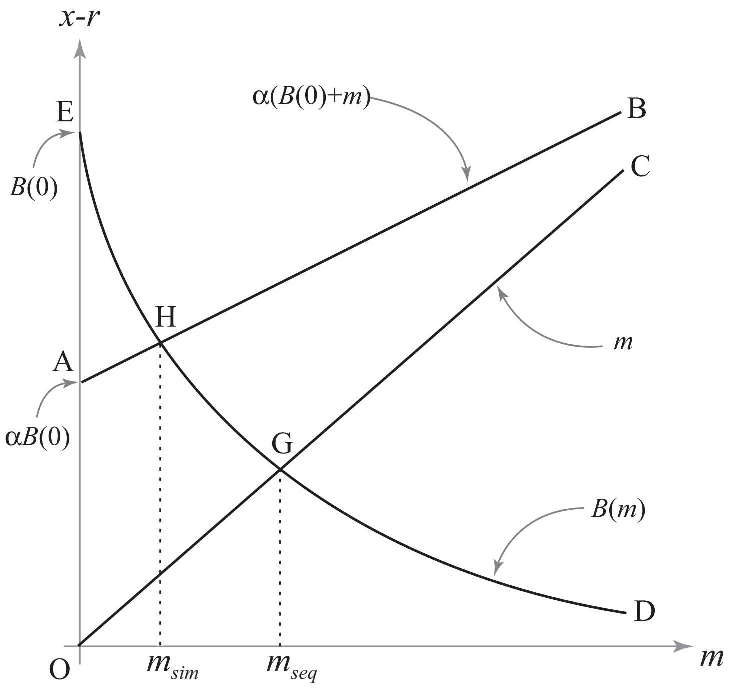

FIGURE 4. Monitoring Intensities in Group Lending

3.5. **Simultaneous Group Lending.** This section examines the lending efficiency of group lending under costly monitoring as described by Assumption 3. In simultaneous group lending, borrower form into groups of two before they approach the lender for a loan. The lender offers the group a contract contingent on the state of the world, i.e., the outcome of the project. Without loss of generality, we can confine ourselves to the contract where each borrowers are obliged to pay interest rate r on their

[23]This just means that the lender cannot penalise the monitoring for the failure of the project.

loans if both the projects succeed and 0 if both project fails. If only one of the two projects succeeds, joint liability kicks in and the lender confiscates the *full* output x of the project.[24] To summarise, the borrowers get a positive payoff only if both projects succeed. In all other cases, they get a 0 payoff.

If they accept the contract offered by the lender, the borrowers first decide the intensity with which they would monitor each other and subsequently choose the effort level. Once the project's outcome is realised, the borrower get their payoff depending on the outcome of the project. The contract space is determined by the following two constraints.[25] For the proof, see the appenxix in Aniket (2006).

(1) The individual borrower's incentive compatibility condition in group lending (ICC-Sim) which ensures that a borrower exerts high effort when her peer exerts high effort ($j = h$) and both choose to monitor with intensity m.

$$(\pi^h)^2(x-r) - m \geqslant \pi^l\pi^l(x-r) + B(m) - m \tag{ICC-Sim}$$

$$r \leqslant x - \left(\frac{B(m)}{\pi^h\Delta\pi}\right)$$

(2) The group's collective compatibility condition (GCC) ensures that the borrowers in the group collectively (and symmetrically) choose to exert high effort and monitor each other.

$$(\pi^h)^2(x-r) - m \geqslant (\pi^l)^2(x-r) + B(0) \tag{GCC}$$

$$r \leqslant x - \left(\frac{B(0)+m}{(\pi^h+\pi^l)\Delta\pi}\right)$$

(ICC-Sim) and (GCC) can be summarised in the following condition:

$$r \leqslant x - \frac{1}{\pi^h\Delta\pi}\max\Big(B(m), \alpha(B(0)+m)\Big)$$

where $\alpha = \frac{\pi^h}{\pi^h+\pi^l}$. Again, the question is to find the optimal level of monitoring. The optimal level of monitoring would be the one which creates the greatest surplus, which would be achieved when $\alpha(B(0) + m) = B(m)$. (H in Figure 4) Assumption 3 ensures that there would be positive level of monitoring in group lending.

4. Sequential Group Lending

In sequential group lending, one borrower gets the loan while the second borrower is waiting for her loan. The second borrower only gets the loan if the first borrower succeeds. Again, borrowers only get a positive payoff if both borrowers borrow and the both projects succeed. Aniket (2006) shows that the both borrowers would choose to monitor with intensity m and exert high effort if the following condition is met:[26]

$$r \leqslant x - \frac{1}{\pi^h\Delta\pi}\max\Big(B(m), m\Big) \tag{ICC-Seq}$$

The surplus would be maximised and the optimal level of monitoring would be achieved when $B(m) = m$. (G in Figure 4) Looking at Figure 4, it should be clear that sequential lending creates a greater surplus than simultaneous lending. This is because in simultaneous lending, the group's collective incentive compatibility conditions (GCC) has to be satisfied. This is akin to the group behaving co-operatively just like it was able to do in Stiglitz (1990). Even though a group behaving co-operatively does better than individual lending, it is not much of an improvement in a multi-tasking environment, i.e., the two-task environment in Aniket (2006) where the lender has to incentivise monitoring and effort level. In a two-task environment, the sequential lending does much better because the lender has to incentivise the tasks individually (ICC-Seq) and not collectively (GCC).

