Monitoring by Delegates or by Peers? 
Joint Liability Loans under Moral Hazard* 

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May 2005 Draft

Abstract

This paper analyzes the conditions under which joint liability loans to encourage peer-monitoring would be offered and chosen instead of monitored individual liability alternatives on a competitive loan market when production and monitoring activities are subject to moral hazard. In contrast to other analyses, the case for joint liability loans does not rest on an assumed monitoring or information advantage by borrowers but instead on an incentive diversification effect that cannot be replicated by outside intermediaries. Joint liability clauses are chosen to implement a preferred Nash equilibrium in a multi-agent, multi-task game, where each borrower must be given incentives to remain diligent as a financed entrepreneur and as a monitor of others.

Keywords: Joint-Liability; Group-Lending; Credit-Cooperatives; Financial-Intermediation.

JEL Codes: D82, 016, G2, G24

*I would like to thank three anonymous referees, Timothy Guinnane, Bengt Holmstrom, Malgosia Madajewicz, Ingmar Nyman, Ashok Rai, and T.N. Srinivasan for helpful discussions on earlier versions of this paper. Comments: jconning@hunter.cuny.edu.

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1 Introduction

Joint-liability or solidarity-group lending mechanisms such as those used by the non–profit Grameen Bank of Bangladesh or the commercial Banco Solidario of Bolivia extend loans to members of a circle of borrowers on condition that each borrower should become liable for some portion of the loan obligation of other members of the group should any of the latter become unwilling or unable to repay. Building on important initial successes, group lending programs have spread very rapidly over the past few decades to reach tens of millions of borrowers worldwide. They have been financed, often generously, by donors and international aid organization and sometimes private investors intrigued and excited about a contractual innovation that would seem to achieve the apparent miracle of enabling previously marginalized borrowers to lift themselves up by their own bootstraps by substituting ‘social collateral’ for missing physical loan collateral.

Economists also took notice, and a flurry of papers have been written over the past decade or more proposing theoretical explanations for how joint liability clauses might work in a variety of asymmetric information contexts to create incentives for borrowers to peer-select, peer-monitor, or peer-sanction each other in ways that outside lenders might find difficult or costly to imitate.¹ Empirical economists also took note and number of impact evaluation studies of group lending projects have since been carried out (e.g. Pitt and Khandker, 1999; Morduch, 1998). More recently, some economists have begun to empirically test some of the implications of alternative theories to try to distinguish between them (e.g. Ahlin and Townsend, 2003).

Yet despite the widespread adoption and frequent celebration of group lending programs, the theoretical and empirical case for group loan projects is far from settled. Microfinance practitioners are themselves far from agreed

¹The case for group loans in the context of ex-ante moral hazard problems has been argued under different assumptions for example by Arnott and Stiglitz (1990), Stiglitz (1990), Conning (1996, 1999), Madajewicz (1997) and Laffont and Rey (2000). The case for group loans to ameliorate the costs of ex-post moral hazard has been explored by Besley and Coate (1991), Diagne (1998), Che (1999) and others. The adverse selection case has been explored by Ghatak (1999, 2000), Sadoulet (1998), van Tassel (1999), Wydick (1999), Armendariz de Aghion and Gollier (2000) and N’Guessan and Laffont (2000). Literature surveys include Ghatak and Guinnane (1999) and Morduch (1999).
about the merits of group loans. Critics contend that the purported benefits of group loans have been grossly exaggerated and that the group methodology is often rigid and poorly adapted to borrowers’ changing circumstances. They argue instead for simpler individual liability loans monitored by locally recruited loan officers, which they claim can achieve results that are every bit as good or better than group loans.\footnote{Morduch (2000) and Conning (1999) summarize several of the important disagreements in the field amongst practitioners and policymakers. One camp, the so-called ‘institutionalists’ tends to favor individual liability lending and ‘financial sustainability,’ while a ‘welfarist’ camp is more likely to support group lending and targeted outreach over financial sustainability. Disagreements over the econometrically measured impact of group-based lending programs have not helped to clarify matters (see for example the exchange between Morduch, 1998 and Pitt, 1999).} Perhaps the most important and revealing policy decision that has pressed this issue to the fore is the relatively recent decision by pioneer group lender Grameen of Bangladesh to completely revamp its lending activities in ways that borrowers’ increase individual liability and transfer many monitoring and control activities away from groups and toward trained staff loan officers. This policy decision raises the question of whether delegated monitors such as these might not in fact be just as good or better at monitoring than peer-monitors, and perhaps better at enforcing loan repayment.

Grameen Bank founder Muhammed Yunus provides interesting opinions on this question in a recent article describing why the bank adopted its new “Grameen Generalised System (GGS)” lending methodology:

“Now both the bank and the borrowers can be free from all tension - no more chasing of the problem-borrowers or defaulters. Nobody needs to look at anyone with suspicion. Group solidarity is used for forward-looking joint-actions for building things for the future, rather than for the unpleasant task of putting unfriendly pressure on a friend ... GCS [the earlier group loan system] is a "single-size-fits-all" kind of methodology. This feature gives GCS the simplicity which was most needed for the implementation of an idea which was totally unknown to the world. Now microcredit has matured ... GGS is different. It allows a staff to be creative. He can design his loan product to make it a best fit for his client in terms of
duration, timing of the loan, scheduling of the installment, etc. The more a staff becomes a creative artist, the better music he can produce ... duration, size of weekly installments can be varied. A borrower can pay more each week during peak business season, and pay less during lean period ... An agreed repayment schedule is signed by both the lender and the borrower, before the loan is disbursed ...(Yunus, 2003)

Because borrowers from poor households lack much pledgeable collateral, costly monitoring activities are an essential strategy to keep borrowers focused in their efforts to make their financed projects succeed and to earmark project cashflows toward repayments to the lender rather than other purposes. Costly monitoring is therefore a defining element of microfinance lending for both group liability and individual liability loan systems. Monitoring and control activities aim at reducing borrowers’ scope for moral hazard and take place through a variety of mechanisms and devices, including the establishment of regular weekly payments to trigger off alarms should a borrower miss a repayment, regular group meetings, and heavy involvement and other ‘creative’ actions by loan officers or other borrowers in the peer group to insure proper selection and execution of projects. In Grameen’s original group methodology (GCS) many of these tasks fell to other borrowers in the group. Joint liability clauses no doubt worked at generating peer monitoring to avoid borrower moral hazard, as suggested by the evidence of consistently high repayment rates maintained over many years, but the quoted passage suggests that it also imposed heavy burdens on peer-monitors and some times created tensions within groups. The problems are perhaps best summarized by a paraphrase of a common expression: ‘the problem with lending to (or in this case becoming liable for) a friend is that you may lose both your money and a friend.’

Some recent papers have also raised theoretical questions about the purported optimality of joint liability loans in different contexts, or have ques-

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3 Diagne (2000) and Wydick (2000) report survey evidence from Malawi and Guatemala that also suggest that peer pressure is effective when it is applied, but that group borrowers find it very onerous to actively pressure delinquent group members. Jain (1996), Fuglesgang (1993) and Pitt and Khandker’s (1999) description of Grameen’s operating practices suggest that the Bank has in fact always relied on a mix of monitoring by highly motivated loan officers and peer-monitoring.
tioned the empirical validity of some assumptions upon which earlier arguments were premised. One obvious criticism is that several analyses of group loans simply assume that borrowers enjoy an information or enforcement advantage relative to outsiders. While such an information advantage may well be an important element in practice, joint liability loans cease to be quite as surprising or revolutionary once it is made clear that ‘closeness’ amongst borrowers has been assumed rather than derived.

The purpose of this paper is to present a model framework to encompass and extend several different versions of the group lending problem and to help clarify the relationships between these problems and the canonical principal agent problem. The provides an organizing framework around which to build an analytic survey of the literature, as well as to demonstrate several new results. More broadly the framework is useful to understand and interpret the structure of financial markets in developing countries where various financial contracts and intermediary structures often co-exist and compete to serve different segments of the population. Finally the framework helps to understand the possibilities and limits of creating new efficiency enhancing financial intermediation in those markets. The framework considers the range of potential financial relationships between a risk neutral uninformed outside investor and a risk-neutral potential borrowers who may operate projects subject to moral hazard and limited liability. Lenders may choose to lend to borrowers directly via collateral-based contracts, or through the intermediation of a borrowing group or a third party delegated monitor.

Limited liability constraints, which arise due to borrower’s lack of collateral or problems of enforcement, restrict the feasible level of repayment that a borrower can make following low project outcomes. In such cases incentives for borrowers to choose actions necessary to bring expected project returns to a level sufficient to cover lending costs have to be created via costly ‘bonuses’ that leave the borrower with a large enough share of project returns in the good outcome states. Since ‘bonuses’ have to substitute for monetary punishments the borrower therefore often has to earn a limited liability rent for incentives to be maintained. If a delegated monitor is also involved, additional delegation rents associated with providing incentives for the monitor to monitor must

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4 This is for example the main interpretation highlighted in recent literature surveys by Morduch (1999) and Ghatak and Guinnane (1999).
also be covered. If the total value of these rents and monitoring costs becomes too large however, not enough expected project returns may be left to cover the lender’s cost of funds. Lenders’ will then lose interest in participation and borrower’s will be excluded from the loan market. In the analysis to follow, alternative contracts and intermediary structures will be compared in terms of how cost effectively they reduce the size of these limited liability and delegation rents, and therefore how they enable borrowers’ access by reducing collateral requirements and/or borrowing costs.

The analysis commences by re-examining the group loan problem with costless side-contracting as studied by Stiglitz (1990), demonstrating that this problem is isomorphic to a principal agent problem with a single agent in a multi-task setting (Holmstrom and Milgrom, 1990; Itoh, 1993) with limited liability constraints (e.g. Laux, 2002). This problem can in turn be mapped onto the even better studied canonical principal agent problem with an agent managing a single task, multiple-outcome project subject to moral hazard and limited liability (Innes, 1990). In this costless side-contracting case borrowers act as a single minded coalition and the representative borrower in effect now manages a collection of imperfectly correlated projects and internalizes the impact of her own production actions on the expected returns that accrue under the contract to the entire group.

Limited liability rents, that might have been large had the borrower only held claims to her own initial project, can now be reduced by having the borrower agree to pay for a failure on any one project out of the returns generated by other successful projects. Compared to the individual liability case where expected returns only depend on the outcomes on the borrowers’ own project, the representative borrower in a coalition faces a more relaxed set of constraints. Since larger punishments can now be meted out following signals of non-diligence on any one project, there is now less need to pay out the costly bonuses and limited liability rents will be reduced. Previously excluded borrowers may now gain loan access and group loans therefore help ‘crowd-in’ new lending. The result is much stronger in fact, and leads to somewhat of an embarrassment of riches: since limited liability rents per borrower are monotonically declining in group size the optimal group size should be unbounded.

The analysis of this benchmark version rests on the strong assumption that borrowers can costlessly observe and side-contract on actions and this ability.
When this is not the case, and borrowers can only side-contract on observable project outcomes and choose their actions non-cooperatively, the analysis shows that due to free-riding, joint liability loans cease to offer any advantage over individual liability loans. It is easy to argue in fact that if borrowers were even slightly risk-averse, or if additional monotonicity constraints were added to restrict the range of feasible contracts, then exclusive individual liability contracts may dominate other forms of contracting. This is because outcome-contingent side-contracts amongst borrowers could undermine incentives that a lender might have wanted to build into a contract. Hence the possibility of side-contracts amongst borrowers may ‘crowd-out’ or hold back the entry of outside finance. These observations flow from an earlier literature on contracting with coalitions (Arnott and Stiglitz, 1990; Holmstrom and Milgrom, 1990; Itoh, 1993) which observed quite obviously that contracting with a coalition – here joint liability contracting – can only lead to efficiency gains if the agents can side-contract on contingencies that a principal could not have already included in the contract (see Conning and Kevane, 2004 for a further discussion).

