The role of collateral in joint liability group lending: Evidence from a framed field experiment in Tanzania*

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Abstract

Both collateralized individual loan contracts and joint liability group lending contracts have received much attention in the microfinance literature, yet neither contract has been found to be optimal from a welfare perspective. On the one hand, a heavily collateralized individual loan contract is very risky for borrowers, resulting in low levels of credit market participation. On the other hand, while joint liability contracts are designed to harness the social collateral among community members, numerous studies have shown that such contracts are prone to moral hazard, free-riding, and collusion. This paper analyzes an alternative contract which combines joint liability with a modest collateral requirement. Using a simple theoretical framework, I show that adding a collateral requirement to a joint liability contract reduces moral hazard but has an ambiguous effect on credit market participation. To test the predictions of the model, I conduct a unique framed field experiment among active credit group members in Tanzania. The results demonstrate that adding a collateral requirement reduces moral hazard among borrowers and helps increase repayments without compromising the effect of the social collateral in the groups. Moreover, I find evidence that a collateral requirement leads to a modest reduction in credit market participation.

Keywords: Credit Rationing, Moral Hazard, Collateral, Field Experiments, Microfinance, Group Lending, Joint Liability

JEL Classification Codes: D82, G21, O16, Q14

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1 Introduction

Over the past three decades, microfinance has helped ease liquidity constraints for millions of poor people around the developing world and has been an effective tool in reducing poverty. However, in an environment characterized by small loan sizes and high monitoring costs, lenders face significant problems with moral hazard and adverse selection, leading to credit rationing and high default rates. To combat these challenges, banks typically rely on either heavy collateralization or joint liability, but there is no clear evidence in the literature that either of these contract features separately presents the optimal solution to the microfinance problem. In this paper, I consider a third type of contract, which combines joint liability with a modest collateral requirement. In particular, I ask how the interaction between joint liability and collateral affects moral hazard, repayments and credit rationing. Using data from a unique framed field experiment, I show that such a contract effectively reduces moral hazard relative to a pure joint liability contract and that credit market participation is only slightly lower. To the best of my knowledge, this is the first paper to study the role that a collateral requirement plays in a group lending context.

As Stiglitz (1981) demonstrated in his seminal paper, the lender's inability to distinguish between different borrower types and to enforce and monitor borrower behavior results in adverse selection and moral hazard, respectively. To combat these issues, a profit-maximizing lender will set an interest rate lower than the market-clearing rate, thus leading to credit rationing. In response to these findings, Bester (1985a) extends Stiglitz' model and shows that when banks can set the interest rate and the collateral requirement simultaneously, perfect sorting of borrowers is possible, thus eliminating adverse selection and thereby credit rationing. Later, Bester (1987) finds that also moral hazard can be eliminated if banks can vary both the interest rate and the collateral requirement.

Hence, collateralization can be an effective screening and incentive device that helps reduce adverse selection and moral hazard in lending. However, its effectiveness is limited both by the borrower's collateralizable wealth and by her risk preferences. In particular, Bester (1987) shows that if borrowers have insufficient wealth to cover the collateral requirement, perfect sorting is no longer possible, and some credit rationing will persist. This is especially a problem in a developing country context, where borrowers are typically poor and often limited in their ability to pledge collateral. Moreover, Boucher et al. (2007) identify another type of rationing which they call risk rationing. This occurs when available contracts exist but the agent prefers a safe lower-yielding activity instead due to the high risk inherent in the collateralized contract.

Given its popularity among microfinance practitioners, joint liability group lending has received much attention in the literature. Under a typical group liability contract, borrowers form groups consisting of usually five to twenty members, who receive individual loans but are all mutually responsible for the total repayment to the lender. Proponents of group liability contracts argue that this feature can help overcome problems of moral hazard and adverse selection in small-scale lending where lenders lack credit information about potential borrowers and do not have the resources to monitor individuals. In particular, positive assortative matching in group formation can reduce informational asymmetries (Ghatak, 1999; van Tassel, 1999), and strong social collateral within existing groups might help reduce voluntary default and other morally hazardous behavior (Besley and Coate, 1995; Anderson and Nina, 1998). Despite these potential benefits of group liability, there is mixed evidence, both theoretical and empirical, on the relative merits of group versus individual liability (Morduch, 1999; Huppi and Feder, 1990; Gine and Karlan, 2010). Critics of group liability argue that such contracts are prone to free-riding and collusion (Gine et al., 2009; Laffont and Rey, 2003), that they deter relatively safe borrowers who would not default under an individual contract but would do so under a group lending contract (Besley and Coate, 1995), and that they may induce excessively prudent behavior (Banerjee et al., 1992). Moreover, positive assortative matching may only work partially, especially if group sizes are large. Finally, social hierarchies within groups or strong social ties among group members may distort or weaken the value of the social collateral, as successful borrowers might be reluctant to pressuring less fortunate, less abled, or more powerful group members to repay (Wydick, 1999; Gine and Karlan, 2010).

