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Malgosia Madajewicz

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Columbia University
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Malgosia Madajewicz*
Columbia University

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Abstract

I compare welfare generated by a credit contract with individual liability and a contract with joint liability. The problem is credit rationing caused by limited liability and unobservable investment decisions. Joint liability induces borrowers to monitor each other, however the lender can also monitor. I show that wealthier borrowers may prefer riskier investments when liability is joint, which causes the lender to offer them smaller loans than he would if liability were individual, *even if he cannot monitor the individual-liability loan*. Therefore, wealthier borrowers prefer individual-liability loans. The result may explain why small businesses grow larger when funded with individual rather than with joint-liability loans. Poorer borrowers may prefer joint-liability loans, because borrowers monitor more efficiently, even when their monitoring technology is the same as the lender's, making joint-liability loans cheaper.

JEL Codes: C21, C72, D82, I38, O16

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1. Introduction

Joint liability in credit contracts has received a lot of attention in recent years. Borrowers linked by joint liability have to help repay the debt of any one of them who does not repay fully.[1] Microcredit lenders, such as the Grameen Bank, rely

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[1] Lenders who use the contract, typically ask borrowers to self-select into groups of five to seven members.

primarily on this contract to offer small loans to low-income business owners, and they credit the contract with their success in lending to people who had been shunned by formal lenders. The World Bank and other international organizations channel most of their large financial support for microcredit into group lending programs.[2] A number of academic papers have identified advantages of joint liability, explaining some of the popularity.[3] However, the spotlight also illuminates a puzzle. Given the advantages, why has joint liability not spread more widely, for example to commercial banks? More problematically, why do some microcredit lenders use only individual-liability loans, in which each borrower is only responsible for her own loan, while serving very similar borrowers? Their record looks no less successful. The contribution in this paper is to determine for whom joint liability is optimal.

Lenders who use individual-liability loans look no different than do group lenders when judged by repayment rates and they tend to be more profitable.[4] The record of individual and group lending programs seems to differ mainly in the impact which they have on their borrowers' businesses and on their access to credit.

Two "stylized facts" emerge from anecdotal evidence. First, lenders who use individual-liability loans seem to have a better record of funding small businesses which grow and raise their owners' incomes.[5] Businesses funded with group loans tend to remain small and the owners remain poor. Second, the poorest borrowers served by group lending programs are often poorer than the poorest clients of individual lenders. The model below offers explanations for both of the observations. It has a simple and important policy implication. Currently almost all microcredit lenders offer only one type of contract, joint or individual, and most lenders use the former. Borrowers would be better off if lenders offered a choice of contracts, since the poorer among them may benefit more from joint-liability loans while the wealthier benefit more if loans are individual.

I assume that contracts are enforceable, therefore the incentive problem is whether the borrower is *able to repay* the loan, not whether she is willing. Two

[2] In 1997, a consortium of policy makers pledged to raise $20 billion to increase the reach of microcredit to 100 million poor households by 2005. (Morduch [34])

[3] Examples are Besley and Coate [11], Ghatak [18] Armendáriz de Aghion [4], Armendáriz de Aghion and Golier [5], Stiglitz [38], Varian [42], Conning [15]. I discuss papers which describe shortcomings of joint liability later in the introduction.

[4] The better lenders, both individual and group, have repayment rates as high as 95%. Fewer lenders are profitable, for example Banco Sol in Bolivia, which uses group loans, Bank Rakyat Indonesia, which uses individual loans, ADEMI in the Dominican Republic, which uses both. See Christen, Rhyne and Vogel [14], Otero and Rhyne [35], and Morduch [34].

[5] See Otero and Rhyne [35] and Pirela Martínez [36] for anecdotal evidence, and Madajewicz [32] for econometric evidence.

identical borrowers invest in one of two risky projects. The safe project has a higher probability of success than the risky project, but the risky project yields a larger return if it succeeds. However, the risky project does not succeed often enough to allow the lender to break even. Neither the lender nor the other borrower observe which project a borrower chose. There is limited liability. Borrowers' wealth is not sufficient to repay a loan that maximizes expected project returns.

The problem from the lender's point of view is that the borrower wants to choose the risky project, because the punishment for failure is limited by the available wealth.[6] The incentive problem results in credit rationing. The lender offers a smaller loan than the borrower would like, since, as seems reasonable, a larger loan makes the risky project more attractive. Two instruments, collateral and monitoring, allow the lender to punish the borrower for choosing the risky project and therefore offer a larger loan. Collateral depends on wealth. Monitoring may reveal which project a borrower chose, allowing the monitor to confiscate returns if the project was the risky one. The expectation of the punishment dissuades the borrower from choosing the risky project. Monitoring is costly.

The first result is that wealthier borrowers may prefer the individual-liability contract even if the lender cannot monitor, because the unmonitored individual loan may be *larger* and no cost of monitoring is incurred. The result is unexpected for the following reason. Whether liability is joint or individual determines who monitors. When borrowers are linked by joint liability and one of them switches from the safe to the risky project, the probability that her partner will have to pay the liability rises, since a borrower cannot repay fully when her project fails. This gives the partner an incentive to monitor, since borrowers will choose the safe project only if threatened with the punishment which monitoring makes possible. Borrowers have no incentive to monitor when liability is individual.[7] In a group contract, they may monitor and choose the safe project even when each of them obtains a loan that would cause each to choose the risky project if the contract were individual, because they want to avoid having to pay the liability.[8] This effect is the reason why Stiglitz [38] concludes that joint liability can always increase welfare by increasing the size of the loan *if monitoring is costless for the borrowers,* while the lender cannot monitor.

Joint liability has another effect, however. The liability imposes risk. If

[6] The effect is in the spirit of the analysis in Stiglitz and Weiss [39].

[7] The only punishment for choosing the risky project in the individual contract is the loss of collateral. This punishment does not differentiate the two contracts, since it is also present in the group contract.

[8] Whether or not the borrowers do monitor and choose the safe project depends on the terms of the contract.

a borrower's project succeeds in a group, her payoff depends on her partner's outcome. If her partner's project succeeds, she obtains a high payoff. Otherwise, she has to pay the liability. I will refer to this outcome as the bad state. In an individual contract, a borrower receives a high payoff if her project succeeds, regardless of the other borrower's outcome. The payoff in the bad state depends on which project the borrower chose. Since the risky project has a higher return when it succeeds, it mitigates the risk imposed by the liability by raising the payoff in the bad state. This effect makes the risky project more attractive than the safe project to borrowers in a group, but it is absent from an individual contract, therefore it reduces the size of a group loan relative to an individual one.

The risk imposed by joint liability matters when borrowers are risk-averse and monitoring is costly. If monitoring is costless for the borrowers, an in Stiglitz [38], joint liability can always raise utility. Consider a marginal increase in the payment in the bad state, starting from a payment which does not depend on the other borrower's outcome. Such a marginal liability will elicit some monitoring and therefore can increase the size of the loan. The risk which it imposes has only a second-order effect, because the utility function is linear around a point. However, when monitoring is costly, such a marginal liability may not induce monitoring. A larger liability imposes risk.

Under natural conditions, the effect of monitoring dominates when borrowers are very poor, but the effect of risk imposed by joint liability dominates above some level of wealth. The contract in which the lender cannot monitor may not be of interest in itself. However, the result implies that wealthier borrowers prefer individual-liability loans when the lender can monitor.

The second contribution in this paper is a reason for delegating monitoring to the poorer borrowers. I show that borrowers are more efficient monitors than is the lender even when the lender and the borrowers have access to the same monitoring technology. Therefore, joint liability loans are cheaper.

Existing literature commonly assumes that the lender cannot monitor.[9] While this assumption is useful for highlighting the advantages of joint liability, lenders do monitor in practice.[10] The assumption is neither necessary nor sufficient for the joint-liability contract to be preferred.

The intuition for the second result is that allocating the task of monitoring to the lender distorts the incentive to choose the safe project. By assumption, borrowers cannot repay the loan fully unless the project succeeds. Suppose that

[9] Banerjee et al [7], Itoh [27], Stiglitz [38], Varian [42]

[10] Also, anecdotal sources report that the borrowers' main complaint about joint liability loans is the high cost of monitoring, which raises the question whether the borrowers have a better monitoring technology than does the lender. (Otero and Rhyne [35])

the joint and the individual-liability contracts offer the same size loan. In order to allow the lender to break even, the payment made when the project succeeds must be higher in the individual contract to allow the lender to recover the cost of his monitoring, which he incurs in the individual but not in the group contract. If the lender wants to extract more surplus, he must raise the payment in the case of success even further. The cost of the lender's monitoring is a tax on success, which makes the risky project more attractive, therefore requiring more monitoring. If the borrowers monitor, the cost of monitoring comes from their labor endowment. Since it does not have to be paid out of limited wealth, it does not matter whether the project succeeds or fails, and there is no effect on the choice of project.

The model helps to explain the two stylized facts which motivate the analysis. Small businesses grow more if funded with individual-liability loans, because individual loans may be larger than group loans for wealthier borrowers, allowing these borrowers to invest more.[11] Joint-liability loans may be larger and less costly for poorer borrowers, potentially explaining why the poorest clients of group lending programs are poorer than those served by individual-liability lenders.[12]

In another paper, I use data from Bangladesh to show that the explanation may be empirically important.[13] In the data, group loans are larger than individual loans only for the poorest among rural borrowers. Furthermore, the difference in loan size affects business profits. The somewhat wealthier borrowers earn smaller profits when the lender uses group loans than when loans are individual. I present descriptive statistics in section 5.

Several other papers describe shortcomings of joint liability. Banerjee et al [7] also consider the moral hazard problem when contracts are enforceable, and they show that peer monitoring may cause borrowers to choose projects which are too safe. Besley and Coate [11] assume that contracts are not enforceable, and they show that joint liability can either increase or decrease the probability of repayment relative to individual liability. Neither paper determines which contract is optimal. Rai and Sjöström [37] assume that contracts are not enforceable and they show that joint liability by itself does not motivate borrowers to help repay each other's loans at an efficient level. Borrowers should also send reports about each other to the lender.

[11] As I noted earlier in the introduction, almost all microcredit lenders offer only one type of contract, either the group or the individual one, and, typically, borrowers in a given area only have access to one lender. Hence this implication.

[12] The individual loan available to a very poor person may be either not worth taking or not worth offering given transaction costs of processing a loan.