The paper also extends Stiglitz’ (1990) benchmark analysis to cases where borrowers can observe each other’s actions but will only comply with action-contingent side agreements if sufficient social sanctions can be threatened against those who deviate. This leads to the derivation of a relationship between optimal group size and social sanctions and other parameters.

Since joint-liability lending provides no advantage compared to exclusive individual liability loan contracting except if borrowers can costlessly side-contract on actions, I turn next to the more interesting and realistic scenario where monitoring is a costly and imperfect activity to ask whether joint liability loans can serve any purpose here. The analysis here takes an extended version of Holmstrom and Tirole’s (1997) model of financial intermediation and costly delegated monitoring as a benchmark. In this model a third party can, at some cost, carry out monitoring and control activities that directly lower the borrower’s return to non-diligence. This helps to lower the cost of

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5 The possibility of ‘crowding out’ in the face of increasing competition has become increasingly mentioned possibility in case studies and empirical literature on microfinance. Due in part to the absence of credit bureaus and effective legal enforcement lenders often have trouble establishing liens or enforcing exclusive contracts.
providing indirect incentives and hence the borrower’s limited liability rent. Monitoring will be worthwhile however only if monitoring and delegation costs – the cost of providing the monitor with incentives to monitor – do not rise too rapidly.

Delegation costs can be reduced by asking the delegated monitor to put some of their own intermediary capital at risk in the borrower’s project. In such a case the delegate could be interpreted as an intermediary lender who leverages or crowds-in finance from outside lenders that might otherwise not have been willing to loan funds to an unmonitored borrower. I also allow for delegates to monitor \(N\) borrowers with imperfectly correlated risks. In the fashion of Diamond (1984) I show that delegation costs can be reduced, and leverage ratios increased, as the number of borrowers \(N\) in the delegates’ portfolio increases. This last result here follows the same logic used earlier to explain multi-task loans and group loans with costless monitoring.

The main contribution of the paper however is to examine how this delegated monitoring arrangement can be extended to yield an intermediary structure in which the lender contracts with each member of a group both as a monitor of the other borrowers actions and as a borrower choosing actions on a lender-financed production project.6 Peer-monitors are assumed to have the same monitoring technology as a would be delegated monitor. Joint liability contracts emerge as an optimal way to implement a preferred Nash equilibrium in a multi-agent, multi-task game, where each borrower must be given incentives to remain diligent as a financed entrepreneur and as a monitor of others. The advantage of this setup is that whereas separate limited liability rents and delegation rents (or at a minimum monitoring costs) must be paid to the borrower and to an outside delegate respectively, joint liability places borrowers into a multi-task setting where a single rent provides incentives for the borrower to be diligent at both production and monitoring tasks. Borrowers are forced to pay the cost of monitoring out of their limited liability rent, a cost which the borrower would otherwise have had to credibly commit

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6In independent work, Madajewicz (2002) examined a related arrangement and finds some related results. One difference between our approaches is that where I build on Holmstrom and Tirole’s (1997) model in which monitoring affects the borrowers’ opportunity cost of diligence (or the cost of effort), she instead extends Banerjee, Besley and Guinnane (1994) who have ‘monitoring’ affecting the probability of projects success.
to pay the delegated monitor.

The model also examines the role that side contracting or collusion may play in group loan design. Although the contract is chosen to implement diligence by each borrower, and minimum required monitoring intensities, the contract must also guard against disruptive collusion or side contracting by borrowers to choose another possible subgame perfect Nash Equilibrium – one where neither borrower monitors or applies diligence in production. The analysis discusses the important role of timing and commitment in shaping each of these results and discusses how this might relate to policy choices.7

In the end the framework provides a model for understanding the ways that financial intermediaries expand and transform the set of trades that can take place both within communities and across communities by carrying out monitoring and control activities. Understanding the nature and potential impact of side-contracting activities lies at the heart of any theory of financial intermediation because side-contracts with a third person typically change the incentives faced by the parties to a bilateral contract, for better or for worse. In some cases, as in the case of joint liability loans, side-contracts amongst locals, or with other financial intermediaries may well help to ‘crowd-in’ local or outside resources and build more complex intermediary structures that enable transactions that would not have taken place. In other contexts, the possibility of side-contracts may ‘crowd-out’ potential finance and policymakers and regulators may want to facilitate exclusive contracting.

Putting all of the variants of the model together ends up providing a rich set of predictions regarding the shape of market structures that may emerge on a competitive loan market with heterogenous borrowers that differ in terms of initial collateral asset holdings and project characteristics. Some borrowers are offered, and will choose, joint liability loans, other may prefer individual liability contracts with or without delegated monitors. Yet others will remain excluded from the loan market.

7Aniket (2004) has extended the model of this paper to ‘sequential group loans,’ or arrangements where one borrower monitors the other and only receives a loan on the condition that the other borrower repays.
2 Model elements

Consider a population of risk-neutral entrepreneurs identical in every respect except for their initial holding of collateral assets $A$. Each has access to a risky production project that requires a non-recoverable lump-sum investment $I$ to be initiated. If funded, a project generates verifiable return $X_1$ if it succeeds and $X_0 < X_1$ if it fails. The probability of success is shaped by the entrepreneur’s choice of diligence. If she chooses diligence, say by exerting effort and using all funds $I$ to purchase required inputs then the project will succeed with probability $\pi$ and fail with probability $(1 - \pi)$. If, on the other hand, the entrepreneur chooses to be non-diligent she captures private benefits $B$ from diverting effort and/or funds to other private consumption or production activities but the probability of success is reduced from $\pi$ to $\pi'$. By assumption, outsiders cannot observe the agent’s diligence choice nor can they observe or seize any part of $B$.

The analysis will be extended to consider the case of entrepreneurs that can operate a portfolio of $N$ identical independent sub-projects or tasks. If the entrepreneur operated $N = 2$ independent tasks there would be $2^N = 4$ separate possible joint outcomes depending on whether each task succeeds or fails. If task outcomes are independent and identically distributed it becomes convenient and sufficient to index joint outcomes simply by the total number of tasks that succeeded. In this example there are $N + 1 = 3$ contingencies, $x_0, x_1$ and $x_2$, corresponding to the value of output when neither projects succeeds ($x_0 = X_0^1 + X_0^2$), where one but not the other project succeeds ($x_1 = X_1^1 + X_0^2 = X_0^1 + X_1^2$), or when both succeed ($x_2 = X_1^1 + X_1^2$).

Expression $E[x|N, k]$ indicates total expected project returns from $N$ different tasks or sub-projects when the entrepreneur has chosen to be diligent on $k$ out of $N$ tasks. Since the outcome on each task is a Bernoulli trial, the probability of obtaining exactly $j$ successes on $N$ independent Bernoulli trials follows a Binomial distribution. The total expected return when the borrower is diligent on all $N$ tasks can hence be written:

$$E[x|N, N] = \sum_{j=0}^{N} \frac{N!}{(N-j)!j!} \pi^j (1-\pi)^{N-j} x_j$$

(1)
Similar, appropriately modified, expressions can be found for $E[x|N,k]$ for any $k < N$. Expected returns to a diligent borrower who operates a simple one-task, two-outcome project are $E[x|1,1] = \pi x_1 + (1 - \pi)x_0$ and $E[x_i|1,0]$ when she is not diligent.

Parameters will be assumed such that diligence is the efficient choice on any single task project, whereas non-diligence is socially wasteful:

$$E[x|1,1] - \gamma \geq E[x|1,0] - \gamma I + B$$  \hspace{1cm} (2)

where $\gamma$ is the social opportunity cost of funds (one plus the interest rate). This implies that no self-financed entrepreneur would ever choose non-diligence and that no outside investor would willingly finance $I$ unless the contract included explicit incentives for the borrower to credibly commit to diligence. To economize on notation we will often simply write $EX = E[x|1,1]$.

Figure 1 graphs the binomial distribution of joint outcomes when there are $N = 10$ tasks, each task yields a return of 1 or 0. The distribution on the left is the binomial distribution when the entrepreneur is diligent on zero tasks, while the distribution on the right corresponds to an entrepreneur who is diligent on all $N$ tasks given that $\pi = 0.8$ and $\bar{\pi} = 0.7$. Two useful properties of the binomial distribution, demonstrated in the appendix, are the following:

**Claim 1** For all $N$ the likelihood ratio

$$\frac{\pi^n(1 - \pi)^{N-n} - \pi^n(1 - \bar{\pi})^{N-n}}{\pi^n(1 - \pi)^{N-n}}$$  \hspace{1cm} (3)

satisfies the monotone likelihood ratio property (MLRP) – it is monotonically non-decreasing in the number of successes $n$. In addition, the likelihood ratio for the ‘all success’ outcome

$$1 - l^N = \frac{\pi^N - \bar{\pi}^N}{\bar{\pi}^N}$$  \hspace{1cm} (4)

is monotonically non-decreasing in $N$, where $l = \pi/\bar{\pi}$.

The likelihood ratio (3) measures the increased (or decreased) probability of observing exactly $n$ successes when the agent is diligent on all tasks compared
to when she is diligent on zero tasks, normalized by the probability of actually observing that outcome under full diligence. The MLRP property will generally imply that it will be more efficient to provide incentives to overall diligence by rewarding higher joint outcomes compared to lower joint outcomes, a fact that will account for the optimal structure of multi-task contracts for a single borrower and, under certain circumstances, for the optimality of joint-liability loans.

2.1 Individual liability loans

An individual liability financial contract for a one-task project establishes how verifiable project claims $x_i$ are to be divided between returns $s_i$ to an entrepreneur/borrower and repayments $R_i = x_i - s_i$ to a lender. The loan market is assumed to be competitive so that borrowers are able to obtain their most preferred feasible loan contract. For the moment we also assume that a lender can stipulate and enforce exclusive contracting. This will later be relaxed. The contract design problem for a borrower with collateral assets $A$ can then be stated as finding contract terms $s_i$ to solve the following program:

$$\begin{align*}
\text{Max} & \quad E[s|1, 1] \\
E[x|1, 1] - E[s_i|1, 1] & \geq \gamma I \\
E[s|1, 1] & \geq 0 \\
E[s|1, 1] & \geq E[s_i|1, 0] + B \\
x_i - s_i & \geq X_i + A \text{ for } i \in \{0, 1\}
\end{align*}$$

Constraint (6) and (7) are the investor’s and the borrower’s participation constraints requiring, respectively, that expected repayments at least cover the lender’s opportunity cost of funds and that the borrower earn at least as much via the contract as in her next best activity (here normalized to be zero). Since on a competitive lending market this last constraint will typically be satisfied with slack it will not be mentioned again until it becomes relevant. The borrower’s incentive compatibility constraint (8) assures that any feasible contract will credibly commit the borrower to choosing diligence. Expanding
and rearranging this constraint yields:

\[ s_1 \geq s_0 + \frac{B}{(\pi - \bar{\pi})} \]  

(10)

Intuitively, the borrower’s return to success \( s_s \) must be made to be sufficiently greater than the return to failure \( s_0 \) so as to generate incentive for the borrower to want to raise the probability of success by choosing diligence. Limited liability constraints (9) restrict repayment in any given state to not exceed the value of the realized project outcome \( x_i \) plus available collateral \( A \). Subtracting \( x_i \) from each side, these inequalities can be restated as a restriction on the minimum return to the borrower, or \( s_i \geq -A \) for \( i \in \{0, 1\} \).