While previous research discusses individual lending and group liability as two separate contracts, there is no reason to assume that either of these extremes represents the optimal contract. Adding a collateral requirement to a joint liability contract transfers some the responsibility back to the individual borrower while preserving the interdependence of group members' outcomes. If the social collateral in the group is ineffective or insufficient, a moderate level of physical or monetary collateral might help provide stronger incentives for group members to act in the best interest of the group and will thus also reduce the potential for free-riding. Moreover, a collateral requirement can also help reduce the probability of group default, thus making group lending more attractive to safer borrowers. In my theoretical model, I formalize these ideas and show that a collateral requirement in joint liability group lending reduces moral hazard as long as the social collateral is not too strong.

To test the predictions of the theoretical model, I conducted a framed field experiment, in which a sample of Tanzanian smallholder sunflower farmers played a series of microfinance games. My experimental design is closest to that of Gine et al. (2009), with some notable differences. First, while Gine et al. (2009) consider groups where members are from the same community, my experimental groups are subsets of established credit groups, allowing me to harness the potentially strong social collateral that already exists between members. In this aspect, my experiment is most similar to that in Cassar et al. (2007). Moreover, in Gine et al. (2009), borrowers' morally hazardous behavior coincides with the social optimum, whereas in my experiment, moral hazard is modeled as a diversion of effort, which may be optimal for an individual but not for the group. Finally, instead of providing various types of information treatments as in Gine et al. (2009), I induce exogenous variation in the social collateral and impose a monetary collateral requirement.

The results of my experiments show that a collateral requirement reduces moral hazard and increases repayments in joint liability group lending. However, my findings also suggest that the negative effect of the collateral requirement on credit market participation due to borrowers' fear of losing their collateral is greater than the positive effect due to a reduction in joint liability cost, resulting in a net reduction in the number of borrowers.

The remainder of the paper is structured as follows. Section 2 presents a theoretical model of joint liability group lending with collateral. In section 3, I discuss the design of the framed field experiment and the data collected, while section 4 lays out the empirical approach and presents the results. The final section concludes and discusses potential policy implications.

2 Theoretical model

In this section, I present a simple theoretical framework for studying the effect of adding a collateral requirement to a joint liability group lending contract. The model presented here is a simplified version of a more general model, which is extensively analyzed in a separate paper. While the simplified model is more restrictive, it produces tractable results which highlight the basic incentive mechanisms of the problem. Moreover, with the exception of the assumption of risk neutrality, the simple model is generally consistent with the experimental setup.

In what follows, I first describe the setup of the general model and highlight the simplifying assumptions that I make in this paper. I then use this model to analyze the effects of having a collateral requirement in an individual lending contract and in a joint liability group lending contract. Finally, I discuss the theoretical findings and explain their relevance for understanding the results of the framed field experiment.

2.1 General model setup

The general model is based on a standard single-period principal agent problem with moral hazard, in which the lender maximizes its profits by offering a loan contract subject to a borrower incentive compatibility constraint and a participation constraint. I assume there is one lender who offers a loan contract $K(r, C)$ to borrowers, where r is the interest rate and C is the collateral requirement. In the simplified model, I assume that r and C are exogenously determined and only consider the borrower's maximization problem without regard to the lender's response function. This is consistent with the experimental setup, in which the contract terms are fixed, and it is consistent with the reality of microfinance lending in the short run.

Under the incentive compatibility constraint, borrowers maximize expected utility $\mathbb{E}\, U(e|r, C)$, by choosing an effort level, and taking the contract $\mathrm{K}(r, C)$ as given. Rather than making the required effort level a function of project size as in Stiglitz (1990), I assume project size to be fixed and let agents choose the amount of effort to supply. Moreover, in the simplified model, I assume borrowers are risk averse, such that $U(\pi) = \pi$. In the general model, I relax this assumption and allow for risk averse borrowers.

Once the agent has chosen an effort level, she will undertake a risky, but potentially profitable project, $\wp$, that yields a stochastic payoff of X. In the general model, payoffs are distributed according to the CDF $F(X|e)$ with corresponding density function $f(X|e)$, and such that $F_e(X|e) < 0$, which captures first order stochastic dominance for higher effort. This implies that expected returns are increasing in effort. In the simplified model, I only consider two states of nature, success and failure, with the payoff being $\overline{X}$ in the event of success and zero if the project fails. By increasing their effort, agents can influence the probability of success, $p(e)$. I assume the relationship is simply $p(e) = e$, which also implies that $e \in (0, 1)$. To induce moral hazard, I assume that effort is costly for the agent. In particular, I assume a additively separable utility function, in which utility is penalized by a function $d(e)$, which in the simplified model, I assume takes the form $d(e) = \frac{1}{2}\gamma e^2$.

In order to study the effect on credit market participation, I assume that agents have the option not to borrow and instead can work for a subsistence wage, which yields a fixed income of ω. This is equivalent to the borrower participation constraint discussed above, which states that the lender must offer a contract such that $\mathbb{E}\, U(e|r, C) \geq U(\omega)$.

Next, to capture dynamic incentives, I assume that borrowers are subject to a constant default penalty, $\delta > 0$. While it may be argued that the penalty depends on r and future expected effort, my analysis does not depend on the form of δ, but simply on the fact that default is not costless to the borrower.

Finally, I do not consider adverse selection as in Ghatak (1999) and van Tassel (1999), and I abstract away from strategic default considerations (as in Besley and Coate, 1995), by assuming borrowers will always repay their loans if they have the funds to do so. These assumptions are consistent with the setup of the experiment, which only considers moral hazard in the sense of effort diversion.