[13] Madajewicz [32]

The remainder of the paper is organized as follows. Section 2 presents the model. In section 3, I determine the welfare-maximizing terms of an individual-liability and a joint-liability contract. In section 4, I characterize the optimal loan contract as a function of wealth. Section 5 presents descriptive evidence. Section 6 concludes.

2. The model

I analyze a one-period, principal-agent model, with two identical, risk-averse agents (borrowers) and one risk-neutral principal (the lender). I consider two borrowers in order to allow contracts in which borrowers monitor each other, and only two borrowers for simplicity.

Each borrower has some amount of wealth, w, which is observable and verifiable to all parties. Each borrower has an investment opportunity in which she would like to invest more than w.

I assume that contracts are enforceable. The incentive problem is the choice of project, which determines whether or not the borrower will be able to repay, not strategic default.

2.1. Projects

Each borrower chooses between a safe project which yields a return $R_s(L)$ with probability p_s and zero otherwise, and a risky project which yields $R_r(L)$ with probability p_r and zero if it fails, where $p_r < p_s$. L is the size of the loan.

$R_j(L)$ is a continuous, at least once-differentiable function. Each project requires a minimum investment, $\underline{L}_s$ for the safe project and $\underline{L}_r$ for the risky project. $R_j(\underline{L}_j) = 0$, $j = r, s$ and $R'_j(L) > 0\ \forall L > \underline{L}_j$, $j = r, s$. Assume that $\underline{L}_r > \underline{L}_s$. One reason may be that the risky project is more capital-intensive.

I will make assumptions which will imply that $R_r(L) > R_s(L)$. This can only hold for some range of loan sizes if $\underline{L}_r > \underline{L}_s$(see Figure 1). Define $\underline{L}$ as the loan size for which the returns to the safe and risky project are equal, i.e. $R_s(\underline{L}) = R_r(\underline{L})$. Define $\overline{L}$ as the loan size which maximizes the net return to the safe project,

$$R'_s(L) - \rho > 0 \quad \forall L < \overline{L} \qquad \text{and} \qquad R'_s(L) - \rho < 0 \quad \forall L > \overline{L}$$

The range of loan sizes which is relevant for my analysis is $\underline{L} < L < \overline{L}$. The reason for this structure will become clearer below.

$R_j(L)$ is observable only to the borrower undertaking the project. However, everyone knows (costlessly) whether a project succeeded or failed and this information is verifiable, i.e. everyone knows whether the amount available to the borrower for repayment is w or $R_s(L) + w$, but not whether $R_r(L) + w$ is available.[14]

I assume that the risky project yields a larger expected net return to a borrower who has no wealth.

$$A.1 \quad p_s U(R_s(L) - \rho L) < p_r U(R_r(L) - \rho L) \qquad \forall L \text{ such that } \underline{L} < L < \overline{L}$$

where $U(\cdot)$ is a continuous, twice-differentiable function and $U(0) = 0, U' > 0$, $U'' < 0$. ρ is the opportunity cost of the loan funds. If the assumption holds for ρ, it will hold for any interest rate which must be higher than ρ. Also, the safe project is worth funding, while the risky project yields a negative expected return.

$$A.2 \quad p_s R_s(L) - \rho L > 0 \qquad \forall L \text{ such that } \underline{L} < L < \overline{L}$$

$$A.3 \quad p_r R_r(L) - \rho L < 0 \qquad \forall L \text{ such that } \underline{L} < L < \overline{L}$$

Claim 1: Assumptions $A.1$and $A.3$ together imply that $R_r(L) > R_s(L) \quad \forall L$ such that $\underline{L} < L < \overline{L}$.

Proof: Fix L. Suppose that $R_s(L) = R_r(L)$ and replace $R_r(L)$ with $R_s(L)$ in the inequality in assumption $A.1$. Then the inequality can be rewritten in the following way

$$(p_s - p_r)U(R_s(L) - \rho L) < 0$$

Then the inequality cannot hold because $A.3$ implies that the argument of the utility function must be positive. Since the right-hand-side of the inequality in $A.1$ must be larger than it is when $R_s(L) = R_r(L)$, it must be true that $R_r(L) > R_s(L)$. ■

The incentive problem is in the spirit of the analysis in Stiglitz and Weiss [39].[15] It is due to limited liability. A borrower who has no wealth prefers the risky project to the safe project, because she has to repay only if the project succeeds and the safe project is more likely to succeed. At the same time, the risky project yields a larger return if it succeeds. However, the lender does not want to fund the risky project.

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[14] A motivation for this information structure is that a coarser signal, such as whether a business exists or not, may be more easily observable than is a finer one which reveals the exact return and/or the riskiness of the project. The borrower can affect the riskiness of her investment in many ways which are difficult to observe and which she prefers to hide from the lender, such as the choice of strategy, choice of inputs, etc.

[15] Allowing for a continuous probability distribution of project returns, as Stiglitz and Weiss [39] do, would make the model more complicated to solve without adding insight.

Note that I only consider the case of risk-averse borrowers. Risk aversion does not cause the incentive problem. In fact it mitigates it, since more risk-averse borrowers will have weaker preferences for the risky project, i.e. an increase in risk aversion raises the left-hand-side of A.1 relative to the right-hand-side. Risk aversion will be essential to the trade-off between the individual-liability and the joint-liability contract.

Assumptions A.2 and A.3 imply that the expected return from the safe project is larger than that from the risky project,

$$p_s R_s(L) > p_r R_r(L) \qquad \forall L \text{ such that } \underline{L} < L < \overline{L}$$

Assumption A.4 guarantees that the incentive problem grows with loan size.

$$A.4 \;\; p_r R_r'(L) \geq p_s R_s'(L) \qquad \forall L \text{ such that } \underline{L} < L < \overline{L}$$

The assumption implies that if the borrower is indifferent between the safe and the risky project, and the lender increases the loan size while holding collateral fixed, the borrower will choose the risky project.[16]

The fact that $p_s R_s(L) > p_r R_r(L) \quad \forall L$ such that $\underline{L} < L < \overline{L}$ together with $A.4$ imply that $\underline{L}_r > \underline{L}_s$. This implication together with Claim 1 are the reasons why project returns have the structure presented in Figure 1.

The model is quite structured. However, it is the simplest model in which one can show the difference between the individual-liability and the joint-liability contract. Limited liability does not always give rise to credit rationing. Assumptions 1 - 4 and 5 (below) ensure that the analysis treats the case in which borrowers do face credit rationing because they cannot offer sufficient collateral. Otherwise, the comparison between individual and joint liability is uninteresting. The assumption that borrowers are risk-averse is essential as will become clear in section 4.1.

2.2. Limited liability

The maximum which the borrower can pay in any state of the world is her wealth plus any return to the project. I assume that wealth varies over a range, $w \subset [0, \overline{w}]$. The next assumption states that a borrower who can offer $\overline{w}$ as collateral will still choose the risky project if offered a loan size $\overline{L}$.

$$A.5 \;\; p_s U(R_s(\overline{L}) - \rho\overline{L} + \overline{w}) < p_r U(R_r(\overline{L}) - \rho\overline{L} + \overline{w})$$

[16] The assumption is stronger than necessary for the results.

Thus, at each level of wealth there exists some $\widehat{L} < \overline{L}$, such that for $L > \widehat{L}$ the borrower chooses the risky project. Since the lender will not offer a loan which causes the borrower to choose the risky project, A.5 confines the analysis to the case in which borrowers are facing credit rationing due to limited liability.

2.3. The monitoring technology

Monitoring technology consists of gathering information and imposing punishment. The monitor observes the actions of the borrower before returns are realized. That is she observes the project which the borrower is choosing as the borrower implements the project. The monitor punishes the borrower for choosing the risky project after the returns are realized. The borrower knows how much she is being monitored and she takes the expected punishment into account in choosing the project. Therefore, monitoring serves to prevent the borrower from choosing the risky project.[17]

The monitoring technology is stochastic. The monitor detects that the borrower is choosing the risky project with some probability, $b < 1$. She learns nothing with probability $(1 - b)$. If she determines that the borrower chose the risky project, she can impose a punishment of size d in utility units. The *expected* punishment which the borrower faces is $b \times d$. The monitor chooses the *certainty equivalent*, c, of the *expected* punishment, i.e. the monitor chooses $c = CE(b \times d)$.

Imposing c costs the monitor $W(c)$. $W(c)$ is a continuous, at least once-differentiable function, $W'(c) > 0$ and $W''(c) \geq 0$.

The monitor can vary the expected punishment faced by the borrower by varying b or d. The monitor can alter b by visiting the borrower's business more often, spending more time and being more inquisitive during the visits. I will interpret d as confiscation of the return to the risky project. The typical assumption in literature on group loans is that other borrowers impose social sanctions against any borrower who misbehaves. In this interpretation, d is the disutility associated with the exclusion from benefits associated with social networks, e.g. getting help from one's neighbors or simply feeling accepted in the community.

Either the lender or a borrower can monitor. The borrower who is being monitored observes c. Since the punishment yields a benefit to the monitor, she has an incentive to carry it out.

I assume that the lender cannot observe whether the borrowers are monitoring each other or not. This assumption is important, since if the lender could observe whether borrowers monitor, he would not need to use joint liability to induce

[17] The way of modeling monitoring is based loosely on Banerjee et al [7].

borrowers to monitor.[18]

2.4. The players' objectives

I consider the contracting problem between one lender and two borrowers, however I assume that they function in a competitive credit market with many lenders. I assume that all lenders know which loan applicant borrowed how much from whom and on what terms, therefore I can analyze the contract between one lender and two borrowers in isolation from other contracts. Since the market is competitive, a profit-maximizing lender will offer a contract which maximizes a borrower's utility subject to the constraint that the lender break even.

I assume that the distribution functions of returns to projects are independent. Then the lender's profit is

$$\Pi = p_i p_j S^{uu} + p_i(1-p_j)S^{uf} + p_j(1-p_i)S^{fu} + (1-p_i)(1-p_j)S^{ff} - \rho L - W(c_l) \qquad i,j = s,r$$

where borrower 1 chooses project i and borrower 2 chooses project j. S^k, $k = uu, uf, fu, ff$, are payments which are contingent on the outcomes observable to the lender without monitoring. S^{uu} is the amount which borrower 1 has to repay when both borrowers' projects succeed. S^{uf} is the amount which borrower 1 pays when her project succeeds and 2's project fails. S^{fu} is the amount which 1 pays when 1's project fails and 2's project succeeds. S^{ff} is the amount when both projects fail. c_l is the amount of monitoring which the lender plans to undertake.