Since by limited liability a borrower with collateral \( A \) cannot be punished with a return any lower than \( s_0 = -A \). Since this is the case incentive constraint (8) can only be satisfied if the borrower is given an incentive ‘bonus’ in the success state that leaves her with at least \( s_1 = B/(\pi - \bar{\pi}) - A \). Hence, to satisfy limited liability and have incentives to remain diligent, a borrower with assets \( A \) must earn a minimum expected return of at least

\[ E[s|1,1] = \frac{\pi B}{(\pi - \bar{\pi})} - A \]

\[ = \frac{B}{(1 - l)} - A \]  

(11)

where the ratio \( l = \pi / \bar{\pi} \) measures how much less likely the project is to succeed when the borrower is non-diligent compared to diligent as in Claim 1 above. When expression (11) exceeds the borrower’s reservation payoff (here assumed to be zero) the lender will have to yield an economic rent to the borrower. The term \( B/(1 - l) \) will be labeled a limited liability rent (Laffont and Martimort, 2002) since it measures the additional cost of providing indirect incentives due to the presence of limited liability constraints. If this rent becomes too large, expected project returns \( EX = E[x|1,1] \) might no longer be sufficient to cover both this rent and the lender’s opportunity cost of funds \( \gamma I \). The lender would then refuse to participate in the contract, even though the same project would be profitable in the hands of an entrepreneur who self-financed or who had more collateral wealth (Stiglitz and Weiss, 1981).
Substituting expression (11) into the lender’s binding participation constraint (6) and solving for \( A \) leads to an expression for the minimum collateral requirement, or the lowest value of \( A \) that must be posted by the borrower if the lender is to be willingly enticed to provide an exclusive individual liability loan of size \( I \):

\[
A_1 = \frac{B}{(1-l)} - [EX - \gamma I]
\]  

(12)

where the subscript on \( A_1 \) indicates that this is a one-task project. The minimum collateral requirement is equal to the limited liability rent less the expected value of net project returns. The minimum collateral individual liability contract offered on a competitive loan market will therefore be \( s_0 = -A_1 \) and \( s_1 = B/(1-l) - A_1 \). Borrowers with assets \( A \) larger than or equal to \( A_1 \) can obtain competitively priced loans of size \( I \) and will earn the full surplus \( Ex - \gamma I \). Entrepreneurs with assets less than \( A_1 \) will be excluded from this particular loan market.

The minimum collateral requirement rises with the size of the requested loan \( I \), with the lender’s opportunity cost of funds \( \gamma \), and with the scope for moral hazard, as captured by the opportunity cost of diligence \( B \). The requirement will also be lower the higher are expected project returns \( EX \) and the ‘safer’ is the diligent project relative to the non-diligent project, as captured by a lower value of the inverse likelihood ratio \( 1/(1-l) \) in the limited liability rent expression. A lower \( l \) reduces \( A_1 \). This last result suggests that lenders might prefer to steer asset poor borrowers toward safer sectors or borrowing activities,\(^8\) and provides an early clue as to why grouping tasks under one borrower, or borrowers into a group may help reduce collateral requirements, as will now be shown.

### 2.2 Loans for multiple tasks

Suppose now that instead of working on a single production project the entrepreneur could operate \( N \) smaller independent projects each \( 1/N \)th the size of the original. If the original project yielded \( X_0 \) or \( X_1 \), each subproject or task \( n \) now yields \( X_0/n \) or \( X_1/N \), and requires \( I/N \) investment funds. The

\(^{8}\text{For example, asset-poor farmers might for example be given access to credit for safer traditional crops but not for riskier but possibly higher yielding non-traditional crops.}\)
opportunity cost of diligence on each task is now also $B/N$. If the entrepreneur is diligent on all tasks, this portfolio of subprojects will generate the same expected return $EX$ as the original larger single-task project and at the same total opportunity cost of diligence $B$. For example, rather than work a single agricultural plot, a farmer might scatter her plots around the village, or might scale back on farming activities in order to also diversify into non-farm activities. Diversified production strategies of this sort are common and widespread in poor households in developing countries although this has usually been explained as a consumption smoothing strategy by risk-averse households (McCloskey, 1976). The analysis below will suggest why diversification activities of this sort might also be part of a strategy to improve access to financial contracts.

If this entrepreneur were to seek outside funding from a single lender for this portfolio of $N$ subprojects the problem would have to be analyzed as a multi-task principal agent problem (Holmstrom and Milgrom, 1991) with limited liability constraints. Since there are two outcomes per task, there are in principle $2^N$ possible joint outcomes or contingencies. Each contingency can be indexed by an $N$-element vector $I = (i_1, \ldots, i_N)$ where $i_n \in \{0, 1\}$ indicates success or failure for each task $n$. However, when subprojects are identical there are in effect only $N+1$ possible aggregate project outcomes in which case it will be convenient to economize on notation and index joint outcomes by the number of successful outcomes $j = 0, 1, N$ as described earlier.$^9$

There are now also $N+1$ action choices or different ways that the borrower can affect overall expected returns, ranging from choosing to be diligent on zero to all $N$ subprojects. The contract design problem is now to maximize expected borrower returns $E[s|N, N]$ subject to the lender’s participation constraint, limited liability, and each of the following $N+1$ incentive compatibility constraints to assure that the borrower prefers to choose diligence on all $N$ projects rather than on any smaller number of projects $k < N$:

$$E[s|N, N] \geq E[s|N, k] + (N-k)B/N \quad \text{for } k \in \{1, N\}$$

$^9$This involves a slight abuse of notation, since on a few occasions below contracts will be indexed by the full $N$-tuple. The context or the text will make the meaning clear. In all cases the parties can observe individual outcomes and not just only the aggregate ones and they would use this information in the contract if it served a useful purpose.
The key advantage of diversification and multi-tasking is that this set of incentive constraints is more relaxed than the earlier incentive constraint on a single larger project (8). This will mean that subdividing the original project into smaller independent sub-tasks and financing all tasks together under a single contract expands access by lowering the overall minimum collateral requirement relative to the individual liability alternatives of either separate ‘unlinked’ individual liability contracts for each task, or the single individual liability contract for the original undivided larger project:

**Proposition 2** On a competitive loan market, an optimal loan contract for an \( N \)-task project implements diligence on all tasks at minimum collateral requirement

\[
\Lambda_N = \frac{B}{(1-l^N)} - (EX - \gamma I) \tag{14}
\]

The contract rewards the borrower when all projects succeed, \( \tilde{s}_N = Z - \Lambda_N \), and punishes fully under all other contingencies, \( \tilde{s}_j = -\Lambda_N \) for \( j \neq N \) where

\[
Z_N = \frac{B}{(\pi^N - \pi^N)} \tag{15}
\]

The collateral requirement \( \Lambda_N \) is monotonically decreasing in the number of independent subprojects \( N \).

Details are in the appendix but intuition can be gleaned from the \( N = 2 \) case. A multi-task contract allows the borrower to now pledge to pay for failure on any one task out of the returns from any other successful tasks. By increasing the expected ‘punishment’ to the borrower for failure on any one task compared to two separate individual liability contracts (one for each task) without such interdependencies, the contract is able to also economize on the ‘incentive bonus’ paid out when tasks succeed without disrupting incentives. This reduces the size of the limited liability rent and hence lowers the minimum collateral requirement for loan access.\(^{10}\)

Another way to see this is to note that this multi-task principal-agent problem maps into the more canonical contracting problem studied by Innes

\(^{10}\)See Laux (2001) for a discussion of similar, independently derived results in the context of task allocation within firms.
(1990), namely that of a risk-neutral principal contracting with a risk-neutral agent who manages a single-task project with multiple outcomes subject to moral hazard and limited liability. To see this note that the $N+1$ possible aggregate returns that can result from $N$ identical subprojects can be indexed by the number of subprojects $j \in \{0, N\}$ that succeed, as in $x_j = jX_1/N + (N-j)X_0/N$. The borrower now also has $N+1$ distinct 'action levels' indexed by $k$, corresponding to the total number of tasks operated with diligence. Aggregate outcome $x_j$ will be distributed according to the binomial distribution conditioned on the diligence level chosen, as previously described in (1) and illustrated in figure 1.

As is well understood, if the agent were not subject to limited liability constraints, a first-best solution to this single-task moral hazard problem with a risk neutral agent is to make the agent a full residual claimant. A fixed debt contract (FDC) that obligated the borrower to repay $\gamma I$ regardless of project outcome, or $s_j = x_j - \gamma I$, would offer one such solution. This however will not be feasible due to limited liability if the fixed repayment $\gamma I$ exceeds total project returns $x_j$ plus available collateral $A$ in any state(s). In such a context, and given MLRP, the optimal contract is instead a live-or-die contract (LDC) which places all of the reward on the highest project outcome (Innes, 1990; Proposition 2). Adapted to the multi-task setting this implies the entrepreneur is rewarded only when all projects succeed and earns a fixed return $-A$ (i.e. makes repayment $x_j + A$) under all other outcomes, as in the Proposition above.

The highly fine-tuned nature of the LDC reward structure arises because the most cost-efficient way to provide incentives to a risk-neutral agent is to concentrate all reward on the single outcome with the highest likelihood ratio, which by Claim 1 is the 'all success' outcome where all $N$ tasks succeed. Innes (1990) demonstrationed however that if one imposes a few reasonable additional monotonicity constraints on the contracting environment and assume MLRP (which is guaranteed by our assumptions) the optimal contract solution is transformed from an LDC form into the more familiar and ubiquitous Standard Debt Contract (SDC) which has the borrower pay a fixed repayment $R$ for all joint outcomes above a given threshold and repay all output plus available collateral otherwise. That is $R_j = \min(x_j + A, R)$, leaving $s_j = \max(-A, x_j - R)$ to the borrower.
‘Monotonicity constraints’ simply impose the requirement that any repayment schedule \( R_j = x_j - s_j \) must be non-decreasing in the size of the joint outcome, or that \( R_j \geq R_{j'} \) for all \( x_j \geq x_{j'} \). There are good reasons to justify such constraints. First, if the optimal contract did not satisfy monotonicity then a lender might be easily tempted to try to sabotage or mis-measure the borrower’s project outcomes in an effort to avoid the low repayment (or ‘bonus’ outcome). Similarly, under non-monotonic contracts entrepreneurs might be tempted to secretly borrow output from other agents to pretend to have higher output in order and get away with a low repayment to the lender in ways that could undermine the contract (Innes, 1990).

If any of the monotonicity constraints bind an SDC solution emerges. Since new constraints have been imposed the SDC contract obviously cannot improve on the unconstrained LDC and may provide weaker incentives. This may imply a somewhat higher minimum collateral requirement than \( A_N \) in the Proposition above. With or without monotonicity constraints the underlying logic of ‘incentive diversification’ remains the same however: pledging returns from successful subprojects to cover obligations arising from failures on other subprojects can lower limited liability rents and increase loan access. Since this is the case the results that follow are first derived using the more simple and intuitively explained LDC case, before then discussing how monotonicity constraints may lead to (sometimes important) qualifications.

2.3 Joint Liability Loans with Costless Monitoring

Stiglitz (1990) offered an early treatment of group lending under the assumption of costless ‘peer-monitoring’ or what Tirole (1992) has labeled the full side-contract assumption that agents can costlessly observe each others action choices and enter into binding action-contingent side-contracts or cooperation. Borrowers’ actions can now be analyzed as if they were decided by a single-minded collective or coalition. Each borrower’s project is now a task or subproject managed by the coalition, and the contracting problem is then exactly like the multi-task case of the last section. This section briefly restates and extends Stiglitz’ results to establish a relevant benchmark against which to compare the non-cooperative, costly-monitoring scenarios to follow. Stiglitz demonstrated that a two person joint-liability loan could be used to encourage
costless side-contracting (or ‘peer-monitoring’) that increased the size of the loans that could be offered to borrowers with zero collateral. Here we adapt his model to the fixed loan size, variable-collateral setting analyzed above with groups of arbitrary size $N$.