2.2 Individual lending under the basic model

To establish a baseline, consider first the case of self-financing. The agent's expected payoff, less the disutility of effort, is then:

$$\mathbb{E}\, \pi_i(e_i) = e_i \bar{X} - \frac{1}{2}\gamma e^2 \tag{1}$$

To make the problem interesting, I assume that the disutility of effort is sufficiently large to ensure an interior solution. In the case of self-financing, this only requires that $\gamma > X$; however, under a loan contract, I must impose the following stronger assumption:

$$\gamma > \bar{X} + \delta \tag{2}$$

Moreover, I assume that the agent chooses to undertake the project instead of opting for the subsistence wage. Given these assumptions, optimal effort can trivially be shown to equal $e^*_{i,SF} = \frac{X}{\gamma}$

Now, consider the case of an individual liability loan contract, wherein the agent must borrow the full investment amount from the lender in order to finance the project. Moreover, the borrower is only responsible for repaying her own loan, i.e. there is no joint liability. The agent's optimization problem can be written as follows:

$$\begin{aligned} &\max_{0 \le e_i \le 1} \quad \mathbb{E}\,\pi_i(e_i|r,C) = e_i(\bar{X} - r) + (1 - e_i)(-C - \delta) - \tfrac{1}{2}\gamma e_i^2 \\ &\text{subject to:} \\ &\qquad\qquad \mathbb{E}\,\pi_i(e_i|r,C) - \omega \ge 0 \end{aligned} \tag{3}$$

Given assumption 2, and assuming for a moment that the participation constraint holds, the level of effort which maximizes expected income is:

$$e^*_{i,IL} = \frac{((X - (r - C) + \delta))}{\gamma} \tag{4}$$

This result is consistent with that in Ghatak and Guinnane (1999), who show that optimal effort is decreasing in the interest rate. However, it also shows that $e^*_{i,IL}$ is increasing in both the collateral requirement and in the dynamic incentive. Hence, by imposing penalties for defaulting, the bank can effectively reduce moral hazard.

Next, consider the effect on credit market participation. First, define $\widetilde{\omega}_{i,IL}) = \mathbb{E}\,\pi_i(e^*_{i,IL}|r,C)$, or the highest possible subsistence wage such that the agent still chooses to borrow. Now, using the envelope theorem, I can show that $\frac{\widetilde{\omega}_{i,IL}}{\partial C} = -(1 - e^*_i) < 0$. This finding implies that as the collateral level increases, the agent would require a lower subsistence wage to still be enticed to borrow. Hence, assuming some distribution of ω across the population, credit market participation is decreasing in the collateral level. These findings can be summarized in the following proposition:

Proposition 1. *Under individual lending with exogenous contract terms and risk neutral borrowers, an increase in the collateral requirement will:*

a) unambiguously increase the borrower's optimal level of effort, and

b) unambiguously reduce credit market participation.

2.3 Joint liability group lending under the basic model

Under the standard group lending model used by most microfinance institutions (MFIs), a set of borrowers form a group and apply for individual loans from the bank. However, instead of borrowers being liable for only their own loan, the joint liability clause in group lending specifies that all group members are jointly responsible for repaying the loan. If the group as a whole fails to repay all the individual loans, the bank will consider every member of the group to have defaulted. Moreover, an individual borrower might have to default even if she would have been able to repay under an individual liability contract. Similarly, an individual borrower who would not have been able to repay under an individual liability contract might not default under group lending since other borrowers might cover her liability in order to prevent the group from defaulting. The tradeoff between these two mechanisms and their effect on repayments are discussed in Ghatak (1999).

Here, I consider a simplified version of the joint liability model, in which a group consists of only two agents, and borrowers are randomly assigned to each other. In order words, groups are not endogenously formed as in Ghatak (1999) and van Tassel (1999). Moreover, borrowers simultaneously and non-cooperatively choose a level of effort, anticipating the level of effort that the other will choose.

I also assume that there is some level of social collateral between the borrowers. In my model, social collateral represents the disutility that a person incurs from causing another group member to cover her loan, and in real life, this disutility can take several different forms. For example, other group members may impose social sanctions on the non-paying member, such as refusing to do business with her. Other forms include shame and public humiliation. For ease of analysis, I express the social collateral as a monetary equivalent that is a linear function of the amount of money that the other group member has to cover. In particular, I assume the social collateral cost can be written as $\lambda(r - C)$. Moreover, I impose the following restriction on λ, which implies that the social humiliation of having your partner pay your loan is never negative or greater than the monetary cost of paying it yourself[1].

$$0 \leq \lambda \leq 1 \tag{5}$$

Now, consider the payoff of borrower $i = 1$ when entering into a joint liability group lending contract with borrower $i = 2$. Note that in the case of two borrowers, there are four different outcomes and thus four different payoffs for borrower 1:

1. Both borrowers have a successful project: $\pi_{1,ss} = (\bar{X} - r)$

2. Borrower 1 is succeeds, borrower 2 fails: $\pi_{1,sf} = (\bar{X} - 2r + C)$

[1]A value of $\lambda > 1$ would be theoretically possible, but unlikely in most cases, as it implies that borrowers would rather have paid the full interest amount under an unsuccessful project than to have the other group members cover the loan.