I noted in the introduction that borrowers in most areas only have access to one microcredit lender. This observation suggests that the lender has monopoly power. However, that is not quite right. Microcredit lenders face competition from other sources of credit, such as moneylenders, informal or formal community networks and occasionally commercial banks.[19] The competition is far from perfect, since some of these other sources have much smaller supplies of credit than microcredit lenders do, and others are more reluctant to lend to the poor, lending only to a selected subset of microcredit clients. However, there is competition.

An alternative perspective on the lender's objective consistent with the model is that the lender maximizes social surplus subject to the constraint that he be able to break-even. This is reasonable for microcredit lenders, since their objective is to raise the welfare of the borrowers.

[18] While giving the borrowers an incentive to monitor each other may not be the only reason why we observe joint-liability contracts, anecdotal evidence suggests that it is an important reason. Otero and Rhyne [35]

[19] For example, one of the more careful studies of moneyenders finds little evidence for the existence of monopoly rents. Aleem [3]

Borrowers maximize their utility. The expected utility function of borrower 1 when she implements project i and 2 implements project j, $i, j = s, r$ is

$$\begin{aligned} V_{ij}(S^k, L) &= p_i p_j U(R_i(L) + w - S^{uu}) + p_i(1-p_j)U(R_i(L) + w - S^{uf}) + \\ &\quad (1-p_i)p_j U(w - S^{fu}) + (1-p_i)(1-p_j)U(w - S^{ff}) \\ i, j &= s, r \end{aligned}$$

Similarly, $V_{ji}(S^k, L)$ would be the expected utility of borrower 2.

2.5. The game

The timing is the following. The lender offers a contract, $\{L, S^k, c_l\}$, $k = uu, uf, fu, ff$. The borrowers decide whether or not to accept. If they accept, the lender begins to monitor. Then borrowers choose their levels of monitoring and projects. I will describe the game which determines their choices below. Finally, returns are realized and payments are made. Figure 2 shows the time line.

If each borrower's payments, S^k, do not depend on the outcome of the other borrower's project, i.e. $S^{uu} = S^{uf} = S^u$ and $S^{fu} = S^{ff} = S^f$, then the contract is an *individual-liability* one. In this case, borrowers do not monitor and each chooses a project to maximize her expected utility, independently of the other's choice. Each borrower chooses the safe project if

$$V_s(S^k, L) \geq V_r(S^k, L) - c_l \qquad (1)$$

where $V_i(S^k, L) = p_i U(R_i(L) + w - S^u) + (1-p_i)U(w - S^f)$ for $i = s, r$.

If a borrower's payments depend on the outcome of the other borrower's project then the contract is a *joint-liability* one. If $S^{uu} \neq S^{uf}$, then $S^{uf} > S^{uu}$, i.e. each borrower helps to repay the other's debt if her project succeeds and the other's fails.[20] I refer to the payment S^{uf} as the *joint liability*. In this case borrowers play the following non-cooperative game. I summarize the results here. I explain the details in section 7.1 of the appendix.

Knowing the terms of the contract, both borrowers simultaneously choose levels of expected punishment c_g^m, $m = 1, 2$. m denotes the borrower and g stands for a group. Borrowers observe each other's choices, but the lender does not. Then they simultaneously choose projects. I assume that borrowers implement the strategies, i.e. level of monitoring and choice of project, which constitute a subgame perfect Nash equilibrium (SPNE) of this game.

The game has three possible SPNEs. Both borrowers monitor and choose the safe project, neither monitors and both choose the risky project or both

[20] I prove this statement in section 3.3.

monitor and choose the risky project. By backward induction, consider the subgame in which borrowers choose projects after both choose not to monitor. Only symmetric strategies constitute a NE, because borrowers' actions are strategic complements. If one borrower chooses the risky project, the probability that she will have to pay the liability declines from $p_s(1-p_s)$ to $p_r(1-p_s)$, while the probability that the other borrower will have to pay the liability rises from $p_s(1-p_s)$ to $p_s(1-p_r)$. Then the other borrower obtains the same gain as the first from choosing the risky project, plus a larger decrease from $p_s(1-p_r)$ to $p_r(1-p_r)$ in the probability that she will have to pay the liability. Thus, if one chooses the risky project, the other one will as well. In this subgame, this is the only NE.

Both borrowers choosing the risky project is also the only NE in each of the subgames after asymmetric monitoring decisions. A borrower who monitors will choose c_g such that the other borrower prefers to choose the safe project if the monitor chooses the safe project, i.e. c_g satisfies

$$V_{ss}(S^k, L) \geq V_{rs}(S^k, L) - c_g \qquad (2)$$

I show in section 7.1 of the appendix that this is the least costly level of monitoring which ensures that the partner chooses the safe project. This level of monitoring is not sufficient to induce a borrower to choose the safe project if her partner chooses the risky project.[21] Anyone who is not being monitored will choose the risky project and then so will her partner.

A NE in which both borrowers choose the safe project exists only in the subgame after both borrowers choose to monitor. It is a NE in this subgame, because a borrower who monitors chooses c_g to satisfy (2). Both borrowers choosing the risky project is also a NE in this subgame under some conditions.

Consider the game as a whole. The decisions whether or not to monitor are also symmetric. The SPNE in which both borrowers monitor and both choose the safe project exists if the terms of the contract satisfy the following group incentive constraint[22]

$$V_{ss}(S_g^k, L_g) - W(c_g) \geq V_{rr}(S_g^k, L_g) \qquad (3)$$

If the expected benefit from punishing the other borrower for choosing the risky project is not too large, then the two other SPNEs noted above exist. However, the SPNE in which both borrowers monitor and both choose the safe project is the Pareto dominant (or strong) one.[23] I assume that the borrowers play this latter equilibrium.

[21] See section 7.1 for details.

[22] The constraint can be interpreted as a no-collusion constraint.

[23] Since borrowers can collude, the strong equilibrium may be the relevant concept. This equilibrium is unique. I discuss this further in section 1 of the appendix.

In summary, if the contract is an individual-liability one, borrowers do not monitor each other and each chooses a project according to condition (1). If the contract is a joint-liability one, borrowers monitor each other with intensity defined by (2) and both choose the safe project if condition (3) is satisfied.

3. The terms of the individual and joint-liability loan contracts

The lender's decision can be analyzed in two steps. He can determine first what should be the terms of the contract conditional on the assignment of monitoring responsibility, i.e. conditional on whether liability is individual or joint. In the second step, he determines which contract he should offer in order to maximize welfare. In sections 4.2 and 4.3, I carry out the first step.

3.1. The first-best

If the choice of project were observable, the lender would offer a loan which maximizes the return to the safe project, $L = \overline{L}$, and payments which offer the borrowers full insurance while enabling the lender to break even, for example $S^{uu} = S^{uf} = (1 - p_s)R_s(\overline{L}) + \rho\overline{L}$ and $S^{fu} = S^{ff} = -(p_s R_s(\overline{L}) - \rho\overline{L})$. He would confiscate returns if the borrower chose the risky project.

The first best would also be attainable if the choice of project were not observable but monitoring were costless. The lender would simply have to monitor sufficiently that the borrower would choose the safe project even given full insurance.

In general, first best cannot be achieved if the choice of project is not observable and monitoring is costly. If payments are such that borrowers are fully insured, the borrowers will not monitor each other and the cost of monitoring required of the lender may be too high.

3.2. The lender-monitored and the unmonitored individual-liability loan contract

Since the credit market is competitive, the lender offers a contract which maximizes the utility of the borrower subject to the constraints that the lender break even and the borrower choose the safe project, as discussed in section 2.4.

In an individual-liability contract, the lender offers contract terms $\{L_l, S_l^k, c_l\}$, $k = u, f$, where the subscript l denotes the lender-monitored contract, to maximize

$$\max_{S_l^k, L_l, c_l} V_s(S_l^k, L_l) \qquad k = u, f \tag{4}$$

$$
\begin{aligned}
s.t. \qquad & V_s(S_l^k, L_l) \geq V_r(S_l^k, L_l) - c_l \\
& p_s S_l^u + (1-p_s) S_l^f - \rho L_l - W(c_l) \geq 0 \\
& S_l^u \leq R_s(L_l) + w \qquad S_l^f \leq w
\end{aligned}
$$

The first constraint is the incentive constraint, equation (1) in section 2.5.[24] The second is the lender's break-even constraint. The third is the set of limited liability constraints.

In general, the solution to the problem depends on the degree of risk aversion, however the following lemma presents a case in which it does not. In the remainder of the paper I focus on this case.

Lemma 3.1. *Under assumptions A.1 - A.5, there exists $\overline{p}_s^l$ such that for $p_s > \overline{p}_s^l$, the solution to problem (4) specifies $S_l^f = w$ and*

$$
S_l^u = \frac{\rho L_l - (1-p_s)w + W(c_l)}{p_s}
$$

Proof. The proof is in section 7.3 of the appendix.

The lemma states that when the probability of success of the safe project is large enough, the borrower gives up all of her wealth when the project fails. The larger is the payment in case of failure, the less incentive the borrower has to choose the risky project, therefore the less costly is monitoring for a given size loan. Lowering the cost of monitoring increases welfare for two reasons. The first effect is direct. Second, an increase in the cost of monitoring increases the payment which the borrower has to make if the project succeeds. It is a tax on success, which makes the risky project more attractive and therefore reduces the loan size which the lender can offer.

On the other hand, the maximum possible collateral imposes risk. However, the bigger is the probability of success of the safe project, the less likely is failure to occur in equilibrium. Thus, if the probability of success is large enough, the maximum collateral is optimal regardless of the degree of risk aversion.[25]

Considering a large enough probability of success is one way of imposing the condition that the borrower faces credit rationing.[26] The lender can always

[24] I discuss the choice of the level of monitoring, c_l, in section 7.2 of the appendix.

[25] The contract in the lemma is optimal if borrowers are risk-neutral regardless of the probability of success of the safe project.

[26] Interestingly, almost every study of microenterprises notes that businesses undertaken by low-income entrepreneurs have very high success rates. The evidence is anecdotal. One indirect indicator of rates of success are repayment rates, which are 92% to 98% in well-managed programs, both individual-liability and joint-liability ones. See for example Christen et. al. [14], Hossain [23], Mann et. al. [33], Otero and Rhyne [35].

increase the loan size and the collateral while holding the interest rate fixed, as long as the borrower has more collateral available. If such an increase lowers utility, one could argue that the borrower is not facing credit rationing, because she does not demand a larger loan at the equilibrium interest rate.