The notation is as in the multi-task case with $j$ indexing the total number of borrowers’ whose projects that succeed. Let $X_I = (X_{i_1}^1, ...X_{i_n}^n ...X_{i_N}^N)$ indicate a given realization of project returns across the group, where $i_n \in \{0, 1\}$ for $n \in \{1, N\}$. Let $x_j = (jX_1 + (N - j)X_0)/N$ indicate the average return per borrower where $j$ indexes the number of projects that succeed. The lender now establishes a contract with the entire coalition in which the entire group is responsible for repayments on any given project. For simplicity we shall assume for now that members of the group simply divide up net project returns symmetrically amongst themselves. This is without loss of generality because, subject only to each agent’s participation constraint, the exact division of net group returns amongst members does not really matter because a side-contracting coalition of risk-neutral agents will always choose to first maximize total expected group returns per borrower $s_j$ before efficiently redistributing returns via side transfers. This will be true regardless of whatever particular redistributive preferences (or balance of bargaining power) may exist within the group.

On a competitive lending market the coalition now chooses the group contract that maximizes expected net return per borrower $E[s|N,N]$ subject to the lender’s and the agents participation constraints as well as to incentive constraints to commit the group to diligence on each of the $N$ subprojects or tasks within the group.

When all constraints of this problem are stated in per-borrower terms, and $s_j$ is the average return per borrower, the problem becomes exactly the same as the multi-task problem of the last section.

**Proposition 3** On a competitive loan market, the optimal $N$-borrower loan contract implements diligence on all borrowers’ projects at minimum collateral requirement per borrower

$$A_N = \frac{B}{(1-l^N)} - (EX - \gamma I)$$  \hspace{1cm} (16)
The contract involves a joint-liability structure that rewards the group when all projects succeed, $s_N = Z_N - A_N$, and ‘punishes’ all borrowers for the failure of any one borrower, $s_j = -A_N$ for all $j \neq N$ where

$$Z_N = \frac{B}{(\pi^N - \pi^N)}$$

(17)

The intuition is just as before. When all projects can be consolidated under the management of a single-minded coalition the most efficient way to economize on the costly incentive ‘bonuses’ that had lead to limited liability rents and exclusion under individual liability is to now re-allocate rewards toward the single outcome with the highest likelihood ratio where all projects succeed. This solution imposes a joint-liability structure that punishes each borrower for the failure of any one other borrower in the group.

With additional monotonicity constraints imposed, it may no longer be possible to concentrate all reward on the highest likelihood ratio, forcing the contract to redistribute rewards toward the next highest-likelihood ratios until all constraints are satisfied and borrowers’ obtain access. The result would be a group-level standard debt contract, which also implies joint liability.

Unfortunately, Stiglitz’ result turns out to be somewhat of an embarrassment of riches as the collateral requirements can be driven ever lower simply by increasing group size.

**Corollary 4** The minimum collateral requirement $A_N$ is monotonically decreasing in group size $N$.

This follows simply from the observation that $l_N$ in (16) falls with $N$. In the limit $A_N$ converges to $-(EX - \gamma I)$, so the coalition could provide each borrower with a nearly secure return $EX - \gamma I$ in nearly every state even while maintaining incentives. This is a consequence of the law of large numbers: with a very large and diversified group the variance of average project returns, and the cost of providing incentives, become vanishingly small.

**Free Riding and Optimal Group Size** Although microfinance lenders such as FINCA International have created ‘village banks’ of twenty or more jointly liable borrowers most microfinance providers tend to limit group sizes
between two and seven borrowers. One factor that might be expected to limit group size is the concern that borrowers could find it difficult to sustain cooperative arrangements and enforce side-contracts. Costless side-contracting implicitly assumes that group members can not only observe each others’ diligence choices but can also credibly threaten social sanctions against any deviation from the cooperative agreement reached via side-contracts.

The ability of a group of individuals to costlessly side-contract is laid down to the group’s assumed information and enforcement advantage relative to an outside lender. To insure that compliance with the proposed cooperative equilibrium is sustained the group has to be able to credibly threaten to impose a social sanction of at least size $F_N$ to satisfy the following individual level incentive compatibility constraints for each and every borrower

$$\frac{\pi^N B}{(\pi^N - \pi^N)} - A_N \geq \frac{\pi^{N-1} B}{(\pi^N - \pi^N)} - A_N + B - F_N$$

(18)

It is easy to show that if no social sanctions is available, so $F_N = 0$, the above incentive constraint will always be violated. Individual borrowers will always have an incentive to free-ride and defect from the cooperative arrangement. If $F_N = 0$ borrowers interact non-cooperatively and much stronger individual-level incentives must be provided to insure that every borrower chooses diligence. If we insist on a joint liability LDC form (which we argued weakly dominates other forms) then incentives to remain diligent at minimum incentive cost to borrower $n$ requires $s^n_{l-s} = Z - A$ and $s^n_I = -A$ for all other $I \neq l-s$ where $s^n_{l-s}$ indicates the return to borrower $n$ when all other borrowers’ projects succeed. Solving for $Z$ then gives

$$Z = \frac{B}{(\pi^N - \pi^{N-1})}$$

and the expected return under this joint liability contract would then be $\pi^N Z - A = B/(1-l) - A$. This, however, is exactly the same limited liability rent (11) that was obtained when we analyzed separate individual liability contracts for each borrower. This means that

Remark 5 Without an assumed enforcement advantage that gives group members the ability to enforce action-contingent side-contracts, joint-liability contracts offer no advantage over individual liability loans.
The full side-contract assumption amounts to maintaining that collusion—or incentives against defection—can be costlessly maintained. It in effect allows us to substitute a collection of individual incentive compatibility constraints (8), one for each borrower, by the easier to satisfy coalition incentive constraints (??). But if such costless side contracting cannot be simply assumed, then the problem becomes like a classic Cournot duopoly problem where each borrower has an incentive to free-ride or defect from the cooperative solution and raise their personal payoff at the expense of joint profits unless some kind of sanction can be imposed to deter it. In such a setting joint liability clauses offer no relief. Che (2002) constructs an example to argue furthermore that if monotonicity constraints are also imposed—so as to restrict feasible contract solutions to standard debt contracts—then, depending on parameters, individual loans may actually dominate group loans for \( N > 2 \).

To see the implicit role that ‘social sanctions’ play in sustaining the costless side-contracting case, let \( F_N \) be the minimum required social sanction that would exactly deter a borrower in a group of size \( N \) from defecting from the contract of Proposition 1. In a repeated game framework, \( F_N \) might be the present discounted value of the cash stream lost from being forever cut off from group loans. \( F_N \) is defined to be the smallest value that satisfies (18)

\[
\frac{\pi^N B}{(\pi^N - \pi)} - A \geq \frac{\pi^{N-1} B}{(\pi^N - \pi^N)} + B - A - F_N
\]

Solving for \( F_N \) and examining its properties leads to the following observation:

**Claim 6** The minimum social sanction \( F_N = \frac{(l)N}{(1-l)N}B \) required to sustain the minimum collateral peer-monitoring equilibrium of Proposition 3, rises with group size \( N \) to reach upper bound \( \lim_{N \to \infty} F_N = l \cdot B \).

In other words, it becomes harder and harder to contain free-riding as group size increases. Suppose the available social sanction per borrower were fixed at \( F < l \cdot B \), which we take to be exognously given. Typically the ability to impose social sanctions depends on the nature of the community and how well the borrowers know each other and interact in other social spheres. An optimal joint-liability group size can be determined by searching for the largest integer \( N \) such that \( F_N \leq F \). Larger groups enjoy the benefits of
diversification but have to impose larger social sanctions to deter free-riding. Since, as is often argued, rural agents are usually less mobile and live in more tightly-knit and tradition and social norms ruled communities than their urban counterparts, joint liability groups could be expected to be less frequent and/or smaller in size in urban areas. Larger joint liability groups such as village banks would tend to be found mostly in rural areas. On the other hand, project returns are perhaps more likely to be correlated in rural areas, and this would tend to work toward making the opposite prediction, as discussed later.

2.4 Intermediation with costly delegated monitoring

To analyze costly monitoring and non-cooperative interactions, it will be useful to build on a variant of Holmstrom and Tirole’s (1997) model of costly delegated monitoring with individual liability loans. I will extend that model to allow for variable monitoring, and in the next section, to joint-liability lending.

Consider again an uninformed lender trying to finance a single borrower only that now the lender may also involve a delegated monitor or intermediary who, at variable expense $c$, may carry out monitoring and control activities aimed at directly limiting the borrower’s scope for moral hazard by reducing the borrower’s private benefits from $B = B(0)$ to $B(c) < B$. For example, is not at all uncommon in microfinance for a loan office to make frequent unexpected visits to an entrepreneur’s business to check that loan funds and effort are being put into the financed activity and not re-directed toward private uses. Although non-diligence may still remain unobserved the obvious effect of such activities is to reduce the borrower’s expected return to non-diligence, perhaps because costly evasion and concealment activities would now be required to get away with it. The return to non-diligence might also be reduced simply because a borrower may feel more guilt or shame at deceiving a monitor who has established a personal stake in the project. This last effect is likely to be more pronounced the better known is the monitor to the borrower.

To fix ideas, let’s assume quite reasonably that monitoring effort $c$ lowers $B(c)$ but at a diminishing rate.$^{11}$

$^{11}$A simple function that satisfies this property is $B(c) = B/(c + 1)$. In a sense, the ability to enter into action-contingent loans in the cooperative case described above is like
Assumption 1: $B(c) \geq 0, B'_c < 0$ and $B''_c > 0$ for all $c \geq 0$.

A financial contract now divides expected property claims $x_i$ between repayments to an uninformed lender $R_i$, payments to a delegated monitor $w_i$, and returns to the borrower $s_i = x_i - R_i - w_i$. Following the literature, the timing of the game is as follows: A contract is proposed and accepted or rejected by the parties. If a monitor is involved, she then chooses and commits to her monitoring intensity $c$. Monitoring cannot be verified by the outside lender but is evident to the borrower who then chooses her own unobserved diligence choice based upon it. Project outcomes are then realized and project returns are distributed according to the terms of the contract.

Consider first the simple case of an uninformed lender that hires a delegate to monitor just one borrower. Since the delegate’s monitoring cannot be verified by the lender, incentives have to be provided by tying the delegate’s renumeration $w_i$ to the observable outcomes on the borrower’s project. A monitor’s rewards may also be subject to limited liability. When this is the case contracts that are restricted in how much they can punish a monitor for a borrower’s project failure will have to provide monitoring incentives via costly delegation rents or bonuses to the monitor when the borrower’s projects succeed. Just as a borrower may commit to lower the size of limited liability rents by posting collateral, a delegated monitor may commit to lower delegation rents by offering to put some of their own capital at risk in the borrower’s project. All else equal delegates who have access to more of their own intermediary capital will in general tend to make more attractive monitors.

The amount of intermediary capital available to local monitors will typically vary by context. It will be useful to distinguish between what we will call fully bonded (or fully intermediary) and non-bonded (or non-intermediary) monitors. An example of the first type of monitor might for example be a well-capitalized product trader that makes a loan advance to a farmer financed partly out of his own equity, and partly from funds leveraged from an outside bank lender. The trader’s own stake in the project helps bond or commit him to monitoring the loan, and hence helps to convince the bank to to become involved in the transaction. A non-bonded monitor is one where the delegate monitor has no capital of their own to place at risk, or where legal or other having each borrower have an extremely cost effective monitoring strategy that lowers other borrower’s private benefits from $B$ to 0 at infinitesimally small cost.
restrictions might impede its use. A local loan officer hired by a bank or microfinance provider is typically in this position. In this case incentives to monitor have to be provided via incentive pay bonuses. High-powered incentive contracts are in fact exceedingly common in microfinance where employee compensation is typically also the most important element of operating costs.

Consider the general case where a delegate can place \( I^m \) of his own capital at risk in the borrower’s project. We assume the opportunity cost of these funds is \( \gamma I^m \). One interpretation is that the delegate herself finances \( I^m \) of the loan project leaving \( I^u = I - I^m \) to be financed by the outside lender. Alternatively, but equivalently, one may think of the delegate as instead agreeing to co-sign the outsider’s loan \( I \) by agreeing to be liable for up to \( \gamma I^m \). In either case, the delegate’s maximum liability in the event of borrower failure is \( w_0 = -\gamma I^m \).