3. Borrower 1 is fails, borrower 2 succeeds: $\pi_{1,fs} = (-\lambda(r - C) - C)$

4. Both borrowers fail: $\pi_{1,ff} = (-C - \delta)$

Borrower 1's optimization problem now becomes:

$$\begin{aligned}
\max_{0 \leq e_1 \leq 1} \quad \mathbb{E}\,\pi_1(e_1|r, C, \widetilde{e}_2]_2) = \quad & e_1 \widetilde{e}_2(\bar{X} - r) \\
& + e_1(1 - \widetilde{e}_2)(\bar{X} - 2r + C) \\
& + (1 - e_1)\widetilde{e}_2(-\lambda(r - C) - C) \\
& + (1 - e_1)(1 - \widetilde{e}_2)(-C - \delta) \\
& - \tfrac{1}{2}\gamma e_1^2
\end{aligned} \tag{6}$$

subject to:

$$\mathbb{E}\,\pi_1(e_1|r, C, \widetilde{e}_2]_2) - \omega \geq 0$$

Here, $\widetilde{e}_2$ represents the effort level exerted by borrower 2. Note that joint liability is complete, that is, a borrower cannot choose to cover only a portion of her partner's loan. Whereas some models in the literature allow borrowers to choose the optimal level of joint liability (as in Ghatak (1999), van Tassel (1999), and Katzur and Lensink (2012)), the idea of all-or-nothing joint liability is consistent with practices among most MFIs.

Again, given assumption 2 and assuming both agents choose to borrow, the optimal effort for agent 1 can be written as follows:

$$e^*_{1,JL} = \frac{(\bar{X} - (2 - (1 + \lambda)\widetilde{e}_2)(r - C) + (1 - \widetilde{e}_2)\delta)}{\gamma} \tag{7}$$

Similarly, for agent 2, the optimal effort level is given by:

$$e^*_{2,JL} = \frac{(\bar{X} - (2 - (1 + \lambda)\widetilde{e}_1)(r - C) + (1 - \widetilde{e}_1)\delta)}{\gamma} \tag{8}$$

In a symmetric Nash equilibrium, where both borrowers are identical, it must be that

$$e^*_{1,JL} = e^*_{2,JL} = e_{JL} = \frac{(\bar{X} - 2(r - C) + \delta)}{(\gamma - (1 + \lambda)(r - C) + \delta)} \tag{9}$$

Note first that social collateral λ has an unambiguously positive effect on optimal effort. This is intuitive as increasing the penalty of default raises the cost of undersupplying effort for both members. Next, consider the effect of the collateral requirement on optimal effort. Computing $\frac{\partial e^*_{JL}}{\partial C}$ yields:

$$\frac{\partial e^*_{JL}}{\partial C} = \frac{2\gamma - \bar{X}(1 + \lambda) + (1 - \lambda)\delta}{(\gamma - (1 + \lambda)(r - C) + \delta)^2}$$

Given assumptions 2 and 5, it is trivial to show that $\frac{\partial e^*_{JL}}{\partial C} > 0$. Hence, the monetary collateral has an unambiguously positive effect on effort.

Moreover, to study the interaction between social collateral and monetary collateral, I calculate $\frac{\partial e^*_{JL}}{\partial C \partial \lambda}$:

$$\frac{\partial e^*_{JL}}{\partial C \partial \lambda} = \frac{-((\bar{X}+\delta)((\gamma-(1+\lambda)(r-C)+\delta))^2 + 2(\gamma-(1+\lambda)(r-C)+\delta)(r-C))}{(\gamma-(1+\lambda)(r-C)+\delta)^4} \tag{10}$$

It can be shown that $\frac{\partial e^*_{JL}}{\partial C \partial \lambda} < 0$, which implies that the effect of the monetary collateral on effort is decreasing in the level of social collateral. This suggests substitutability between social and monetary collateral.

Finally, to study the effect of collateral on participation under a joint liability contract, define $\widetilde{\omega}_{1,JL} = \mathbb{E}\,\pi_1(e^*_{1,JL}|r, C, e^*_{2,JL})$. I have:

$$\frac{\partial \widetilde{\omega}_{1,JL}}{\partial C} = (1-e^*_{JL})e^*_{JL}\lambda - (1-e^*_{JL})^2 \tag{11}$$

This result implies that the effect of collateral on participation under joint liability is ambiguous and depends on the level of social collateral among the borrowers. If $\lambda = 0$, then $\frac{\partial \widetilde{\omega}_{1,JL}}{\partial C} < 0$. It is also possible that $\frac{\partial \widetilde{\omega}_{1,JL}}{\partial C} > 0$, in particular if both λ and e^*_{JL} are high. Also note that $\frac{\partial \widetilde{\omega}_{1,JL}}{\partial C} > \frac{\widetilde{\omega}_{i,IL}}{\partial C}$, which implies that adding collateral to a joint liability contract reduces credit market participation (or perhaps even increases participation) by a lesser amount compared to adding collateral to an individual contract.