The contract in which the lender does not monitor is simply the special case in which $c_l = 0$. The contract is then analogous to what would be a debt contract in a model with a richer state space.

3.3. The joint-liability loan contract

The lender offers a contract, consisting of the following terms, $c_l = 0$ and $\{L_g, S_g^k\}$, $k = uu, uf, fu, ff$, where subscript g denotes the group contract, which maximize[27]

$$\max_{S_g^k, L_g} V_{ss}(S_g^k, L_g) - W(c_g) \qquad k = uu, uf, fu, ff \tag{5}$$

$$\begin{aligned}
s.t. \qquad & V_{ss}(S_g^k, L_g) - W(c_g) \geq V_{rr}(S_g^k, L_g) \\
& c_g \geq V_{rs}(S_g^k, L_g) - V_{ss}(S_g^k, L_g) \\
& p_s^2 S_g^{uu} + p_s(1-p_s)S_g^{uf} + p_s(1-p_s)S_g^{fu} + (1-p_s)^2 S_g^{ff} - \rho L_g \geq 0 \\
& S_g^{uu} \leq R_s(L_g) + w \qquad S_g^{uf} \leq R_s(L_g) + w \qquad S_g^{fu} \leq w \qquad S_g^{ff} \leq w
\end{aligned}$$

The first two constraints are the incentive constraints (3) and (2) discussed in section 2.5, the third is the lender's break-even constraint and the fourth is the set of limited liability constraints.

As in the case of the individual-liability contract, in general the solution depends on the degree of risk aversion. The following lemma characterizes a solution which does not.

Lemma 3.2. *Under assumptions A.1 - A.5, there exists $\overline{p}_s^g$ such that for $p_s > \overline{p}_s^g$, the solution to problem (5) specifies $S_g^{fu} = S_g^{ff} = w$, $S_g^{uf} = R_s(L_g) + w$, and*

$$S_g^{uu} = \frac{\rho L_g - (1-p_s^2)w - p_s(1-p_s)R_s(L_g)}{p_s^2}$$

Proof. The proof is in section 7.3 of the appendix.

The contract takes away all of the borrower's wealth if the borrower's own project fails and the return to the safe project plus the wealth if her partner's

[27] I do not consider the possibility that the lender may also monitor in the joint-liability contract.

project fails but her own succeeds, i.e. in equilibrium her payoff is zero unless both projects succeed. The borrower pays the maximum possible when her own project fails for the same reason as in the case of individual liability. The maximum joint liability has two advantages. First, it lowers the payment in the state in which both projects succeed as much as possible, thereby rewarding the choice of the safe project by both borrowers. This effect minimizes the cost of monitoring necessary for any given loan size. Second, the larger is the liability the larger is the maximum loan size at which the borrowers will still monitor each other, rather than switching to the equilibrium in which they do not monitor and choose the risky project.

The contract is optimal if the probability of success of the safe project is large enough.[28] However, this probability needs to be larger for the maximum joint liability and maximum collateral to be optimal than it does for maximum collateral alone to be optimal, holding all else constant. The subsequent results do not require that maximum joint liability be optimal. I will use this contract to simplify the presentation, however all conclusions are valid for the case in which the joint liability is some fraction of the wealth available to the borrower when her project succeeds, $S_g^{uf} \leq R_s(L_g) + w$, as long as $S_g^{uf} \gg S_g^{uu}$.[29]

4. The optimal contract as a function of wealth

In this section, I compare welfare under a joint-liability contract to welfare under an individual-liability contract. The theme of the results is that the optimal contract depends on the wealth which a borrower can offer as collateral.

4.1. A comparison between joint-liability and individual-liability when the lender cannot monitor

I first consider whether borrowers ever prefer an individual contract with no monitoring to a joint-liability contract. I am considering here an individual contract in which the lender cannot monitor, i.e. the lender *does not* choose c_l optimally. This is a comparison most favorable to joint liability, since one would expect that monitoring reduces the attractiveness of the risky project and allows the lender to offer a larger loan. The unmonitored, individual contract is not necessarily of

[28] The contract is optimal if borrowers are risk-neutral regardless of the probability of success of the safe project.

[29] The results do require that the difference between S_g^{uf} and S_g^{uu} be more than an incremental one. Otherwise, the risk which the liability imposes has only a second order effect, because a utility function is approximately linear around a point. The results depend on the fact that joint liability imposes risk which has a first-order effect.

interest in itself. However, if borrowers prefer it to the joint-liability contract, they will also prefer the individual contract when the lender chooses the level of monitoring optimally.

I assume that the cost of monitoring is composed of a fixed cost and a marginal cost. The fixed cost may be the cost of screening potential partners, forming the group and agreeing upon the rules which the group should follow. Let FC denote this fixed cost. Then $W(c) = FC + w(c)$, where $w(c)$ is the part of the monitoring cost which increases with the intensity of monitoring. Let a be the coefficient of absolute risk aversion. V_n^* and V_g^* are the borrower's utilities in equilibrium when the loan is an unmonitored one and a group one, respectively, and ρ is the opportunity cost of capital.

The proposition states that, if at some level of a borrower's wealth her cost of monitoring is such that she is indifferent between the joint-liability and the unmonitored, individual contract, then a marginally wealthier borrower prefers the individual contract if the stated conditions hold. I state the result in terms of an increase in one borrower's wealth from a point at which both borrowers have the same wealth levels.

Proposition 4.1. *Suppose that for some level of wealth, $\widehat{w}$, $V_n^* = V_g^*$. Assume that $R_s''(L) = R_r''(L) = 0$. There exists a $\overline{p}_s$ such that for all $p_s > \overline{p}_s$ there exists a $\overline{a}$, $\overline{\rho}$ and $\overline{FC}$ such that for all $a > \overline{a}$, $\rho > \overline{\rho}$ and $FC > \overline{FC}$, $\frac{\partial V_g^*}{\partial w} < \frac{\partial V_n^*}{\partial w}$.*

Proof. The proof is in section 7.4 of the appendix.[30]

Both welfare and loan size increase more in the individual contract than in the group contract when a borrower's wealth increases. A borrower may prefer the unmonitored, individual contract even when the joint-liability loan is larger, because the utility lost due to the risk which joint liability imposes and the cost of monitoring may be larger than utility gained from the larger loan. I outline the proof in footnote 32.[31] This outline offers a full explanation of why welfare

[30] The proof of the proposition is based on the extreme group contract which sets the group liability at its maximum. The proof for the case in which $S^{uf} < R_s(L_g) + w$ is available from the author.

[31] An increase in wealth above the level at which borrowers are indifferent between the individual and the group contract has two effects. It increases welfare directly. It also has an indirect effect, relaxing the incentive constraint and allowing an increase in loan size.

The direct effect of an increase in wealth is larger in the individual contract because of declining marginal utility of wealth. In order for borrowers to be indifferent between the contracts, the payoff in case of success must be larger in the group contract, since it occurs with a smaller probability. Therefore an equal increase in wealth raises utility less in the group contract.

The indirect effect is also larger in the individual contract. An increase in wealth relaxes the group incentive constraint less than the individual one. This is because the effect of an increase increases more in the individual contract. In the text below, I offer an intuitive discussion of why the individual loan may increase more than a join-liability loan when wealth increases.

The joint liability has two incentive effects. One makes the risky project less attractive, allowing the lender to offer a larger loan. The second works in the opposite direction. Under the assumptions in the proposition, the adverse incentive effect begins to dominate above some level of wealth.

The positive incentive effect of joint liability induces borrowers to monitor each other. I describe this effect in more detail in section 2.5 and in section 7.1 of the appendix. In the absence of monitoring, borrowers' project choices are strategic complements. If one borrower chooses the risky project, her partner does as well, raising the probability that the borrower will have to pay the liability. As a result, borrowers in a group may monitor and choose the safe project even when the loan size is such that an individual borrower, not linked by joint liability, would choose the risky project. Therefore, the lender may be able to offer a larger loan to members of a group than he could to borrowers who have individual contracts. This effect becomes stronger as the size of the liability grows with a borrower's wealth. It is the only effect which liability has on incentives if borrowers are risk-neutral. Therefore, if borrowers are risk-neutral, the joint-liability contract dominates the individual, unmonitored contract at all levels of wealth.[32]

If borrowers are risk-averse, joint liability also has an adverse incentive effect. Joint liability imposes a risk on borrowers which is absent in the individual contract. If a project fails, the individual contract and the group contract yield the same payoff, zero, since the borrower gives up all of her wealth. If the project succeeds, an individual contract offers a sure payoff, while the group contract offers a lottery. The payoff in the lottery depends on the outcome of the partner's project. Table 1 summarizes the payoffs in the two contracts. A borrower guarantees herself a larger income in the low-payoff state of this lottery (the state in which she has to pay the liability) when she chooses the risky project simply

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in wealth on utility obtained from choosing the safe project is smaller in the group contract (this is the direct effect of wealth). When borrowers are sufficiently risk-averse, one can effectively ignore the effect of wealth on the utility obtained from choosing the risky project. This will be small, because the return to the risky project is larger than the return to the safe project, conditional on success. Figure 3 illustrates this argument.

Finally, an equal increase in loan size tightens the group incentive constraint more than it tightens the individual incentive constraint. The reason is the risk which joint liability imposes, which I discuss in the text below. The risky project mitigates this risk and increasingly so as the loan size grows. Therefore an increase in loan size raises the utility from the risky project more relative to utility from the safe project in the joint-liability contract than in the individual one. Thus, loan size can increase more in the individual contract than in the group one.

[32] A proof of this statement is available from the author.

because the risky project yields a larger return when it succeeds, and this larger return is unobservable to the lender. This effect makes the risky project more attractive to borrowers in a group, if they are risk-averse, since the project reduces the risk imposed on them by the liability.

The adverse incentive effect grows with wealth, because a wealthier borrower obtains a larger loan and assumption A.4 implies that the difference between the return to the risky and the safe project grows with loan size. If borrowers are sufficiently risk-averse, i.e. they care enough about the low payoff, above some level of wealth the risky project may be more attractive to members of a group than to an individual borrower. Therefore, the lender can offer a larger loan to an individual borrower than he can to a member of a group.