Assuming competition in both lending and monitoring activities, an optimal individual liability contract will be offered to maximize the borrower’s expected return subject to

\[
\max_{s_i, w_i} E[s_i|1,1] \\
EX - E[s_i|1,1] - E[w_i|1,1] \geq \gamma I \\
E[w_i|1,1] - c \geq 0 \\
E[s_i|1,1] \geq E[s_i|1,0] + B(c) \\
E[w_i|1,1] - c \geq E[w_i|1,0] \\
s_i \geq -A \quad w_i \geq -\gamma I^m
\]

where (20) is the investor’s participation constraint, (21) is the delegated monitor’s break-even condition that the expected return per borrower exceed monitoring cost per borrower, (22) is the borrower’s incentive compatibility constraint, (23) is the delegate’s global incentive compatibility constraint that he prefer to monitor each borrower to not monitoring at all\(^{12}\), and (24) are limited liability constraints for the borrower and the monitor respectively.

\(^{12}\)There are in fact be \( N + 1 \) incentive constraints needed to assure that the delegate prefer to monitor all \( N \) borrowers rather any number \( k < N \) of them, but following earlier arguments, it is easy to show that under the optimal contract examined below all these other constraints will hold if the global one does.
A range of different financial contracts and intermediary structures can be analyzed by varying the amount of borrower collateral $A$, the amount of available ‘intermediary capital’ $I^m$, and the number of borrowers that a delegate simultaneously monitors.

2.4.1 Simple delegated monitoring

If any funds from outside investors are to be raised (i.e. if $I^u > 0$), investors will want to be sure that the monitor faces contractual incentives to monitor. Since monitoring lowers $B(c)$ and this in turn increases a borrower’s incentive to remain diligent, contracts should reward a delegate for successes on the monitored project and ‘punish’ them for failures. Monitoring incentive constraint (23) can be written:

$$w_s \geq w_f + c/(\pi - \bar{\pi})$$

(25)

The least costly way for a contract to provide a delegate with incentives to monitor at intensity $c$ is to set $w_f = -\gamma I^m$ and $w_s = c/(\pi - \bar{\pi}) - \gamma I^m$ so that (25) binds exactly. The expected return to a monitor net of the cost of monitoring $c$ must therefore be at least

$$E[w|1,1] - c = \frac{\pi c}{(\pi - \bar{\pi})} - c - \gamma I^m$$

$$= \frac{lc}{(1-l)} - \gamma I^m$$

(26)

This is a delegation rent exactly analogous to the limited liability rent in (11). The delegate can commit to reducing the size of the rent by increasing the amount of funds $\gamma I^m$ she is able and willing to put at risk in the project. From (26) it is clear that the delegation rent will be strictly positive unless the delegate can commit to a personal liability of at least

$$I^m(c) = \frac{lc}{\gamma(1-l)}$$

(27)

Difference cases need to be distinguished depending on whether the monitor has ‘intermediary capital’ of her own to put at risk. A fully-bonded monitor
is able to place the full amount $I^m_1(c)$ at risk, whereas a non-bonded monitor will have no capital at risk, or $I^m = 0$. In intermediate cases where $0 < I^m < I^m_1(c)$ the monitor will be described as being partially-bonded. How much monitoring intensity, and what minimum collateral requirement will be required per borrower in each case? An uninformed lender will only be willing to lend via a contract with a delegated monitor if expected project returns are sufficient to cover the uninformed lenders’ opportunity cost of funds, or if

$$EX - E[s|1, 1] - E[w|1, 1] \geq \gamma I$$

Consider first the fully-bonded monitor case. In this case the delegation rent is zero so the total cost of delegation is simply monitoring costs $E[w|1, 1] = c$. Superseding this and $E[s|1, 1] = B(c)/(1 - l)$ into the above constraint and solving for the level of $A$ at which this lender is just willing to participate yields a new expression for the minimum collateral requirement, now written as a function of the monitoring intensity $c$:

$$A^m_1(c) = \frac{B(c)}{(1 - l)} - [Ex - \gamma I] + c$$ (28)

In the case of a non-bonded monitor, where $I^m = 0$, the expression would instead be:

$$A^d_1(c) = A^m_1(c) + \frac{lc}{(1 - l)}$$ (29)

At any level of monitoring, $A^d_1(c)$ exceeds $A^m_1(c)$ by the size of the delegation rent needed to sustain monitoring incentives. An increase in monitoring intensity $c$ can be seen to have two opposed effects on either $A^m_1(c)$ or $A^d_1(c)$. By directly reducing the borrowers’ return from moral hazard $B(c)$, monitoring lowers the size of the limited liability rent $B(c)/(1 - l)$ and hence also the collateral requirement. On the other hand, an increase in monitoring raises delegation costs. These costs rise dollar for dollar with $c$ in the fully bonded case and more rapidly when a delegation rent is needed to sustain incentives. If $B'(0) < -1$ the first dollar of monitoring reduces both $A^m_1(c)$ and $A^d_1(c)$, and

13Recall that the monitor’s reservation wage was normalized to zero.
monitoring can expand loan access by lowering collateral requirements. The assumption of diminishing returns to monitoring guarantees however that delegation costs will eventually rise more rapidly than limited liability rents fall, and so there will be a cutoff monitoring level \((c_m^* \text{ or } c_d^*)\) beyond which further monitoring becomes counter-productive.\(^{14}\) Figure 2 illustrates how the minimum collateral requirements \(A_m^m(c)\) and \(A_d^d(c)\) might both first fall and then rise with monitoring intensity \(c\).

Since delegation costs must be paid out of expected project returns, monitored finance must by definition always be more expensive than non-monitored lending. Hence, only borrowers who do not have sufficient collateral assets to gain access to unmonitored loans (i.e. those with assets \(A\) below \(A_1 = A_m^m(0)\)) would ever turn to monitored finance, and would then only agree to a loan with just enough monitoring to reduce the collateral requirement to their available assets \(A\). As illustrated, a borrower with collateral \(A\) would choose a loan with monitoring intensity \(c_m = c_m(A)\) given by \(A_1^m(c_m) = A\). This borrower would pay an implicit cost of funds of \(\gamma + c_m(A)/I\). The contract involves the monitor putting up \(I_m^m(c_m) = c_m l/\gamma(1-l)\) worth of funds and leveraging an additional \(I_u = I - I_m^m(c_m)\) from the outside lender. Since monitoring substitutes for collateral, borrowers with fewer assets pay higher borrowing costs and will have a higher share of monitored versus unmonitored finance \(I_m^m(c_m)/I\).

Since \(A_d^d(c) > A_m^m(c)\) for all \(c>0\), fully bonded lenders can offer loans at lower cost (i.e. \(c_m(A) < c_d(A)\) for all \(A \in \{A_1, A_d^d(\bar{c}_d)\}\)) compared to loans involving only partially-bonded monitors and also offer access to more collateral-poor borrowers (i.e. they can reach borrowers with \(A \in \{A_d^d(\bar{c}_d), A_m^m(\bar{c}_m)\}\) which would otherwise not be served.). The following summarizes the results for they fully bonded intermediary:

**Proposition 7** If delegated monitors have abundant intermediary capital and \(B'(0)/(1-l) > -1\), then borrowers on a competitive loan market will be

\(^{14}\)This implicitly assumes the borrower’s own participation constraint does not bind before either cutoff has been reached, but adding this as an explicit constraint does not change the essential tradeoffs described here.
matched to monitored individual liability loans according to their initial collateral $A$ as follows:

<table>
<thead>
<tr>
<th>Loan Type</th>
<th>Collateral Assets</th>
<th>Monitoring</th>
<th>Cost funds $\gamma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-monitored Loans</td>
<td>$A \geq A_i$</td>
<td>0</td>
<td>$\gamma$</td>
</tr>
<tr>
<td>Monitored Loans</td>
<td>$A_i &gt; A \geq A_{m1}(\overline{c_m})$</td>
<td>$c_m(A)$</td>
<td>$\gamma + c_m(A)/I$</td>
</tr>
<tr>
<td>Excluded</td>
<td>$A &lt; A_{m1}(\overline{c_m})$</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

where $\overline{c_m}$ is given by $B_c(\overline{c_m})/(1-l) = -1$ and $c_m = c_m(A)$ is given by $A_{m1}(c_m) = A$.

2.4.2 Monitor diversification strategies

Intermediary capital is not always available in poor communities. Inhabitants of an area may have a dense network of relationships with others which would seem to make them good monitors but are also poor and therefore cannot offer the intermediary capital that might be needed to reassure an outside investor. In a seminal paper Diamond (1984) argued that there may be a way around the need to post financial intermediary capital. Diamond’s paper was built around a model of ex-post moral hazard and costly state verification, but his insights can be adapted to the ex-ante moral hazard case here.

Consider the case where an uninformed lender contracts a delegated monitor who in turn simultaneously monitors $N$ different individual-liability borrowers. This is a common case. A microfinance organization might for example hire a loan officer to monitor anywhere from one to several hundred loans. The monitor’s return $w_I$ can now be made explicitly contingent on the outcomes on each of the $N$ borrowers in his portfolio. Consider first the simple case where the total cost to monitoring is a simple linear function of the number of borrowers monitored, so that if it takes $c$ to reduce the opportunity cost of funds of a single borrower from $B(0)$ to $B(c)$ then it takes $Nc$ to reduce $N$ borrowers to $B(c)$.

The uninformed lender contracts separately with $N$ different borrowers each with collateral assets $A$. Each borrower is offered a monitored individual liability contract of the form $s_{in}$ where $i_n \in \{0,1\}$ indexes output on borrower $n$’s project. Since borrowers are identical we analyze the terms of the representative borrower’s contract $s_i$. The lender also contracts with a delegate
who receives contract \( w_I \), where \( I = (i_1, \ldots, i_N) \), in exchange for monitoring all \( N \) borrowers. Assuming free entry and competition into lending and monitoring activities, the terms of the optimal contracts, summarized by \( \{ s_i, w_I \} \), will be chosen to maximize expected returns to the representative borrower at minimum monitoring cost:

\[
\max_{s_i, w_i} E[s_i | 1, 1] \\
EX - E[s_i | 1, 1] - E[w_i | 1, 1] \geq \gamma I \\
E[w_i | N, N] - c \geq 0 \\
E[s_i | 1, 1] \geq E[s_i | 1, 0] + B(c) \\
E[w_i | N, N] - c \geq E[w_i | 1, 0] \\
s_i \geq -A \\
w_i \geq -\gamma I^m
\]  

Note that \( A^m(c) \) is independent of the number of borrowers per delegate because the delegate is here assumed to be able to post sufficient intermediary capital to eliminate delegation rents. Monitoring has two opposed effects on the minimum collateral requirement. On the one hand, a marginal increase in monitoring lowers \( B(c) \), which reduces the size of the borrower’s limited liability rent and hence the collateral requirement by \( B_c(c)/(1 - l) \). But each extra dollar’s worth of monitoring cost reduces the net project project returns out of which lender repayments and borrower incentives can be fashioned. If we assume that the first dollar spent on monitoring lowers the collateral hurdle, or that \( B_c(0)/(1 - l) > -1 \), then a positive level of monitoring will be chosen. The assumption of diminishing returns to monitoring \( (B_{cc} > 0) \) guarantees that there must eventually be some monitoring intensity \( \overline{c} \) beyond which further monitoring becomes counterproductive. Threshold \( \overline{c} \) is defined by \( B_c(\overline{c})/(1 - l) = -1 \).

Figure 1 illustrates how the minimum collateral requirement might fall over the range \((0, \overline{c})\) and rise thereafter.

Figure 1 about here

Since delegation costs use up real resources, monitored lending will always be more expensive than uninformed lending. It stands to reason that only
borrowers with assets below \( A_1 = A_1^m(0) \), who cannot gain access to direct collateral-based loans, would turn to monitored finance, and that they would then choose loans with the minimal required level of monitoring to just lower the collateral requirement to their available collateral asset level \( A \). The optimal monitoring intensity is therefore zero for borrowers with assets \( A \geq A_1 \).