These findings can be summarized in proposition 2:

Proposition 2. *Under joint liability group lending with exogenous contract terms and risk neutral borrowers, an increase in the collateral requirement will:*

a) unambiguously increase the borrower's optimal level of effort, but:

b) the increase in optimal effort is decreasing in the level of social collateral. Moreover it will:

c) have an ambiguous effect on credit market participation, but the effect:

d) will be negative if $\lambda = 0$, and

e) may be positive for high values of λ and e^*_{JL}, and

f) any negative effect on participation will always be less than under an individual contract

2.4 Discussion of results

The results from this simple theoretical model suggest that under certain conditions, adding a collateral requirement to a joint liability group contract could simultaneously increase both effort and participation. Whereas under an individual contract, adding a collateral requirement would result in a tradeoff between increased effort and reduced participation, such a tradeoff may not be necessary under a joint liability group contract. In particular, if there is a sufficiently high level of social collateral in the group, and the probability of a successful outcome is sufficiently high, adding a monetary collateral requirement may increase the borrower's expected payoff, making her more likely to borrow. At the same time, the collateral requirement will induce higher effort, which in turn increases repayments. Hence, it is possible that a collateralized joint liability contract is optimal both for the borrower and for the lender, relative to an uncollateralized contract.

While this simple model allows me to study the basic incentive mechanisms of different contracts, it is also based on several restrictive assumptions. In particular, the results depend on the assumption of risk neutrality, which is strong, but nonetheless used in several similar theoretical papers (see for example Che, 2002, Ghatak and Guinnane, 1999, and Besley and Coate, 1995). However, by relaxing the assumption of risk neutrality and allowing for some heterogeneity in the level of risk aversion among borrowers, the problem becomes non-tractable and the results turn ambiguous. While the focus of this paper is not on solving the general model, the basic intuition behind relaxing the assumption of risk neutrality is as follows. If borrowers are risk averse, the optimal effort level under a zero collateral requirement would be lower than in the model assuming risk neutrality. However, the collateral requirement makes the bad outcome worse, which means that the incentive effect of the collateral would be even stronger for a risk averse borrower. Therefore, relaxing the assumption of risk neutrality would increase the magnitude of the effect of collateral on effort. However, at the same time, risk averse borrowers would be more likely to choose the subsistence wage, and hence, credit market participation would be lower.

In a separate paper, I use a simulation approach to extensively analyze the effect of allowing for risk aversion[2]. The focus of this paper, however, is to study the net effect on the behavior of real borrowers using a series of framed field experiments, and the basic theoretical model presented here helps provide some intuition for these results. Moreover, in contrast to the results emerging from the general theoretical model, the findings of the framed field experiment do not depend on the assumption on instrumental rationality. In that sense, the experimental approach allows me to treat this as a behavioral finance problem.

3 Experimental Design and Data

To understand the behavioral effects of adding a collateral requirement to a joint liability group contract, I conducted a framed field experiment, in which participants played a series of microfinance games. Except as described in the previous section, these games closely resemble the theoretical framework and allow me to separately identify the impact of dynamic incentives, joint liability and the collateral requirement both on selection and on effort diversion. The sample consisted of 397

[2]That paper also studies the effect of allowing for endogenous contract terms and continuous project outcomes

sunflower farmers who, at the time of the study, were members of joint liability credit groups under VisionFund Tanzania's (VFT) lending program. The games were organized in sessions, and I invited only members from the same VFT groups to join a single session. This is an important point, since it allows me to harness the social collateral that already exists within the group. Moreover, it also allows me to induce exogenous variation in social collateral as the experimental credit groups are randomly created subsets of the real-life credit groups. As will become clear in the results section, this is an important identification strategy which allows me to separately identify the decision to borrow from the effort decision in the group lending games.

The following sections describe the games and the experimental procedures in detail.

3.1 The games

In each session, the participants played a series of four consecutive games, each of which consisted of multiple rounds, where each round represents a lending cycle. Participants were told that they have access to one acre of good-quality sunflower land, but that they do not have sufficient cash to cultivate it unless they take out a loan. In each game and round, players were given the option to take a loan, which would be automatically used to purchase all the inputs required for their plot. For simplicity, the loan amount was fixed at Tsh 200,000 ($125) and the interest rate was 20%, so full repayment equals Tsh 240,000.

If the participant chose to borrow, she would be able to realize a yield at the end of the round. In order to capture all the dynamics of group lending with and without collateral, I assume three states of the world: good, poor and very poor, which corresponds to a sunflower yield of 13 bags, 5 bags or zero bags, respectively. Each bag could be sold for Tsh 40,000, so the associated revenues for each state were Tsh 520,000, Tsh 200,000, and zero, respectively. Note that full individual repayment of the loan was only possible in the good state.

Moreover, each borrower would have to choose between three levels of effort diversion. A lower level of effort diversion was associated with a higher probability of a good yield but also with a lower guaranteed income, that was private and could not be used for loan repayment. This is consistent with the idea that farmers who dedicate less time to their primary farming activities face a higher risk of crop failure as they may be less prepared for adverse events, such as drought, floods or pests. Instead, they can divert their effort towards less risky, but also less productive activities. While in reality, such activities may include anything that yields a positive utility at a low risk, including leisure or wage work, these are represented by wage employment at a local sunflower factory in my experiment.

Table 1 shows the tradeoff between success probability and fixed income for each level of effort diversion. This was phrased to the participants in terms of "farm days", and each borrower would choose either 1, 3 or 5 farm days. The realization of the project outcome for each participant was

Table 1: Tradeoff between fixed income and probability of success for different levels of effort diversion

		Probability of outcome		
Farm days	Wage income	Good	Poor	Very poor
1	Tsh 90,000	40%	30%	30%
3	Tsh 50,000	60%	20%	20%
5	Tsh -	80%	10%	10%

determined by her drawing a ball from one of three bags, each representing a different number of farm days.