[24] implying $r + c = x$
[25] See Aniket (2006, Pages 30-33)
[26] See Aniket (2006, Pages 33-36)

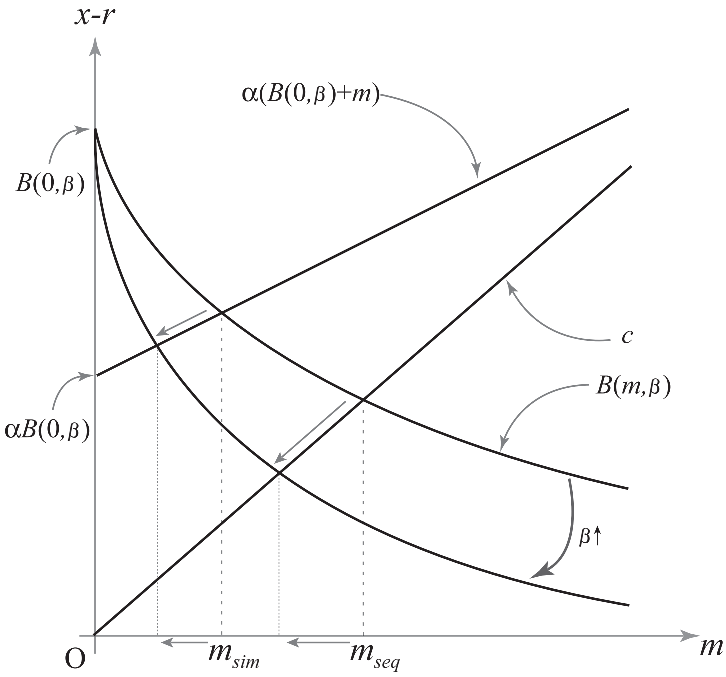

FIGURE 5. Monitoring Intensities as Monitoring Efficiency Increases

Lets now examine what happens if we vary the monitoring function. Lets think of a parameter β that controls the efficiency of the monitoring function. With a higher β increases, a given m is associated with a lower B. Figure 5 shows how the monitoring function moves towards the origin as β increases. What is interesting is that as $\beta \to \infty$, the monitoring becomes more and more efficient and we get closer to the first best world or to *almost* perfect information world. With $\beta \to \infty$, the borrowers are still allocated a positive payoff in the simultaneous lending where as in sequential lending they are allocated 0 payoffs. That is even with *almost* perfect information, sequential group lending can achieve *almost* first best where as simultaneous group lending cannot.[27]

5. Errors Corrected and Changes

(1) A section discussing the significance of Invisible Projects in the first section.
(2) Page 8, paragraph starting with "We assume that the borrower ...". Last line should read: This just implies that borrower's interest rate should be greater than x and she should not be allowed to default in case the project fails.
(3) Page 8, paragraph starting with "The first things to notice...". The first line should read: The first thing to notice about (6) is that an optimal contract and thus a feasible interest rate would exist only if the $x \geqslant \frac{\rho}{\pi_h}$.

References

Ahlin, C. and Jiang, N. (2008). Can micro-credit bring development? *Journal of Development Economics*, 86(1):1–21.
Aniket, K. (2006). Sequential group lending with moral hazard. Link.
Banerjee, A., Besley, T., and Guinnane, T. (1994). The neighbor's keeper: the design of a credit cooperative with theory and a test. *The Quarterly Journal of Economics*, 109(2):491–515.
Banerjee, A. and Duflo, E. (2007). The economic lives of the poor. *The journal of economic perspectives: a journal of the American Economic Association*, 21(1):141.

[27]With almost perfect information, the contract space for simultaneous group lending is $\frac{\rho}{\pi h} \leqslant r \leqslant x - \alpha B(0)$ and sequential group lending is $\frac{\rho}{\pi h} \leqslant r \leqslant x$.

Besley, T. (1995). Savings, credit and insurance. In Behrman, J. and Srinivasan, T., editors, *Handbook of Development Economics*, volume III A, chapter 36.

Conning, J. (1999). Outreach, sustainability and leverage in monitored and peer-monitored lending. *Journal of Development Economics*, 60(1):51–77.

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

Dercon, S. (2004). *Insurance against Poverty*, chapter Risk, Insurance and Poverty: a Review, pages 9–37. Oxford University Press for WIDER. Link.

Galor, O. and Zeira, J. (1993). Income distribution and macroeconomics. *The Review of Economic Studies*, 60(1):35–52.

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. Link.

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.

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