Those who have less than this amount choose a loan with minimum monitoring intensity \( c_m = c_m(A) \) to just bring down the minimum collateral requirement to the level of their assets, or \( A^m(c_m) = A \). Monitored lending can reduce collateral requirements, but only up to monitoring intensity \( \overline{c} \), beyond which it becomes counterproductive.\(^{15}\)

Since a borrower makes expected repayment of \( \gamma I + c^m(A) \) on \( I \) dollars borrowed, the implicit interest rate on any type of monitored loan is \( \rho(A) = \gamma + c^*(A)/I \). Collateral-poor borrowers must pay higher implicit interest rates to cover the delegation costs.

The analysis also points to a possible further distinction between two further types of monitoring lender: those who can leverage outside funds and therefore can act as financial intermediaries and those who are unable to leverage outside funds and therefore must provide finance entirely out of their own equity. Borrowers with lower \( A \) therefore also borrow a larger proportion \( I^m/I \) of total funds from monitoring lenders.

**Corollary 8** Monitored loans can be further sub-divided into

Intermediated Loans \( A_1 > A \geq A^m(\widehat{c}) \quad (I^u > 0, I^m_N > 0) \)

Non-Intermediated Loans \( A^m(\widehat{c}) > A \geq A^m(\overline{c}) \quad (I^u = 0, I^m_N = I) \)

where \( \widehat{c} \) is defined by \( \gamma I = \widehat{c}t^N / (1 - t^N) \) and \( I^m_N = I^m_N(c^m(A)) \).

Since monitoring substitutes for collateral, \( c^m(A) \) rises if a monitoring lender attempts to reach a target group with a lower \( A \). By (27) raises the

\(^{15}\) I’ve implicitly assumed that the borrower’s own participation constraint does not bind before monitoring level \( \overline{c} \) has been reached. If the farmer’s has a reservation utility given by \( K \), then his binding participation constraint \( E(s_i|\overline{\pi}) = E(x_i|\overline{\pi}) - \gamma I - c = K \) defines a cutoff level \( c^k = E(x_i|\overline{\pi}) - \gamma I - K \). The assumption therefore is that \( \overline{c} \leq c^k \).
minimum stake a monitor must be willing to place at risk in the project, $I_N^m(c_m(A))$. It is therefore possible that as one tries to reach target groups with lower $A$, the required minimum level of monitoring will rise to a point $\hat{c}$. So much monitoring is needed at this point that the delegate’s required liability stake $I^m$ equals the entire investment amount $I$. Borrowers with assets less than $A^m(\hat{c})$ but more than $A^m(\bar{c})$ will be able to obtain loans of size $I$ but only from a lender who lends entirely out of her own equity.

Several studies of rural credit markets have characterized informal money-lenders in precisely these terms: moneylenders lend primarily out of own equity, they monitor their borrowers very heavily, and they charge very high interest rates (Aleem, 1994; Bell, 1994). This helps also explain why leverage ratios in microlending appears to have remained so low despite many efforts, or why it has proven so difficult to securitize bank’s small business lending portfolios even in advanced industrial economies. In essence, unsecured small business loans cannot be sold without diluting the bank’s incentive to monitor to protect the quality of its loan portfolio.

To this point we have assumed that the number of borrowers to be monitored by each delegate was exogenously fixed at $N$ per monitor. From expression (27) it is clear however that, all else equal, the minimum investment stake per borrower $I^m_N$ declines monotonically with $N$ and in the limit vanishes. This, of course, is closely related to the observation first made by Diamond (1984) This suggests that, if every borrower’s project is stochastically independent, the infinite size bank.

### 2.5 Joint Liability loans with costly monitoring

Now we consider group lending arrangements that delegate the task of costly monitoring to a group of peers rather than to an outside delegated monitor as in the last section. The fundamental difference from the earlier analysis of joint liability loans with costless sidecontracting ala Stiglitz (1990), is that monitoring is costly and borrowers are assumed to interact non-cooperatively.

One obvious potential advantage of using group peers rather than a non-group delegated monitor is that peers might be more effective monitors for reasons including the fact that they may belong to the same social networks and may already interact in other economic exchange relationships. This
may be important and relevant, although it is also possible that peers may be more likely to collude together against an outside lender, and that over time a professional delegated monitor may come to be as or more effective at monitoring and repayment collection than would a peer, who may not feel comfortable placing pressure on a friend or a relative. The surprising result we shall find is that, under certain circumstances, a peer monitoring arrangement may dominate a delegated monitoring arrangement even if the delegate has a slightly better monitoring technology $B(c)$ and even if the delegate has more intermediary capital and/or a larger portfolio of tasks upon which to build incentive diversification, than a peer-monitor.

Consider the joint liability contract between a single uninformed lender and a symmetric two-member group. Let $s_{ij}^n$ denote the return to borrower $n$ under contract $s$ following outcome $x_1^i$ on borrower 1’s project and outcome $x_2^j$ for borrower two. Without loss of generality we shall focus on the terms of borrower one’s contract denoted simply by $s_{ij}$.

To isolate the contractual mechanisms that give joint liability loans an advantage, as distinct from explanations based on an assumed initial monitoring advantage, we assume that the monitoring technology employed by each borrower cum peer-monitor is the same one available to an outside delegated monitor. Specifically, each group member can act to limit opportunistic behavior of another borrower via costly monitoring actions that lower the private benefit $B(c)$ the other borrower stands to capture from non-diligence.$^{16}$

The contract design problem can be viewed as a mechanism design problem. The terms of the offered contract $s_{ij}$ will determine the payoff structure of a game in monitoring intensities and production action choices played by two borrowers. Figures 3 and 4 depict the payoffs and the timing of the moves. If the contract offered by a lender is accepted, borrowers play a first stage non-cooperative game in monitoring intensities. The monitoring intensity pair $(c_1, c_2)$ chosen at this stage then determines the payoff structure $\zeta(c_1, c_2)$ of a subgame in diligence choices at the second stage. The desired outcome is for each borrower to choose an equilibrium monitoring intensity $c$ at the first game stage which then helps implement diligence as the equilibrium outcome

$^{16}$Monitoring expense $c$ includes the opportunity cost of time and resources as well as the direct disutility from attending regular group meetings, applying social pressure and individual monitoring, etc.
in a second stage game in production actions. We search for a subgame-
perfect Nash equilibrium (SPNE) implementation in pure strategies. Since
monitoring is an expensive activity, an optimal contract will aim to keep the
value of \( c \) to the minimum consistent with incentives.

Figures 2 and 3 about here

The following functions summarize payoffs to borrower 1 in each of the four
cells of a subgame \( \zeta(c_1, c_2) \)

\[
DD(c_1, c_2) : E(s_{ij} | \overline{\pi}, \overline{\pi}) - c^1 \\
ND(c_1, c_2) : E(s_{ij} | \overline{\pi}, \overline{\pi}) - c^1 + B(c^2) \\
DN(c_1, c_2) : E(s_{ij} | \overline{\pi}, \overline{\pi}) - c^1 \\
NN(c_1, c_2) : E(s_{ij} | \overline{\pi}, \overline{\pi}) - c^1 + B(c^2) 
\]

(35)

For example \( ND(c_1, c_2) \) is the payoff to borrower 1 when he is not diligent
(chooses \( \pi \)) and monitors the other borrower at intensity \( c^1 \) while borrower 2
chooses diligence \( \overline{\pi} \) and monitors borrower 1 at intensity \( c^2 \).

If a contract is to implement the diligence strategy profile \( (\overline{\pi}, \overline{\pi}) \) as a Nash
equilibrium within subgame \( \zeta(c, c) \) then the following incentive compatibility
constraint must hold for borrower 1 (and symmetrically for borrower 2):

\[
DD(c, c) \geq ND(c, c) 
\]

(36)

In addition, borrower 1 (and symmetrically borrower 2) must have incentive
to not deviate from the minimum required monitoring intensity \( c \):

\[
DD(c, c) \geq DD(0, c) 
\]

(37)

These incentive contraints provide each borrower with incentives to choose
monitoring and to remain diligent in their non-cooperative strategic choices.
In addition to these a rational lender will want to impose a ‘no-collusion con-
straint’ of the form

\[
DD(c, c) \geq NN(0, 0) 
\]

(38)

to make sure that borrowers as a group earn more by choosing the SPNE to
be implemented than from ‘colluding’ to accept a contract but then choose
to both not monitor and choose non-diligence in production. Since under the optimal contract \( NN(0, 0) \) is also an SPNE the purpose of this constraint is to dissuade borrowers from ‘colluding’ to agree, via pre-play cheap-talk or other coordination device, to not choose a SPNE that might harm the lender’s interests.

**Proposition 9** Consider two borrowers each with assets in the range \( A \in (A^g_0(0), A^g(c^g)) \) where

\[
A^g_0(c) = \frac{B(c)}{1-l} - (Ex - \gamma I) \tag{39}
\]

and

\[
A^g(c) = \frac{B(0) + c}{(1-l^2)} - (Ex - \gamma I) \tag{40}
\]

and \( c^g \) is defined by \( A^g(c^g) = A^g_0(c^g) \). Then, if \( \pi B_0 < -1 \) and \( B(c) > c \), a symmetric joint liability loan contract will be offered to, and preferred by the borrowers over separate individual liability monitored loans. The contract implements diligence on both borrowers’ projects at minimum monitoring intensity \( c(A) \), defined by \( A = A^g_0(c) \), and is of the form \( s_{ss} = \frac{B(c)}{\pi(1-I)} - A \) and \( s_{ij} = -A \) for all \( ij \neq ss \).

The proposed group loan contract uses a joint-liability structure to generate incentives to peer monitor, but in a different way from the costless peer-monitoring case. In that earlier case joint liability helped lower the total cost of providing incentives because, by assumption, each borrower could internalize the consequence of their lack of diligence on expected returns to the entire group and the problem could be analyzed essentially as a multi-task problem. When borrowers’ were instead assumed to interact non-cooperatively, each borrower cares only about the consequence of their diligence choice on their own contract returns, and joint liability contracts no longer provide any advantage, since each borrower is in effect reduced again to a single task problem. In the present setting a joint liability clause forces each borrower to, in effect, divest themselves partly of their own project, and to acquire an equity stake in another borrower’s project. Each borrower still cares only about
his own returns, but she now has been given incentive to commence the new
costly task of monitoring. Incentive diversification becomes again relevant
even though the setting is non-cooperative, although the contract is sensitive
to changes in the assumed sequential timing of the game, and is constrained
by the possibility of collusion amongst borrowers.

Since each risk-neutral borrower now manages two tasks – monitoring and
production choices – subject to moral hazard, the logic of multi-task contract-
ing again dictates an optimal LDC with joint-liability structure that shifts as
much reward as possible onto the joint outcome with the highest likelihood
ratio. Substituting a contract of the form \( s_{ss} = Z(c) - A \) and \( s_{ij} = -A \) for all
\( i j \neq ss \) shows that incentive constraint (36) that provides incentives for each
borrower to choose production diligence can be rewritten

\[
\pi Z(c) - A_2^g(c) - c \geq \pi Z(c) - A_2^g(c) + B(c) - c
\]

while incentive constraint (37) that provides incentive for each borrower to
monitor becomes

\[
Z(c) \geq \frac{B(c)}{\pi^2(1 - l)}
\]

Note that these two incentive constraints could be separated because group
members commit to monitoring choices before making their own production
choices. Clearly, one of these two incentive constraints (42) or (43) will
bind before the other, depending on whether \( B(c) \geq c \). The binding in-
etive constraint and limited liability constraints \( s_{ij} \geq -A \) therefore imply that
each borrower must receive a limited liability rent of at least \( E[s_{ij} | \pi, \pi] = \max[B(c), c]/(1 - l) - A \) to remain diligent in production and monitoring. Sub-
stituting this into the lender’s binding participation constraint (6) allows us
to once again solve for a new minimum collateral requirement \( A_2^g(c) \) at which
the lender is just able to break even:

\[
A_2^g(c) = \max[B(c), c]/(1 - l) - (Ex - \gamma I)
\]

Which is the same as expression (39) under the reasonable assumption that
\( B(c) > c \) for all \( c \) in the relevant range. This tells us how much initial collateral
wealth each borrower has to have to be offered a loan in a group loan arrangement if each borrower is to be motivated to monitor at intensity \( c \) and choose diligence in production. Note that the cost of monitoring is a cost borne by each of the borrowers that is not reflected in any explicit interest rate. The expected return to the borrower is then \( Ex - \gamma I - c \).