The following sections describe each of the four games in detail.

3.1.1 Games 1 and 2: Individual lending

In the first two games, participants were offered individual lending contracts. In game one, there were no dynamic incentives. As such, this game presents the participants with a choice of different single-period lotteries, each representing a different tradeoff between risk and return, and can thus be used to elicit participants' risk preferences. A framed risk preference game was chosen over a standard unframed game (e.g. Holt and Laury, 2002) for various reasons. First, playing this game first would help familiarize participants with the game structure and would provide risk aversion coefficients specifically relevant to a lending context. Second, the results from this game also allows me to measure the effect of adding a dynamic incentive, as this game is essentially identical to the second game, but without dynamic incentives.

In order to eliminate any potential first-round bias, I had the participants play three rounds of the first game. In each round, the subjects first chose whether or not to borrow. Those electing to borrow would then also choose a level of effort diversion before drawing a ball from a bag to reveal the outcome. An individual i's net payoff in round t, can be expressed as:

$$\pi_{IL,i,t,s} = max(X_{s,i,t} - r, 0) + w_{i,t} \tag{12}$$

Here $X_{s,i,t}$ is the farm revenue for outcome s, r is the interest rate, and $w_{i,t}$ is the wage income. Table 2 shows the net payoff for each choice and each outcome. The last two columns also display the expected payoff and the associated CRRA risk aversion range for each choice. The CRRA upper (lower) bounds are calculated by finding the CRRA coefficient that makes the expected utility, based on the CRRA utility function[3], equal between a given choice and the choice that is only slightly less (more) risky but that yields a lower (higher) return. As expected, not borrowing

[3] $U(c) = \frac{1}{(1-\gamma)c^{(1-\gamma)}}$ if $\gamma > 0$ and $\gamma \neq 1$ and $U(c) = ln(c)$ if $\gamma = 1$, where γ is the CRRA coefficient

Table 2: Payoffs and associated CRRA ranges for various choices in the framed risk preference game

Borrow	*Farm days*	*Project Outcome*	*Probalility*	*Net Payoff*	*Expected payoff*	*CRRA Range*
No	N/A	N/A	100%	120	120	(2.52, ∞)
Yes	1	Good	40%	370	202	(0.89, 2.52)
		Poor	30%	90		
		Very poor	30%	90		
	3	Good	60%	330	218	(0.37, 0.89)
		Poor	20%	50		
		Very poor	20%	50		
	5	Good	80%	280	224	(-∞, 0.37)
		Poor	10%	0		
		Very poor	10%	0		

is the safest option, and for borrowers, riskiness is decreasing in effort diversion.

The second game was identical to the first, except that participants who defaulted in a given round were denied a loan in all remaining rounds. Moreover, participants played this game for seven rounds instead of three.

3.1.2 Games 3 and 4: Joint-liability group lending

In the joint-liability group lending games, participants were first asked to indicate whether or not they wished to borrow. Their decision applied to all rounds, so that switching between borrowing and not borrowing throughout the game was not possible. Those participants choosing to borrow were randomly assigned into groups of either two or three members, depending on the number of total borrowers[4]. Just as in the individual lending games, borrowers would privately choose a level of effort diversion. However, the joint liability clause required success borrowers to cover the loans other group members who were unable to repay their own loans. While the borrowers' choices were private information, their outcomes were revealed to the other group members. This is consistent with reality, in which community members can monitor each other's output but not the level of effort supplied.

The only difference between game 3 and 4 is the addition of a 20% collateral requirement in game 4. In particular, those electing to borrow would have to pledge TSh 40,000 in each round. In order to closely simulate the real effect of collateral, I made the participants complete a simple

[4]Allowing the group size to change was necessary in order to ensure that all borrowers were part of a group

activity at the beginning of the session, for which they could earn the required collateral amount. This was intended to give the participants a sense of ownership over these earnings, so that the prospect of losing them in the collateral game would closely resemble the risk of losing their own savings.

In all the joint liability games, the net payoff in round t for borrower i is calculated as follows:

$$\pi_{JL,i,t} = max\left(X_{s,i} - r - \frac{1}{\sum_{j=1}^{n} P_j}\sum_{j=1}^{n} max\left(r - X_{s,j} + C, 0\right), -C\right) + w_{i,t} \tag{13}$$

Where $X_{s,j}$ is the farm revenue for group member j, n is number of joint liability group members, C is the required collateral amount (zero in game 3, TSh 40,000 in game 4), and P_i is a binary indicator of partner j's ability to repay her own debt obligation ($P_i = 1$ if $X_{s,j} - r + C \geq 0$ and $P_i = 0$ otherwise).

Just like in game 2, the joint liability games had dynamic incentives. However, the group would only default if the total farm revenue of the group was insufficient to cover the group's debt obligation. Moreover, if the group defaulted, all group members would be excluded from lending in any remaining rounds and would be forced to choose the no-borrow option. To ensure that the dynamic incentives were sufficiently strong, participants played this game for seven rounds.