Proposition 4.1 offers a reason why credit-constrained borrowers may prefer an individual-liability contract to a joint-liability one. The striking aspect of the result is that it holds *even* in the case most favorable to joint liability, when the lender cannot monitor. The result is true under some conditions, the availability of very safe projects, the availability of risky projects which are more productive than safe projects if they succeed, high degree of risk aversion of borrowers and large opportunity cost of funds. These conditions seem to accurately characterize circumstances faced by lenders who serve small business owners. I discuss evidence which suggests that the result is empirically important in section 5.

4.2. A comparison between joint-liability and individual liability when the lender can monitor

Proposition 4.1 implies that the wealthier among credit-constrained borrowers prefer an individual, lender-monitored contract to a joint-liability contract. Therefore, if any borrowers prefer the joint-liability contract, they are the poorer ones. The remaining question is whether there is ever any reason to delegate monitoring to the borrowers. I first compare the costs of monitoring and then welfare more generally.

4.2.1. The costs of monitoring

In this section, I show that monitoring by the borrowers is more efficient than is monitoring by the lender even when *the lender and the borrowers have access to the same monitoring technology*. Therefore, joint-liability loans are cheaper.

Let $W(c) = FC + w(c)$, as in section 4.1, and let L_n^* be the optimal loan size in the unmonitored contract.

Proposition 4.2. *Fix $L_l = L_g = L > L_n^*$. For such L there exists $\overline{FC}$ such that* for $FC > \overline{FC}$, $c_l > c_g$.

Proof. Fix $L_l = L > L_n^*$. Consider the lowest c_l which induces a borrower to choose the safe project in a lender-monitored contract when this L is offered,

$$c_l = p_r U_r^u (R_r(L) - \frac{\rho L + W(c_l) - w}{p_s}) - p_s U_s^u (R_s(L) - \frac{\rho L + W(c_l) - w}{p_s}) \qquad (1)$$

Assume c_l exists which solves this expression.[33]

Consider the lowest c_g which induces a borrower to choose the safe project in a group contract which offers $L_g = L$,

$$\begin{aligned} c_g \;&=\; p_r^2 U_r^{uu}(R_r(L) - \frac{\rho L - w - p_s(1-p_s)R_s(L)}{p_s^2}) + p_r(1-p_s)U_r^{uf}(R_r(L) - R_s(L)) \\ &\quad - p_s^2 U_s^{uu}(R_s(L) - \frac{\rho L - w - p_s(1-p_s)R_s(L)}{p_s^2}) \end{aligned} \qquad (2)$$

In order to compare the two expressions, first suppose that borrowers are risk-neutral. Then the expression for c_l is

$$c_l = (p_s - p_r)\frac{\rho L + W(c_l) - w}{p_s} - (p_r R_r(L) - p_s R_s(L)) \qquad (3)$$

and the expression for c_g is

$$c_g = (p_s - p_r)\frac{\rho L - w}{p_s} - (p_r R_r(L) - p_s R_s(L)) \qquad (4)$$

The expression for c_g is the difference between utilities generated by the risky and the safe project respectively for a borrower who obtains an individual-liability loan of size L. Since, by assumption, $L > L_n^*$, $c_g > 0$. Then $c_l > 0$ and $W(c_l) > 0$. Therefore, $c_l > c_g$.

Now consider risk-averse borrowers. Suppressing the arguments of the utility functions, the difference between c_l and c_g can be written as

$$c_l - c_g = [p_r U_r^u - p_s U_s^u] - [p_r(p_s U_r^{uu} + (1-p_s)U_r^{uf}) - p_s(p_s U_s^{uu})] \qquad (5)$$

Ignore the term $\frac{p_s - p_r}{p_s} W(c_l)$ in expression (3). Then the only difference between $(c_l - c_g)$ in the risk-neutral and the risk-averse case is the risk introduced by the group liability. The low payoff when the project succeeds and the borrower has chosen the risky project is larger than is the low payoff when the borrower

[33] I analyze existence in section 7.2 of the appendix.

has chosen the safe project, therefore the introduction of risk aversion may lower the payoff to the safe project more than the payoff to the risky project causing c_g to exceed c_l. However, the term $\frac{p_s-p_r}{p_s}W(c_l)$ tends to raise c_l relative to c_g. There exists some $\overline{FC}$ such that for $FC > \overline{FC}$, the latter effect dominates and $c_l > c_g$. ■

The result states that a borrower needs to impose a smaller expected punishment in order for her partner to choose the safe project than would have to be imposed by the lender for a given loan size and amount of collateral. In other words, borrowers need to incur a smaller cost of monitoring to achieve the same result.[34]

In the individual contract, the cost of monitoring distorts the incentive to choose the safe project. Borrowers do not have sufficient wealth to repay the loan fully unless the project succeeds. In order to break even on an individual loan, the lender has to raise the payment in the state in which the project succeeds relative to the payment which would allow him to break even on a joint-liability loan of the same size, since he is incurring the cost of monitoring in the individual contract but not in the group one. If he wants to extract more surplus, he needs to increase this payment even further. The higher payment in case of success renders the risky project, with a smaller probability of success, more attractive, raising the cost of monitoring needed to induce the borrowers to choose the safe project. When they monitor themselves, the borrowers use their labor, an endowment which is not subject to limited liability. Then, the cost of monitoring is not part of the costs of the loan which have to be repaid out of limited wealth. Therefore it does not distort the incentive to choose the safe project.

The importance of the result is that it provides a reason for delegating monitoring in the case which most favors the lender-monitored contract, when borrowers do not have access to a more efficient monitoring technology. Monitoring technologies of lenders and borrowers may differ in reality. However, both lenders and borrowers monitor, often quite extensively, and there is little, if any, systematic evidence about differences in technologies.

4.2.2. Welfare

Even poorer borrowers could prefer a lender-monitored contract if the latter offers a loan which is sufficiently larger to compensate for the difference in the costs of

[34] The high rates of interest charged by moneylenders provide some empirical support for this result. Moneylenders often monitor the borrowers, and they typically charge exorbitantly high interest rates, 150% per year and higher. The rates may reflect market power, but Aleem [3] provides empirical evidence which suggests that they are due to high costs of monitoring.

monitoring. The comparison between loan sizes is ambiguous. I assume that the lender cannot observe whether the borrowers monitor each other or not. This assumption is necessary for joint liability to ever be used. Otherwise, the lender could simply confiscate an amount equivalent to the returns to the safe project if the project succeeds and the borrowers did not monitor. Therefore, a lender who monitors may be able to offer a loan size which would cause borrowers in a group to choose not to monitor and implement the risky project.

Borrowers could also prefer the lender-monitored contract if the lender's cost of monitoring a given size loan is less than the combined cost of monitoring by the borrowers and the risk imposed by the liability.

5. Empirical implications

In a world in which lenders offer a menu of contracts, the theory implies that the wealthier among poor borrowers choose individual loans, lender-monitored or unmonitored. The poorer borrowers may choose joint-liability loans. However, most poor household do not have a choice of contracts. Typically, a given lender offers only one type of contract and many poor households only have access to one lender. I present evidence about the sizes of group and individual loans offered by microcredit lenders and government and commercial banks in Bangladesh. The context illustrates the types of restrictions faced by low-income borrowers. The data comes from households who live in rural areas and who own less than 5 acres of land. All microcredit lenders in the data offer only group loans.[35] Banks offer only individual loans. Access is subject to institutional restrictions. All the microcredit organizations target households which own less than one-half of an acre of land. However, they do not enforce this rule strictly, so wealthier households may be able to obtain a group loan but are less likely to be able to do so. Furthermore, microcredit lenders do not lend to inhabitants of villages in which they do not have an office. Access to bank loans is limited mostly by one's social connections. Therefore, among households with the same level of wealth, some will obtain group loans and some will obtain individual loans, depending on access.

If access to contracts is restricted, the theory implies that poorer borrowers who obtain joint-liability loans will have larger loans than those who obtain individual loans, while the reverse will be true for the wealthier among the credit-constrained borrowers. In order to see this more clearly, imagine that loan contracts are assigned to borrowers randomly. Therefore, a borrower who has a given amount of wealth is equally likely to be assigned a group or an individual loan.

[35] One of the NGOs is the flagship of microcredit programs, the Grameen Bank.

According to the theory, which loan is larger depends on the borrower's wealth. While contracts are not assigned randomly in reality, the important point is that the contract which a borrower obtains depends at least partly on institutional rules and not only on the borrower's preferences.

The data, presented in Table 1, show that group loans are larger than individual loans for households which own less than 0.04 acres of land.[36] For wealthier households, individual loans are larger. 0.04 acres is a tiny amount and far less than the amount above which a household ceases to be eligible for a group loan. The evidence is merely descriptive. In Madajewicz [31], I carry out a more careful econometric analysis. In that analysis, the level of wealth at which individual loans become larger depends on the methodology. One approach yields the same result as the descriptive table. Another implies that the wealth level is 1.8 acres. Even if the higher wealth level is the correct one, borrowers who own 1.8 acres are still very poor. They are considerably poorer than the wealthiest microcredit client, who owns 14 acres, and their access to formal sources of credit is no different than is that of borrowers who own 0.04 acres.

If group loans are larger than individual loans for only the poorest among the borrowers, as the data suggest, then microcredit lenders like the ones in Bangladesh are having less impact on poverty than they would have if they offered individual loans to their wealthier borrowers. The exclusive reliance on group loans is a widespread phenomenon, not particular to Bangladesh. The lenders may be unnecessarily limiting their borrowers' access to capital.

6. Conclusion

The paper makes two main points. First, joint liability in credit contracts has a negative incentive effect, which may cause a group of borrowers linked by joint liability to choose riskier investments than would be chosen by individual borrowers. Consequently, a joint-liability loan may be smaller than an individual loan offered by a lender who does not monitor, since the smaller loan size reduces the incentive to choose the risky project. This negative incentive effect is likely to dominate the positive incentive effect of joint liability for the wealthier borrowers, i.e. those who can offer relatively more collateral. The important point is that even these wealthier borrowers are credit-constrained, however peer monitoring does not help to relax that constraint.

Data from Bangladesh provide evidence of the empirical importance of this effect. The data show that individual-liability loans are smaller than joint-liability

[36] Differences between average loan sizes in the two contracts are significant at a level of 1% for both the poorer and the wealthier groups.

loans only at extremely low levels of wealth.

The disincentive effect of joint-liability has a simple and potentially important policy implication. The great majority of microcredit lenders use only joint-liability loans. The policy may reduce loan sizes and therefore the poor borrowers' ability to invest.[37] The poor may be better off if the lenders offer a choice of contracts.