Note that \( A^2(c) \) can be written

\[
A^2(c) = A^m(c) - c
\]

which reveals that, for any implemented level of monitoring \( c \), joint liability loans will have a lower collateral requirement compared to the most efficient monitored individual liability loan employing an identical monitoring technology. This implies that group loans can be offered at a lower total cost of funds to collateral poor borrowers. To see this consider the borrower with collateral assets \( A \) in figure 3. To lower the collateral requirement to her available level of assets a group loan requires monitoring intensity \( c^g \) given by \( A^g(c^g) = A \). An individual liability monitored by a delegate using the same monitoring technology would require a monitoring intensity \( c^m > c^g \) given by \( A^m(c^m) = A \).

Intuitively, any intermediary structure other than a group loan must cover both limited liability rents and separately pay a delegation cost to get a delegate to monitor. Under a group loan the delegation cost of monitoring can be absorbed into the limited liability rent without disrupting incentives. In a group loan, in contrast, borrowers need only pledge to make outside repayments that cover the opportunity cost of outsiders’ funds, as the monitoring cost is borne within the group. The monitoring costs in the group use up resources just as surely as the costs borne by an outside delegate, but these monitoring costs can be subtracted out of the borrower’s enforcement rent without disrupting incentives. Rewarding the joint outcome \( s_{ss} \) provides incentives to both tasks.

A contract must also insure against the possibility that the borrowers could accept a contract but then collude to choose an action profile other than the proposed equilibrium. To guard against this contracts must be chosen so that
borrowers prefer the payoffs they obtain from choosing diligence and optimal monitoring intensity $c$ to what they could obtain by choosing not to monitor each other and choosing non-diligence:

$$DD(c, c) \geq NN(0, 0)$$

$$E(s_{ij} | \pi, \pi) - c \geq E(s_{ij} | \pi, \pi) + B(0)$$

which once again can be met at minimum collateral expense by using a LDC structure that places as much of the borrower’s reward as possible on $s_{ss}$ while setting all the other $s_{ij}$ as low as possible (which means full payment out of collateral). Substituting the proposed LDC structure into expression (44) above yields:

$$Z(c) \geq \frac{B(0) + c}{\pi^2 - \pi^2}$$

Substituting this into the investor’s participation constraint restricts the minimum collateral requirement to always lie above:

$$A^g(c) = \frac{B(0) + c}{(1 - \pi^2)} - (Ex - \gamma I) \geq A^g(c)$$

Figure 4 shows that group loan contracts will not be offered to any borrower with assets below $A(c^g)$, because these borrowers cannot commit to not colluding against the lender. As depicted, some poorer borrowers with assets below this cutoff may still obtain funding from loans monitored by more expensive moneylenders or intermediaries. As in the scenario described in the previous section, the poorest of the poor – those below $A(\pi)$ remain excluded from the credit market entirely. Both of these results are consistent with analyses that suggest that even Grameen Bank is not really lending to the poorest of the poor (Morduch, 1999) and that microfinance has not completely displaced existing moneylenders.

It is worth dwelling on the reason why an intermediary structure with an outside delegate cannot reproduce these results. Couldn’t an outside monitor also also take advantage of diversification effects? From Diamond (1984) we know that the delegation costs of using an intermediary monitor fall as the monitor’s portfolio of monitored borrowers becomes larger and more diverse.
It is easy to see, however, that this does nothing to help reduce the total costs of lending under the individual liability modality because by construction the delegated monitor-lender earned no enforcement rent and so delegation costs were already zero. Diversification effects would help lower the delegation costs of employing hired staff who cannot post bonds, or lower the amount of capital $I^m$ the delegate needs to have at stake in each borrower’s project. In either case, however, it is the need to repay an outside monitor for his monitoring expense $c$ which is adding to the cost of operating under individual liability loans.

Summarizing the discussion, peer-monitored loans therefore offer an advantage over outside monitored loans, and this advantage does not rest upon a presumed information advantage held by insiders. Any information or enforcement advantage that group members may have relative to an outside intermediary will of course only strengthen the advantage. The scope for employing group loans will be limited, however, by lenders fear that borrowers could collude against a lender and will guard against this possibility by only agreeing to collusion-proof loans.

Note that the explicit money interest charges on group loans is always $\gamma I$ for all qualifying borrowers, although of course the total cost of funds to the borrower must also include the cost of monitoring others. The model predicts that implicit interest charges will be lower on group loans compared to outside monitored loans for borrowers in the same asset class. We again find that the implicit interest rate of borrowing is higher for borrowers with less collateral.

2.6 Discussion and Extensions

2.6.1 Joint versus Relative Performance Evaluation

Following Che and Yoo (2001) let the probability distribution of joint outcomes now depend not only on the agents’ individual diligence choices but also on a common environmental shock. If the common shock is favorable, which occurs with exogenous probability $\sigma$, then both borrowers’ projects will succeed no matter what diligence level each chose. If instead the common shock is unfavorable, which occurs with probability $(1 - \sigma)$, then the probability of success on one’s own project depends on one’s own chosen level of diligence, as before. Hence, when a borrower chooses diligence level $i \in \{0, 1\}$ his project
succeeds with probability $\sigma + (1 - \sigma)\pi_i$ and fails with probability $(1 - \sigma)(1 - \pi_i)$.

The expected monetary return under contract $s$ when borrowers 1 and 2 choose diligence levels $i \in \{0, 1\}$ and $j \in \{0, 1\}$ is then given by:

$$E[s|i, j] = (\sigma + (1 - \sigma)\pi_i\pi_j)s_{11} + (1 - \sigma)[\pi_i(1 - \pi_j)s_{10} + (1 - \pi_i)\pi_js_{01}] + (1 - \pi_i)(1 - \pi_j)s_{00}$$

Suppose each borrower has collateral $A$. Then, adapting Proposition 1 in Che and Yoo (2001), it is easy to demonstrate the following result.

Recall that in the case where $\sigma = 0$ IPE and JPE were equivalent.

**Proposition 10** When $\sigma > 0$ the optimal Nash contract is the RPE contract $s^R = (-A, s_{10}, -A, -A)$ where

$$s_{10}^J = \frac{B}{(1 - \sigma)(\pi_1 - \pi_0)(1 - \pi_1)} - A$$

This is a special case of Holmstrom (1982) and Mookherjee’s (1984) well understood result on relative performance evaluation and tournaments. The optimal contract rewards a borrower.

Notice that the scope for making joint liability loans work depends on the assumed timing of the game in a rather crucial way. As is standard in most of the literature on monitored lending and hierarchical agency structures, I have assumed that monitoring actions by the intermediary or group members are chosen and committed prior to the borrower’s choice of diligence. Any threatened or implied sanctions that might form part of this monitoring strategy are hence assumed to be in place and credibly believed by the borrower to whom they are directed. The possibilities for peer-monitoring unravel under the alternative assumption that both monitoring and productive action strategies are chosen simultaneously:

**Remark 11** If the the game is modified so that borrower-cum-monitors choose their monitoring and productive activity actions simultaneously rather than sequentially, then the scope for creating social collateral through peer-monitoring collapses.
This result is helpful for understanding the strong negative result obtained by Itoh (1991) that teamwork will only be optimal under the assumption that “the marginal disutility of monitoring effort is zero at zero monitoring.” That group lending collapses when the game is simultaneous can be demonstrated by contradiction. For assume otherwise. Then a group contract does exist which implements the symmetric action pair. Since this is the assumed Nash equilibrium outcome, \((\pi, c)\) must be a symmetric best response. But this cannot in fact be the case because borrower 1 will reason that his best response to \((\pi, c)\) is in fact \((\pi, 0)\): given that borrower two will choose diligence, borrower one can only gain by economizing on the costly monitoring activity \(c\). Borrower two will then reason that his best response to borrower 1’s \((\pi, 0)\) is \((\pi, 0)\), which in turn leads borrower one to change to \((\pi, 0)\). Thus the only symmetric equilibrium action-monitoring strategy of the game is \((\pi, 0)\).

This paper therefore shows a way out of Itoh’s dilemma. This points to an important aspect of the design of group contracts. It is not enough simply to create a joint liability contract to induce peer monitoring; the contract must also rely on a particular timing sequence and requires commitment. Actual lending practices may be reflecting these facts. The scheduling of regular group meetings, the use of periodic interim evaluations and monitoring reports, contingent loan renewals over time and the practice of rotating loans amongst borrowers so that not all have a loan at the same time, etc., are all mechanisms that may help to make monitoring strategies credible and may also be aimed at reducing the possibility of collusion. This is an area that merits further investigation.

There are many directions that this analysis can be extended. Allowing the borrowers to operate variable investment scale projects, to choose continuous action choice sets or to operate production technologies with multiple project outcomes should not alter the main findings in a fundamental way; nor should making borrowers risk averse\(^{17}\).

The problem would be complicated in more interesting ways by introducing a more general correlation structure in the production project returns across

\(^{17}\)In work that was carried out independently of my earlier 1996 paper on group loans, Madajewicz (1997) studied a model similar to the one of this paper and extends some results to the case of risk averse agents, under somewhat restrictive assumptions about risk preferences.
borrowers. Several complementary and offsetting forces would then likely come into play to determine the shape of the final optimal contract. On the one hand, one might want the contract to encourage monitoring interaction among the members through joint liability contracts for the reasons analyzed here. The contract would make each borrower’s reward an increasing function of the measured performance of other borrowers in the group. If, however, there is sufficient correlation in the production project outcomes across borrowers, then one might want the contract to work in the opposite direction. For the reasons identified in the relative performance evaluation (RPE) literature, one might want to make each borrower’s reward a decreasing function of the other borrower’s measured performance.

While these two effects will therefore typically be in conflict, in a somewhat more general setting a lender might be able to design a structure that involves elements of both types of contract. For example, the lender might group borrowers into small borrowing circles within which joint liability incentives are used to encourage peer-monitoring, while at the same time using relative performance evaluation across groups.

3 Conclusion

Much of the legal institutional infrastructure that is taken for granted in more affluent and developed areas of the world that helps to frame and enforce economic transactions is often either imperfectly established or entirely missing in poorer areas, developing countries, and economies in transition. In such circumstances, lenders will find it simply unprofitable to lend to small and poor borrowers without additional collateral guarantees, even when they are free to charge whatever interest rate they want to recover expenses. If the poor are to have a chance to build upon their energies and abilities rather than remain marginalized because of the misfortune of having too few liquid resources, then effective intermediary institutions and contract arrangements to build bridges between the poor and new credit and trade opportunities will be needed.

Joint liability lending appears to be one such innovative mechanism, not only because it builds upon existing information and enforcement methods in
local communities but more fundamentally because it may potentially stimulate new monitoring and enforcement activities. While other analyses of group loans under moral hazard have relied upon an assumed information advantage or full side-contracting assumptions and costless monitoring, this paper has shown that an advantage to joint liability loans exists even under the more realistic assumption that borrowers cannot side-contract and monitoring is costly and subject to moral hazard. While group loans were shown to be sometimes optimal, the limits to group lending were also made apparent, and different types of financial contracts will be optimal for different types of borrowers.