3.2 Experimental procedures

The experiments took place in March and April, 2014 in the rural villages near the town of Singida, Tanzania. I constructed the sample by randomly selecting among Visionfund Tanzania's established credit groups in the administrative areas of Mtinko, Kinampanda and Kisiriri. Only groups that had nine or more members were included, and if the group had more than fifteen members, I randomly chose fifteen members. Game trials were conducted with graduate students in Davis, CA, and I pre-tested the experiment with VisionFund credit groups that were not included in the final sample.

The sampled members from a single group were all invited to join an experimental session, and I conducted two sessions per day, each lasting between 3 and 3.5 hours. To give the participants ownership of the amount that might be pledged as collateral in game four, I asked them to complete a simple activity at the beginning of the session, for which they could earn Tsh 1,000. This activity consisted of separating maize from beans that had been mixed together in a cup, and those who completed it within five minutes received their winning in cash immediately. Due to the triviality of this task, everyone in the sample successfully completed it and received their TSh 1000.

After being introduced to the basic setup, the participants played the four games described above, followed by a household survey and a social networks survey. All instructions were presented in Swahili with the aid of a posterboard displaying the payoffs and probabilities associated with each choice (see Appendix A.1 for an English version of this board). At the beginning of each session, participants were provided with game sheets, on which the enumerators would record their decisions, outcomes, payoffs and default status after each round. As part of the introduction, all participants were given a chance to practice drawing balls to familiarize them with the probabilities associated with each choice. Moreover, at the beginning of each game, they would first play one non-incentivized practice round[5], before moving on to the actual game.

To ensure the anonymity of participants' effort diversion choices, I had set up three privacy stations that were each attended by an enumerator. At each station, there were four bags, one for each effort diversion choice and one for the no-borrow decision. Each of the three "borrowing bags" contained ten green, yellow and red balls, where a green ball indicates a good crop, an orange ball a poor crop and a red ball a very poor crop. The ratio of green to yellow and red balls in each bag corresponded to the probabilities listed in table 1. The no-borrow bag contained ten blank balls. A label showing the ratio of balls and the payoffs for each ball color was clearly printed next to each bag.

During the individual lending games, the enumerator would ask before each round whether the participant would like to borrow. If the participant answered affirmatively, she was asked to choose a level of effort diversion and then to draw a ball from the corresponding bag. For the joint liability group games, the participants would make their borrowing decision for the entire game. Those who elected to borrow were then randomly divided into groups of two or three, and were asked to choose a level of effort diversion in each round. In order to ensure that decisions were not affected by a preference for a short playing time, non-borrowers were asked to draw a ball from the no-borrow bag. Moreover, in the group lending games, each borrower received information about the draws of the other group members but not about their effort diversion choices.

In most of the sessions, I played the games in the order 1-4. While it might have seemed useful to randomize the order to control for any potential ordering effect, this would be difficult to implement due to the complexity of the contract features and the fact that playing the games in their natural order made it easier for participants to understand the concepts.

In order to incentivize careful game play, I paid participants in cash based on their earnings from a randomly chosen round in a randomly chosen game. The game earnings from the chosen round were divided by a factor of 40 to compute actual cash payouts. If the collateral game was chosen, and the participant had lost her collateral in the selected round, I would collect the Tsh 1,000 she earned at the beginning of the session. Total payouts, including a show-up fee of Tsh 1,000, ranged from Tsh 1,000 ($0.63) to Tsh 13,000 ($6.88), with an average payout of Tsh 5,300 ($3.32).

[5]In the second game, they played two practice rounds to make sure they understood the dynamic incentives.

4 Empirical strategy and results

4.1 Participant characteristics

Table 3 displays the descriptive statistics for the participants in the sample. The average participant is 41 years old, comes from a household of six members and owns almost 8 acres of land, of which 2.5 acres was dedicated to sunflower during the previous season. Note that most participants are literate (96%) and that the gender balance is fairly even (54% males). The use of fertilizer is quite uncommon with only 10% of the sample indicated having used fertilizer during the previous season.

The average VFT group size is 12 members, and each member borrows on average slightly less than Tsh 250,000 ($150). As many as 76% of group members are currently subject to a collateral requirement in their VFT lending group, and the average collateral amount is almost Tsh 40,000 ($25). This implies a collateral requirement of roughly 16%, which is slightly less than the actual requirement of 20% that VFT has imposed on some groups. Interestingly, a very large fraction of participants (72%) prefers a collateral requirement over no such requirement. This suggests that borrowers believe the collateral requirement will incentivize good behaviors among the other group members.

While the experimental games data are analyzed in further detail in the following sections, note that the percentage of participants who choose to borrow is much lower in the joint liability group games (games 3 and 4) than in the individual games (games 1 and 2). Moreover, the number of farm days chosen seems to increase with both the addition of the dynamic incentives, the joint liability clause and the collateral requirement. As expected, repayments are also much higher in the joint liability group games, and the highest repayment rate is observed in the group game with a collateral requirement (game 4).