The second point in the paper is that monitoring by the borrowers is more efficient than is monitoring by the lender, even when the borrowers and the lender have the same costs of monitoring per unit of effort. The result provides a reason for offering group loans rather than individual loans to poorer borrowers. The efficiency of peer monitoring is not sufficient for poorer borrowers to prefer group loans, since a lender who monitors may be able to offer a larger loan.

The model in this paper only considers the effect of the loan contract on loan size. Empirical analysis in Madajewicz [32] suggests that the loan contract also affects the type of investment undertaken by the borrowers.

The effects of wealth predicted here may appear in contexts other than lending, for example in the choice between a partnership and an individual form of ownership of a firm. The difference between the efficiency of monitoring by one's peers and by an outsider when there is limited liability may also apply to the analysis of firms managed as partnerships. The development of these applications remains for future work.

[37] The policy may give rise to a poverty trap. The point is analogous to Banerjee and Newman's [8] remark that the use of collateral in response to information problems causes a poverty trap since poor people cannot borrow to invest because they are poor.

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Table 1a: Payoffs to borrower 1 by contract type:
borrowers linked by joint liability monitor and choose the safe project
(ignoring costs of monitoring)

State of the world	Payoffs to borrower 1 by contract type	
	Joint liability	Individual liability
both projects succeed	$R_s(L_g) - S_g^{uu} + w$	$R_i(L_n) - S_n^u + w$
own project succeeds, partner's project fails	0	$R_i(L_n) - S_n^u + w$
own project fails, partner's project succeeds	0	0
both projects fail	0	0

In the individual-liability contract, only the project returns depend on the choice of project. $i = s, r$

Table 1b: Payoffs to borrower 1 by contract type:
borrowers linked by joint liability do not monitor and choose the risky project

State of the world	Payoffs to borrower 1 by contract type	
	Joint liability	Individual liability
both projects succeed	$R_r(L_g) - S_g^{uu} + w$	$R_i(L_n) - S_n^u + w$
own project succeeds, partner's project fails	$R_r(L_g) - R_s(L_g)$	$R_i(L_n) - S_n^u + w$
own project fails, partner's project succeeds	0	0
both projects fail	0	0

Table 2: Mean loan sizes by borrowers' wealth and type of contract

Borrowers' wealth	Type of contract	
	Joint-liability	Individual-liability
Amount of land $\leq$0.04 acres	3310 taka	2266 taka
	SE = 232.87 # of obs. = 465	SE = 281.81 # of obs. = 5
Amount of land >0.04 acres	3564 taka	4925 taka
	SE = 158.60 # of obs. = 1571	SE = 523.75 # of obs. = 75

SE is the standard error of the mean estimate. Obs is the number of observations in the cell.

The exchange rate for the relevant years was 33 taka/US$1.

7. Appendix

7.1. The game in which borrowers choose the level of monitoring and projects

Given the terms of the contract, which are loan size L, payments S^k, and the certainty equivalent of the expected punishment announced by the lender, c_l, the borrowers play the following game. Each borrower's strategy set consists of $\{c_g^m, P^m\}$ $m = 1, 2$, where m denotes the borrower who imposes the punishment, c_g^m denotes the CE of expected punishment which the borrower announces and $P^m = s, r$ is the project, safe or risky. Borrowers simultaneously choose c_g^m. They observe the other's choice. Then they simultaneously choose the projects. I look for subgame perfect Nash equilibria (SPNE) of this game.

I suppose that if a borrower chooses $c_g^m > 0$, she chooses c_g^m which ensures that her partner implements the safe project if she herself chooses the safe project, i.e.

$$c_g^m = V_{rs}(S_g^k, L_g) - V_{ss}(S_g^k, L_g) \qquad (A.1)$$

where the first subscript on V denotes the project chosen by the borrower's partner and the second denotes the project chosen by the borrower herself. I solve the game using this level of c_g^m, then I show that this is indeed the level chosen in equilibrium. I assume that the punishment is costless to impose. Since the punishment is confiscation of the borrower's returns, the monitor has an incentive to carry it out even if it were costly.

I summarize the payoffs to borrower one from all possible strategies in Table A.1. Two's payoffs are symmetric. Punishing yields the CE of the punishment, c_g^m, to the borrower who imposes it.

Table A.1: Payoffs to borrower 1

Strategies (c_g^1, c_g^2, P^1, P^2)	**Payoffs to borrower 1**
$c_g^1 > 0, c_g^2 > 0, s, s$	$V_{ss}(S_g^k, L_g) - W(c_g^1)$
$c_g^1 > 0, c_g^2 > 0, s, r$	$V_{sr}(S_g^k, L_g) - W(c_g^1) + c_g^1$
$c_g^1 > 0, c_g^2 > 0, r, s$	$V_{rs}(S_g^k, L_g) - W(c_g^1) - c_g^2$
$c_g^1 > 0, c_g^2 > 0, r, r$	$V_{rr}(S_g^k, L_g) - W(c_g^1)$
$c_g^1 > 0, c_g^2 = 0, s, s$	$V_{ss}(S_g^k, L_g) - W(c_g^1)$
$c_g^1 > 0, c_g^2 = 0, s, r$	$V_{sr}(S_g^k, L_g) - W(c_g^1) + c_g^1$
$c_g^1 > 0, c_g^2 = 0, r, s$	$V_{rs}(S_g^k, L_g) - W(c_g^1)$
$c_g^1 > 0, c_g^2 = 0, r, r$	$V_{rr}(S_g^k, L_g) - W(c_g^1) + c_g^1$
$c_g^1 = 0, c_g^2 > 0, s, s$	$V_{ss}(S_g^k, L_g)$
$c_g^1 = 0, c_g^2 > 0, s, r$	$V_{sr}(S_g^k, L_g)$
$c_g^1 = 0, c_g^2 > 0, r, s$	$V_{rs}(S_g^k, L_g) - c_g^2$
$c_g^1 = 0, c_g^2 > 0, r, r$	$V_{rr}(S_g^k, L_g) - c_g^2$
$c_g^1 = 0, c_g^2 = 0, s, s$	$V_{ss}(S_g^k, L_g)$
$c_g^1 = 0, c_g^2 = 0, s, r$	$V_{sr}(S_g^k, L_g)$
$c_g^1 = 0, c_g^2 = 0, r, s$	$V_{rs}(S_g^k, L_g)$
$c_g^1 = 0, c_g^2 = 0, r, r$	$V_{rr}(S_g^k, L_g)$

The punishment and benefit of punishing do not appear in the payoff in line 4, because if $c_g^m > 0$ for $m = 1, 2$, then $c_g^1 = c_g^2$.

I solve the game by backward induction. Consider the subgame following the decision by both borrowers to monitor. If borrower one (two) chooses the safe project, two (one) chooses the safe project by constraint (A.1). Therefore (s^1, s^2) is a Nash equilibrium. If one (two) chooses the risky project, two (one) also chooses the risky project as long as c_g is small enough so that

$$V_{sr}(S_g^k, L_g) + c_g < V_{rr}(S_g^k, L_g) \qquad (A.2)$$

The reason is that c_g^m defined by (A.1) is not sufficient to induce a borrower to choose the safe project if her partner chooses the risky project. Denote this sufficient level of punishment as c_{gr}

$$c_{gr} = p_r^2 U_r^{uu} + p_r(1 - p_r) U_r^{uf} - p_s p_r U_s^{uu} \qquad (A.3)$$

where I suppress the arguments of the utility functions. c_{gs} is the level defined in $A.1$

$$c_{gs} = p_r p_s U_r^{uu} + p_r(1 - p_s) U_r^{uf} - p_s^2 U_s^{uu} \qquad (A.4)$$

The difference between the two is

$$c_{gs} - c_{gr} = (p_s - p_r)[p_r U_r^{uu} - p_r U_r^{uf} - p_s U_s^{uu}] \qquad (A.5)$$

$U_r^{uu} > U_s^{uu}$ and $U_r^{uu} > U_r^{uf}$. The argument of U_r^{uf}, is at least as large as the difference between the arguments of U_r^{uu} and U_s^{uu}, and it equals this difference, $R_r(L) - R_s(L)$, when the group contract imposes the maximum group liability. Then, given the concavity of U, the expression is negative, and $c_{gr} > c_{gs}$. Therefore, (r^1, r^2) is also a Nash equilibrium if condition $A.2$ holds. As long as the terms of the contract satisfy the group incentive constraint,

$$V_{ss}(S_g^k, L_g) - W(c_g) \geq V_{rr}(S_g^k, L_g) \qquad (A.6)$$

(s^1, s^2) is the Pareto dominant (or strong) equilibrium.

(r^1, r^2) is the unique Nash equilibrium in each of the other three proper subgames.

The game as a whole has three possible SPNEs, $(c_g^1 > 0, c_g^2 > 0, s^1, s^2)$, $(c_g^1 = 0, c_g^2 = 0, r^1, r^2)$, $(c_g^1 > 0, c_g^2 > 0, r^1, r^2)$. If contract terms satisfy $A.6$, then $(c_g^1 > 0, c_g^2 > 0, s^1, s^2)$ is the Pareto dominant (or strong) equilibrium.

The level of c_g determined by $A.1$ is the lowest level which supports the equilibrium in which both borrowers monitor and choose the safe project. A lower level would result in both choosing the risky project, since if one chooses the risky project the other does as well. Any higher level is unnecessarily costly.

7.2. The solution to the lender's monitoring problem

The following constraint defines the level of monitoring in a lender-monitored contract

$$c_l = p_r U_r^u(R_r(L_l) - S_l^u + w) - p_s U_s^u(R_s(L_l) - S_l^u + w)$$

where S_l^u is a function of $W(c_l)$. A c_l which solves this expression may not always exist. Consider L_l such that a borrower would choose the risky project in the absence of monitoring. For such an L_l the right-hand side of the constraint is strictly positive at $c_l = 0$. $W(c_l)$ is convex and $U(\cdot)$ is concave. A solution exists if the right-hand-side is concave in c_l, see figure A.1. If the right-hand-side is convex in c_l, a solution may not exist, figure A.2, or there may be two solutions, figure A.3. I assume the former case does not occur for $L < \overline{L}$. In the latter case, the lender will implement the lower c_l.

7.3. The terms of the contracts

I prove lemmas 3.1 and 3.2.