Are joint liability contracts nothing more than a curious and specialized contract form that has proven useful only to a few microfinance organizations worldwide, and interesting primarily to economic theorists? This is a debate that ultimately needs to be settled empirically, using methods that test the theory. A case can be made that joint liability contracts are in fact ubiquitous in our society: a large part of all economic activity takes place within households, firms, partnerships, work teams, and other sorts of group which are organized at least in part by property relations that imply some form of profit sharing or joint liability (Holmstrom, 1999). Rather than just being narrowly compensated for their individually measured performance or contribution to a project, members share in the fortunes and misfortunes of the overall enterprise. There is much room for further research on these topics.
Appendix??.

Proof. of Proposition 1. The following Claim is helpful for proving Proposition 1. ■

Claim 12 The likelihood ratio

\[ 1 - \frac{\pi^k(1 - \pi)^{N-k}}{\pi^{k+1}(1 - \pi)^{N-k+1}} \]

satisfies the Monotone Likelihood Ratio Property (MLRP). That is, the likelihood ratio is non-decreasing in the number of successes \( k \).

For this we must show that

\[ 1 - \frac{\pi^{k-1}(1 - \pi)^{N-k+1}}{\pi^{k}(1 - \pi)^{N-k+1}} \leq 1 - \frac{\pi^k(1 - \pi)^{N-k}}{\pi^{k+1}(1 - \pi)^{N-k+1}} \]

Note that in the ‘all success’ outcome, when \( k = N \), the likelihood becomes \( 1 - l^N \).

Rearranging,

\[ l^{k+1} \frac{(1 - \pi)^{N-k}}{(1 - \pi)^{N-k}} \leq l^k \frac{(1 - \pi)^{N-k+1}}{(1 - \pi)^{N-k+1}} \]

\[ l \leq \frac{(1 - \pi)}{(1 - \pi)} \]

which is always satisfied as long as \( l = \frac{\pi}{\pi} < 1 \). Q.E.D.

Given that borrowers are risk-neutral, and limited liability restricts the ability to impose large negative punishments on low outcome states, the most efficient way to reduce limited liability rents by economizing on incentive bonuses is to concentrate all reward on the outcome with the lowest likelihood ratio, which by the above Claim is the one associated with the joint outcome where all projects succeed, and the likelihood ratio \( 1 - l^N \).
Stated slightly differently, we must show that the proposed contract satisfies all the constraints and at least weakly dominates any other contract. By construction, the proposed contract satisfies $E[s|N, N] = \pi^N Z_N - A_N = Ex - \gamma I$ and hence the lender’s participation constraint is met exactly. By construction also, the contract exactly satisfies the ‘global’ incentive constraint $E[s|N, N] = E[s|N, 0] + B$ that the borrower prefer diligence on all contracts to diligence on none. Under the proposed contract all the remaining incentive constraints in (13) now take the form

$$\pi^N Z_N - A_N \geq \pi^N \pi^{N-k} Z_N - A_N + (N-k)B/N \quad \text{for } k \in \{1, N\}$$

which can be shown to be always satisfied so long as $\pi > \pi^1$.

To see why a LDC structure weakly dominates all other contract forms, suppose otherwise. Then there is a non-LDC contract $\tilde{s}$ that offers a lower minimum collateral requirement $\tilde{A}_N$ and sets $\tilde{s}_{i_1...i_N} > -\tilde{A}$ for at least one contingency other than the ‘all success’ outcome, where now we are subscripting $\tilde{s}$ by $I = (i_1, ..., i_N)$ to allow for more specific contingencies. Suppose that that outcome involved $k$ successes and $N-k$ failures. Now construct a new contract, call it $\tilde{s}$, that is identical in all dimensions except that it replaces $\tilde{s}_I$ by $-\tilde{A}$ and adds $\pi(1-\pi)^{N-k}(\tilde{s}_I + \tilde{A})$ to the ‘all success’ outcome. The new contract yields the same expected return to the borrower under all diligence yet it is easy to verify that due to the fact that we’ve re-arranged reward to fall on an outcome with a higher likelihood ratio, the new contract will now satisfy the global incentive constraint with slack. This however means that the alternative contract $\tilde{s}$ could not have in fact have been optimal since any slack means the collateral requirement could not have been a minimum.

**PROOF OF...**

To show that the proposed contract $s_{ij}$ is optimal requires that we show that it induces a symmetric subgame perfect Nash equilibrium (SPNE) where each borrower chooses the strategy profile $(c, \pi)$ and monitoring expense $c$ is kept at a minimum. To do this we first characterize equilibria to the subgames $\zeta(\cdot, \cdot)$ and then argue why the contract induces each player to choose minimum monitoring intensity $c$ in the first stage.

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18 Using $Z_N = B/(\pi^N - \pi^N)$ and $(1-l^N) = (\pi^N - \pi^N)/\pi^N$ the incentive constraints can be rewritten $\left(\frac{N^N}{N^N}\right) \left(\frac{1-l^N}{1-l^N}\right) \geq 1$, which can be shown to always hold for all $N, 0 < l < 1$ and $k < N$. 45
Figure 5 helps visualize the payoffs to different cells in the subgames $\zeta(\cdot, \cdot)$ discussed below. The figure is drawn for borrower 1 monitoring at intensity $c$. Borrower 1’s payoff is then drawn on the vertical and borrower two’s monitoring intensity is on the horizontal. Note that the structure of the optimal contract discussed in Proposition ?? requires $DD(c, c) \geq NN(0, 0) \geq NN(c, 0)$ where the first inequality follows from the no-collusion constraint (44) and the second inequality is obvious. Since $DD(c, c) = DD(c, 0)$, it follows that $DD(c, 0) \geq NN(c, 0)$. The figure is drawn for the case where this holds as a strict equality (point $C$).

**Lemma 13**: Under the proposed optimal contract $DD(c, c) - ND(c, c) > DN(c, c) - NN(c, c)$.

**Proof**: Assume not. Then $DD(c, c) - ND(c, c) \leq DN(c, c) - NN(c, c)$. Substituting the optimal contract of the form $s_{ss} = Z(c)$ and $s_{ij} = -A(c)$ for all other $i, j$ and rearranging leads to the conclusion that $\pi Z(c) \leq \pi Z(c)$, a contradiction since by assumption $\pi > \pi$.

The fact that $DD(c, c) - ND(c, c) > DN(c, c) - NN(c, c)$ suggests that the player’s actions in the subgame $\zeta(c, c)$ are strategic complements: player 1’s marginal payoff to choosing diligence over non-diligence is increasing in player two’s level of diligence, and vice-versa. The presence of strategic complementarities alerts us to the possibility of multiple, pareto ranked equilibria in this subgame (Cooper and John, 1988). As the following claim establishes, this is indeed the case.

**Lemma 14**: $(\pi, \pi)$ and $(\pi, \pi)$ are Pareto ranked Nash equilibria of subgame $\zeta(c, c)$, with $DD(c, c) > NN(c, c)$.

**Proof**: $(\pi, \pi)$ is a Nash equilibrium by construction since $DD(c, c) \geq ND(c, c)$ (recall 36). To see that $(\pi, \pi)$ is also a Nash equilibrium requires that $NN(c, c) \geq DN(c, c)$. From the previous lemma the vertical distance $DD(c, c) - DN(c, c)$ is larger than the vertical distance $ND(c, c) - NN(c, c)$ (segment $EG$ is larger than segment $ED$ in the figure). Thus $NN(c, c)$ will intersect $DN(c, c)$ at some point $c^{**} > c$. This is indicated by point $F$ in the figure. Thus $NN(c, c) > DN(c, c)$, and $\pi$ is a best response to $\pi$ and vice-versa.
That the equilibria are pareto ranked follows from the fact that $DD(c,c) \geq NN(0,0) > NN(c,0) \geq NN(c,c)$ where the first inequality follows from the no-collusion constraint, the second one is obvious because monitoring is a cost, and the last inequality follows because $B(0) \geq B(c')$ for all $c' \geq 0$. I assume that the borrowers coordinate on the higher equilibrium. ■

Lemma 15 : $(\pi, \pi)$ is the unique Nash equilibrium to subgames $\zeta(0,c), \zeta(c,0)$ and $\zeta(0,0)$.

Proof: Consider subgame $\zeta(0,c)$. From the figure it is evident that $(\pi, \pi)$ cannot be a Nash equilibrium because $ND(c,0) \geq DD(c,0)$ so borrower one’s best reaction to $\pi$ is $\pi$. However, borrower one chooses $\pi$ as a best response to two’s $\pi$ because $NN(0,c) > DN(0,c)$. Since borrower two would do likewise $(\pi, \pi)$ is the unique Nash equilibrium of the subgame. A symmetric line of reasoning establishes the result for $\zeta(0,c)$ and $\zeta(0,0)$. ■

Moving back in the game tree, since the equilibrium payoff $DD(c,c)$ to borrower one from subgame $\zeta(c,c)$ is higher than the equilibrium payoff $NN(0,c)$ from subgame $\zeta(0,c)$ it is evident that $c$ is a best response to $c$ at the first stage. It is just as easy to see that $(0,0)$ is also a Nash equilibrium of the game in monitoring intensities. The no-collusion constraint (44) requires, however, that payoffs to each borrower under $(c,c)$ exceed those from $(0,0)$ to assume the two borrowers will not collude to choose the former equilibrium. Thus $\{(c,\pi), (c,\pi)\}$ emerges as the chosen subgame perfect Nash equilibrium of the overall game.19

To see that the proposed solution minimizes on monitoring costs, note that the borrower’s overall return $E(s_i|\pi, \pi) = E(x|\pi) + \gamma I - c$ will be maximized when monitoring intensity is at a minimum. The minimum monitoring intensity is obtained when the borrower uses all of his available collateral resources, at $A = A^g(c)$, which is the value used in the proposed optimal contract.

A last step is to check whether there are in fact any gains to monitoring within a group, in other words, whether the first dollar spent on monitoring reduces the collateral requirement or whether $\frac{dA^g(c)}{dc}|_{c=0} < 0$. This condition simplifies to $B_c(0) < -\frac{1}{\pi}$, the condition stated at the outset of Proposition. ■

19It is straightforward to show that the first-stage game in monitoring intensities also displays strategic complementarities, or that $DD(c,c) - NN(0,c) > NN(c,0) - NN(0,0)$. 47
References


Figure 1
First Stage Game in Monitoring Intensities:

Subgames $\zeta(c^1, c^2)$:
Figure 3

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<thead>
<tr>
<th>Borrower One</th>
<th>Borrower Two</th>
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<tbody>
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<tr>
<td>$\pi$</td>
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<tr>
<td>$E(s_{ij} \mid \gamma, \pi) - c^1$</td>
<td>$E(s_{ij} \mid \gamma, \pi) - c^1$</td>
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<tr>
<td>$E(s_{ij} \mid \gamma, \pi) + B(c^2) - c^1$</td>
<td>$E(s_{ij} \mid \gamma, \pi) + B(c^2) - c^1$</td>
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<tr>
<td>$ND(c_1, c_2)$</td>
<td>$NN(c_1, c_2)$</td>
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(only payoffs to borrower one are shown)
Figure 4

The diagram illustrates the relationship between Bank Loan and Loan Group with respect to two different loan types: $A^g(c)$ and $A(c)$. The graph shows the decrease in Monitor Loan (both $A^g(c)$ and $A(c)$) as the c parameter increases, indicating a trend where lower $c$ values are associated with higher loan facilities. The figure highlights the distinction between monitored and unmonitored loan conditions, with $c^g$ and $c^g$ indicating critical points on the graph.
Figure 5

\[ DD(c, c') : E(s_{ij} | \pi, \bar{\pi}) - c \]
\[ ND(c, c') : E(s_{ij} | \pi, \bar{\pi}) - c + B(c') \]
\[ DN(c, c') : E(s_{ij} | \bar{\pi}, \bar{\pi}) - c \]
\[ NN(c, c') : E(s_{ij} | \bar{\pi}, \bar{\pi}) - c + B(c') \]