Let β denote the portion of w which the contract requires the borrower to pay when both projects fail, $S^{ff} = \beta w$, $0 \leq \beta \leq 1$. Let γ be the fraction when borrower one's project fails but two's succeeds, $0 \leq \gamma \leq 1$. In the same state, let δ be the portion of borrower two's income, $(R_s(L_g) + w)$, paid to borrower one, $S^{fu} = \gamma w - \delta(R_s(L_g)+w)$. Let α be the fraction of income borrower one pays when her project succeeds and two's fails, $S^{uf} = \alpha(R_s(L_g)+w)$, $0 \leq (\alpha+\delta) \leq 1$.[38] The payment when both succeed is determined by the lender's break-even constraint.

In lemma 7.1, I determine the optimal payments in a lender-monitored and unmonitored contract, when $S^{uu} = S^{uf}$ and $S^{fu} = S^{ff}$, i.e. $\beta = \gamma$ and $(\alpha + \delta) = \frac{\rho L - (1-p_s)\beta_l w}{p_s(R_s(L)+w)}$.

I rewrite lemma 3.1. The subscript l denotes the lender-monitored contract.

Lemma 7.1. *Assume that $\beta_l = \gamma_l$ and $(\alpha_l + \delta_l) = \frac{\rho L - (1-p_s)\beta_l w}{p_s(R_s(L)+w)}$. There exists $\overline{p}_s^l$ such that for $p_s > \overline{p}_s^l$, $\beta_l = 1$. Therefore, $S_l^{fu} = S_l^{ff} = S_l^f = w$. $S^{uu} = S^{uf} = S^u$ and*

$$S_l^u = \frac{\rho L_l - (1-p_s)w + W(c_l)}{p_s}$$

Proof. The lender chooses β_l to solve problem (4) given in section 3.2. Consider the incentive constraint,

$$\begin{aligned} V_s^l(S_l^k, L_l) &= p_s U_s^u(R_s(L_l) - S_l^u + w) + (1-p_s)U^f((1-\beta_l)w) \geq \\ & \quad p_r U_r^u(R_r(L_l) - S_l^u + w) + (1-p_r)U^f((1-\beta_l)w) - c_l = V_r^l(S_l^k, L_l) - c_l \end{aligned}$$

In order to show that a given β_l is optimal, I only need to show that it relaxes the incentive constraint as much as possible as $p_s \to 1$, since the left-hand side is the objective function.

$$\lim_{p_s \to 1} \frac{\partial V_s^l(S_l^k, L_l)}{\partial \beta_l} = \lim_{p_s \to 1} [(1-p_s)U_s^{u\prime} w - (1-p_s)U^{f\prime} w] = 0$$

$$\lim_{p_s \to 1} \frac{\partial V_r^l(S_l^k, L_l)}{\partial \beta_l} = \lim_{p_s \to 1} [\frac{p_r}{p_s}(1-p_s)U_r^{u\prime} w - (1-p_r)U^{f\prime} w] = -(1-p_r)U^{f\prime} w < 0$$

Therefore, there exists a $\overline{p}_s^l$ such that for $p_s > \overline{p}_s^l$ the optimal value for β_l is $\beta_l = 1$.

S_l^u follows from $\beta_l = 1$ and the lender's break-even constraint. ■

I rewrite lemma 3.2. The subscript g denotes the group contract.

[38] α can include both the portion of the income paid to the lender and the portion paid to borrower two.

Lemma 7.2. *There exists $\overline{p}_s^g$ such that for $p_s > \overline{p}_s^g$, $\beta_g = 1$, $\gamma_g = 1$, $\delta_g = 0$, and $\alpha_g = 1$. Therefore, $S_g^{fu} = S_g^{ff} = w$, $S_g^{uf} = R_s(L_g) + w$ and*

$$S_g^{uu} = \frac{\rho L_g - (1-p_s^2)w - p_s(1-p_s)R_s(L_g)}{p_s^2}$$

Proof. The lender chooses β_g, γ_g, δ_g, and α_g to solve problem (5) given in section 3.3. Consider the group incentive compatibility constraint, in which I substitute in from the constraint which determines c_g,

$$\begin{aligned}
V_{ss}(S_g^k, L_g) - W(c_g) \quad = \quad & p_s^2 U_s^{uu}(R_s(L_g) - S_g^{uu} + w) + p_s(1-p_s)U_s^{uf}(R_s(L_g) + w - \\
& \alpha_g(R_s(L_g) + w)) + p_s(1-p_s)U_s^{fu}((1-\gamma_g)w + \delta_g(R_s(L_g) + w)) + \\
& (1-p_s)^2 U^{ff}((1-\beta_g)w) - W[p_r p_s U_r^{uu}(R_r(L_g) - S_g^{uu} + w) + \\
& p_r(1-p_s)U_r^{uf}(R_r(L_g) - \alpha_g(R_s(L_g) + w) + (1-p_r)p_s U_r^{fu}((1-\gamma_g)w + \\
& \delta(R_s(L_g) + w)) + (1-p_r)(1-p_s)U^{ff}((1-\beta_g)w) - \\
& p_s^2 U_s^{uu}(R_s(L_g) - S_g^{uu} + w) - p_s(1-p_s)U_s^{uf}(R_s(L_g) + w - \\
& \alpha_g(R_s(L_g) + w)) - p_s(1-p_s)U_s^{fu}((1-\gamma_g)w + \delta_g(R_s(L_g) + w)) - \\
(\qquad & 1-p_s)^2 U^{ff}((1-\beta_g)w)] \geq \\
& p_r^2 U_r^{uu}(R_r(L_g) - S_g^{uu} + w) + p_r(1-p_r)U_r^{uf}(R_r(L_g) - \\
& \alpha_g(R_s(L_g) + w)) + p_r(1-p_r)U_r^{fu}((1-\gamma_g)w + \delta_g(R_s(L_g) + w)) + \\
(\qquad & 1-p_r)^2 U^{ff}((1-\beta_g)w) = V_{rr}(S_g^k, L_g)
\end{aligned}$$

In order to show that a particular value of β_g, γ_g, α_g, or δ_g is optimal, it suffices to show that it relaxes the incentive constraint as much as possible as $p_s \to 1$, since the left-hand side is the objective function.

Consider β_g.

$$\begin{aligned}
\lim_{p_s \to 1} \frac{\partial [V_{ss}(S_g^k, L_g) - W(c_g)]}{\partial \beta_g} = \lim_{p_s \to 1} [\qquad & (1-p_s)^2 w U_s^{uu\prime} - (1-p_s)^2 w U^{ff\prime} - \\
& W'(\frac{p_r}{p_s}(1-p_s)^2 w U_r^{uu\prime} - (1-p_r)(1-p_s) w U^{ff\prime} - \\
& (1-p_s)^2 w U_s^{uu\prime} + (1-p_s)^2 w U^{ff\prime}) = 0
\end{aligned}$$

$$\begin{aligned}
\lim_{p_s \to 1} \frac{\partial V_{rr}(S_g^k, L_g)}{\partial \beta_g} \quad & = \quad \lim_{p_s \to 1} [\frac{p_r^2}{p_s^2}(1-p_s)^2 w U_r^{uu\prime} - (1-p_r)^2 w U^{ff\prime}] \\
& = \quad -(1-p_r)^2 U^{f\prime} w < 0
\end{aligned}$$

Increasing β_g relaxes the incentive constraint. Therefore, there exists a $\overline{p_s}^{\beta_g}$ such that for $p_s \geq \overline{p_s}^{\beta_g}$, $\beta_g = 1$ is optimal.

Consider γ_g.

$$\begin{aligned}\lim_{p_s\to 1}\frac{\partial[V_{ss}(S_g^k, L_g) - W(c_g)]}{\partial \gamma_g} = \lim_{p_s\to 1} [\quad & p_s(1-p_s)wU_s^{uu\prime} - p_s(1-p_s)wU_s^{fu\prime} - \\ & W'(p_r(1-p_s)wU_r^{uu\prime} - (1-p_r)p_s wU_r^{fu\prime} - \\ & p_s(1-p_s)wU_s^{uu\prime} + p_s(1-p_s)wU_s^{fu\prime})] \\ = \quad & W'(1-p_r)wU_r^{fu\prime} > 0\end{aligned}$$

$$\begin{aligned}\lim_{p_s\to 1}\frac{\partial V_{rr}(S_g^k, L_g)}{\partial \gamma_g} &= \lim_{p_s\to 1}[\frac{p_r^2}{p_s^2}p_s(1-p_s)wU_r^{uu\prime} - p_r(1-p_r)wU_r^{fu\prime}] \\ &= -p_r(1-p_r)wU_r^{fu\prime} < 0\end{aligned}$$

Therefore, for p_s larger than some $\overline{p_s}^{\gamma_g}$, $\gamma_g = 1$ is optimal.

Consider α_g.

$$\begin{aligned}\lim_{p_s\to 1}\frac{\partial[V_{ss}(S_g^k, L_g) - W(c_g)]}{\partial \alpha_g} = \lim_{p_s\to 1} [\quad & (R_s(L_g) + w)[p_s(1-p_s)U_s^{uu\prime} - p_s(1-p_s)U_s^{uf\prime} - \\ & W'(p_r(1-p_s)U_r^{uu\prime} - p_r(1-p_s)U_r^{uf\prime} - \\ & p_s(1-p_s)U_s^{uu\prime} + p_s(1-p_s)U_s^{uf\prime})] = 0\end{aligned}$$

$$\begin{aligned}\lim_{p_s\to 1}\frac{\partial V_{rr}(S_g^k, L_g)}{\partial \alpha_g} &= \lim_{p_s\to 1}[(R_s(L_g)+w)[\frac{p_r^2}{p_s^2}p_s(1-p_s)U_r^{uu\prime} - p_r(1-p_r)U_r^{uf\prime}]] \\ &= -(R_s(L_g)+w)p_r(1-p_r)U_r^{uf\prime} < 0\end{aligned}$$

Therefore, for p_s larger than some $\overline{p_s}^{\alpha_g}$, $\alpha = 1$ is optimal. Define $\overline{p}_s^g$ as the largest of $\{\overline{p_s}^{\beta_g}, \overline{p_s}^{\gamma_g}, \overline{p_s}^{\alpha_g}\}$.

$\delta_g = 0$ follows from $\alpha_g = 1$. S_g^{uu} follows from the above and the lender's break-even constraint. ■

7.4. Proof of Proposition 4.1

Let V_n^* and V_g^* be the utility in equilibrium when the borrower obtains an individual-liability loan contract in which $c_l = 0$ and a group loan contract, respectively. Subscript n denotes the unmonitored, individual contract and subscript g denotes the group contract. a is the coefficient of absolute risk aversion.

Proof. Using lemmas 7.1 and 7.2,

$$V_n^* = p_s U_s^u (R_s(L_n^*) - \frac{\rho L_n^* - w}{p_s})$$

and

$$V_g^* = p_s^2 U_s^{uu} (R_s(L_g^*) - \frac{\rho L_g^* - w - p_s(1-p_s)R_s(L_g^*)}{p_s^2}) - W(c_g)$$

Consider $w = \widehat{w}$ for which $V_n^* = V_g^*$. I want to show that $\overline{a}$ exists such that for $a > \overline{a}$, $\frac{\partial V_g^*}{\partial w} < \frac{\partial V_n^*}{\partial w}$.

$$\frac{\partial V_g^*}{\partial w} = U_s^{uu\prime} + (p_s R_s'(L_g) - \rho) U_s^{uu\prime} \frac{dL_g}{dw} - W'(\frac{\partial c_g}{\partial w} + \frac{\partial c_g}{\partial L_g}\frac{dL_g}{dw})$$

and

$$\frac{\partial V_n^*}{\partial w} = U_s^{u\prime} + (p_s R_s'(L_n) - \rho) U_s^{u\prime} \frac{dL_n}{dw}$$

$U_s^{uu\prime} < U_s^{u\prime}$, because the payoff in case of success must be larger in the group contract in order for borrowers to be indifferent. The payoff occurs with a smaller probability in the group contract and the borrowers are bearing a cost of monitoring.

If $R''(L) = 0$, then $(p_s R_s'(L_g) - \rho) = (p_s R_s'(L_n) - \rho)$. It remains to compare $\frac{dL_g}{dw}$ and $\frac{dL_n}{dw}$. These are determined by the respective incentive constraints, since both constraints bind. Suppose the group incentive constraint did not bind. Then it would be optimal to insure the borrower. But this contradicts lemma 7.2. An analogous argument shows that the unmonitored incentive constraint binds.

I first compare $\frac{dL_g}{dw}$ and $\frac{dL_n}{dw}$ ignoring the cost of monitoring. Implicitly differentiating the incentive constraints

$$\begin{aligned} \left.\frac{dL_g}{dw}\right|_{P=p_s} \quad = \quad & [U_s^{uu\prime} - \frac{p_r^2}{p_s^2} U_r^{uu\prime}] \div [p_r^2(R_r'(L_g) - \frac{\rho - p_s(1-p_s)R_s'(L_g)}{p_s^2}) U_r^{uu\prime} + \\ & p_r(1-p_r)(R_r'(L_g) - R_s'(L_g)) U_r^{uf\prime} - p_s^2(R_s'(L_g) \\ & - \frac{\rho - p_s(1-p_s)R_s'(L_g)}{p_s^2}) U_s^{uu\prime}] \qquad (1) \end{aligned}$$

where $P = p_s$ denotes that the borrower chooses the safe project, and

$$\left.\frac{dL_n}{dw}\right|_{P=p_s} = \frac{U_s^{u\prime} - \frac{p_r}{p_s} U_r^{u\prime}}{p_r(R_r'(L_n) - \frac{\rho}{p_s}) U_r^{u\prime} - p_s(R_s'(L_n) - \frac{\rho}{p_s}) U_s^{u\prime}} \qquad (2)$$

The numerator of the difference $\left.\frac{dL_n}{dw}\right|_{P=p_s} - \left.\frac{dL_g}{dw}\right|_{P=p_s}$ is positive if

$$\begin{aligned}(\quad & p_r^2 R_r'(L) U_r^{uu\prime} + \frac{p_r^2}{p_s^2} p_s(1-p_s) R_s'(L) U_r^{uu\prime} - p_s^2 R_s'(L) U_s^{uu\prime} - p_s(1-p_s) R_s'(L) U_s^{uu\prime}) \\ (\quad & U_s^{u\prime} - \frac{p_r}{p_s} U_r^{u\prime}) - (p_r R_r'(L) U_r^{u\prime} - p_s R_s'(L) U_s^{u\prime})(U_s^{uu\prime} - \frac{p_r^2}{p_s^2} U_r^{uu\prime}) > 0 \qquad (3)\end{aligned}$$

while the denominator is positive if

$$\frac{p_r R_r'(L) - \frac{p_r}{p_s}\rho}{p_s R_s'(L) - \rho} > \frac{U_s^{u\prime}}{U_r^{u\prime}} \qquad \forall L < \overline{L} \qquad (4)$$

Inequality (3) holds if

$$(U_s^{u\prime} - U_s^{uu\prime}) \geq \frac{p_r}{p_s}(\frac{R_r'(L)}{R_s'(L)} U_r^{u\prime} - \frac{p_r}{p_s} U_r^{uu\prime}) \qquad \forall L < \overline{L} \qquad (5)$$

and

$$(U_s^{u\prime} - U_s^{uu\prime}) \geq \frac{p_r}{p_s}(U_r^{u\prime} - \frac{p_r}{p_s} U_r^{uu\prime}) \qquad \forall L < \overline{L} \qquad (6)$$

Since $R_r'(L) > R_s'(L)$ by assumption A.4, (5) implies (6). Ignoring the right-most term, $\frac{p_r^2}{p_s^2} U_r^{uu\prime}$, I can rewrite (6) as

$$\frac{U_s^{u\prime} - U_s^{uu\prime}}{U_r^{u\prime}} \geq \frac{p_r}{p_s} \frac{R_r'(L)}{R_s'(L)} \qquad \forall L < \overline{L} \qquad (7)$$

Condition (7) holds for a large enough. This is because, as $a \to \infty$, $\frac{U_s^{u\prime} - U_s^{uu\prime}}{U_r^{u\prime}} \to \infty$. To see this, note that when $\alpha = 1$, for any given a, there is a non-degenerate difference between $U_s^{u\prime}$ and $U_s^{uu\prime}$. The argument of $U_s^{u\prime}$ is smaller than that of $U_r^{u\prime}$. As $a \to \infty$, the curvature of the utility function increases, and $U_r^{u\prime}$ becomes small relative to $(U_s^{u\prime} - U_s^{uu\prime})$.

For any a, inequality (4) holds if ρ is large enough. Therefore there exists an $\overline{a}$ and a $\overline{\rho}$, such that for all larger a and ρ the inequality holds and $\left.\frac{dL_n}{dw}\right|_{P=p_s} > \left.\frac{dL_g}{dw}\right|_{P=p_s}$ ignoring the cost of monitoring.

$\left.\frac{dL_n}{dw}\right|_{P=p_s} > \left.\frac{dL_g}{dw}\right|_{P=p_s}$ holds even if I take the cost of monitoring into account, if an increase in wealth and in loan size which just satisfy the unmonitored incentive constraint would result in an increase in c_g. Therefore, I compare

$\left.\frac{dL_g}{dw}\right|_{c_g \text{ constant}}$ and $\left.\frac{dL_n}{dw}\right|_{P=p_s}$.

$$\left.\frac{dL_g}{dw}\right|_{c_g \text{ constant}} = [U_s^{uu\prime} - \frac{p_r}{p_s}U_r^{uu\prime}] \div [p_r p_s(R_r'(L_g) - \frac{\rho - p_s(1-p_s)R_s'(L_g)}{p_s^2})U_r^{uu\prime} + p_r(1-p_s)(R_r'(L_g) - R_s'(L_g))U_r^{uf\prime} - p_s^2(R_s'(L_g) - \frac{\rho - p_s(1-p_s)R_s'(L_g)}{p_s^2})U_s^{uu\prime}] \qquad (8)$$

$\left.\frac{dL_n}{dw}\right|_{P=p_s} > \left.\frac{dL_g}{dw}\right|_{c_g \text{ constant}}$ if

$$\frac{U_s^{u\prime} - U_s^{uu\prime}}{U_r^{u\prime}} > \frac{p_r R_r'(L_g)}{p_s R_s'(L_g)} \qquad \forall L < \overline{L} \qquad (9)$$

This is the same inequality as (7), and it holds for a large enough. Therefore there exists an $\overline{a}$ and $\overline{\rho}$ such that for all larger a and ρ, $\frac{dL_n}{dw} > \frac{dL_g}{dw}$.

Consider the last term in the expression for $\frac{\partial V_g^*}{\partial w}$, $W'(\frac{\partial c_g}{\partial w} + \frac{\partial c_g}{\partial L_g}\frac{dL_g}{dw})$. In order to determine the sign of this term, I compare $\left.\frac{dL_g}{dw}\right|_{P=p_s}$ ignoring the cost of monitoring, as given by (1) and $\left.\frac{dL_g}{dw}\right|_{c_g \text{ constant}}$ as given by (8). $\left.\frac{dL_g}{dw}\right|_{P=p_s} < \left.\frac{dL_g}{dw}\right|_{c_g \text{ constant}}$ if

$$\frac{U_r^{uf\prime} - U_r^{uu\prime}}{U_r^{uf\prime}} \geq \frac{R_s'(L)}{R_r'(L)} \qquad \forall L < \overline{L} \qquad (10)$$

As $a \to \infty$, the left-hand side approaches 1, since $U_r^{uf\prime} > U_r^{uu\prime}$. Since $R_s'(L) < R_r'(L)$, the condition holds for a large enough. If this condition holds, then an increase in the group loan with wealth which just satisfies the incentive constraint ignoring the cost of monitoring, leaves c_g lower than it was before the increase in wealth. The overall incentive constraint does not bind after such a change in L_g and the loan size will continue to increase. However, L_g cannot increase sufficiently to raise c_g to the level it was at before the increase in wealth, because in addition to raising c_g, it also raises the utility from the risky project faster than that from the safe project. Therefore the increase in wealth will leave c_g lower than it was before, and

$$W'(\frac{\partial c_g}{\partial w} + \frac{\partial c_g}{\partial L_g}\frac{dL^g}{dw}) < 0$$

However, there exists a $\overline{FC}$ such that for $FC > \overline{FC}$, $W'(c)$ is sufficiently small that this term will not dominate. If condition (10) does not hold then $W'(\frac{\partial c_g}{\partial w} + \frac{\partial c_g}{\partial L_g}\frac{dL^g}{dw}) > 0$

Then $\frac{\partial V_g^*}{\partial w} < \frac{\partial V_n^*}{\partial w}$. ■