4.2 Distribution of choices

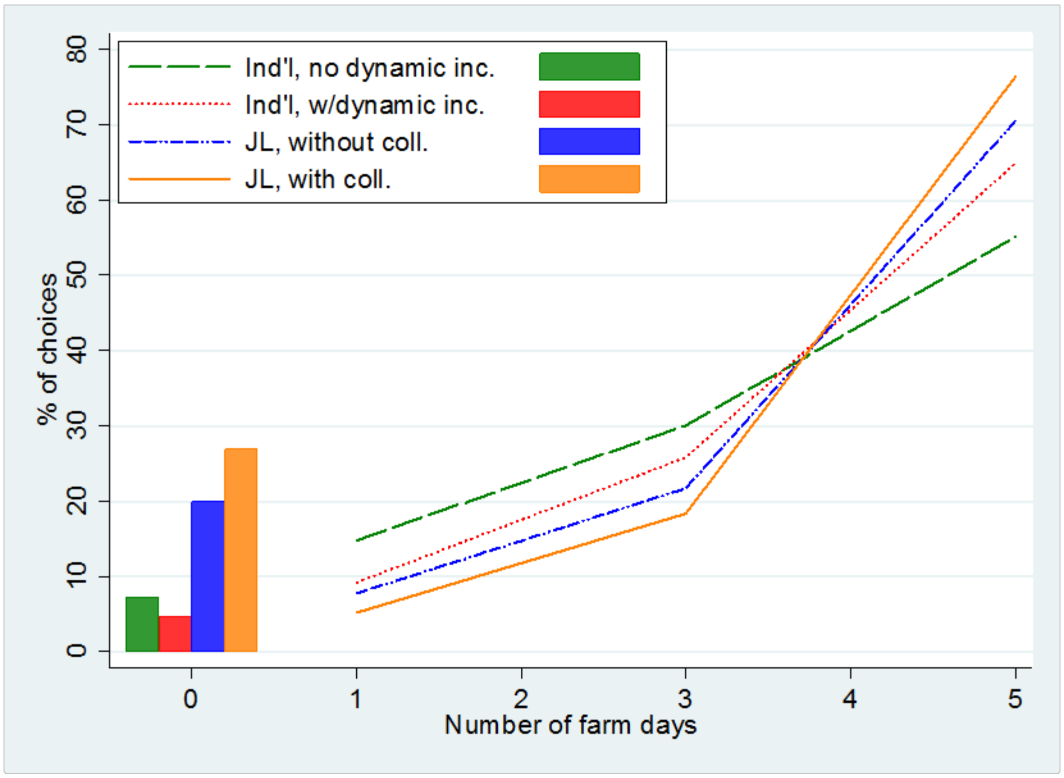
To gain some intuition, consider first the distribution of participants' choices for the different games. Figure 1 shows the percentage of participants, who chose not to borrow (coded as '0', and represented as a bar graph), and the percentage of borrowers who chose 1, 3 or 5 farm days (represented as a connected-line histogram in the same plot), in each game. The green dashed line and leftmost bar represent the individual borrowing game without dynamic incentives, while the individual borrowing game with dynamic incentives is displayed as the red dotted line and second bar from the left. The joint liability group lending games, without and with the collateral requirement, are represented by the blue dash-dotted line and third bar from the left, and the orange solid line and rightmost bar, respectively.

As can be gleaned from the plot, the addition of dynamic incentives to an individual lending contract appears to reduce effort diversion among borrowers but does not seem to affect borrowing

Table 3: Summary statistics

Variable	**N**	**Mean**	**Std. Dev**
Demographics			
Age	396	41.0	10.4
Head of household	396	0.65	0.48
Male	396	0.54	0.50
Married	396	0.83	0.38
Can read and write	396	0.96	0.19
No. of HH members	394	6.03	2.45
Local leader	396	0.38	0.49
Agricultural Production			
Total acres planted	395	7.7	9.7
Total acres, sunflower	385	2.5	3.0
Fertilizer	357	0.10	0.31
Sunflower yield (kg/acre)	274	535.3	297.8
Borrowing			
No. of members in VFT group	392	12.3	2.5
Amt borrowed	391	232,647	104,131
Pledged collateral	381	0.76	0.43
Collateral amount	223	37,967	29,875
Collateral req't is positive	388	0.72	0.45
No. of season borrowed VFT	396	1.76	0.85
Apply for loan next season	377	0.97	0.17
Other borrowing	390	0.06	0.24
Experimental games			
Borrowing, game 1	915	0.89	0.31
No. farm days, game 1	818	3.81	1.47
Repayed, game 1	816	0.73	0.45
Borrowing, game 2	1039	0.86	0.34
No. farm days, game 2	898	4.11	1.31
Repayed, game 2	898	0.72	0.45
Borrowing, game 3	1871	0.77	0.42
No. farm days, game 3	1444	4.25	1.25
Repayed, game 3	1435	0.95	0.22
Borrowing, game 4	1924	0.70	0.46
No. farm days, game 4	1350	4.43	1.11
Repayed, game 4	1350	0.97	0.34

Figure 1: Connected-line histogram of participant choices in each game. The green dashed line and leftmost bar represent the individual borrowing game without dynamic incentives, while the individual borrowing game with dynamic incentives is displayed as the red dotted line and second bar from the left. The joint liability group lending games, without and with the collateral requirement, are represented by the blue dash-dotted line and third bar from the left, and the orange solid line and rightmost bar, respectively.



rates. Moreover, moving from an individual lending contract to a joint liability contract results in significant credit rationing, but does not seem to substantially affect borrowers' desired effort diversion levels. Finally, adding a collateral requirement to a joint liability group contract deters even more people from borrowing, but those who choose to borrow are more likely to pick the maximum number of farm days.

To further understand the effect of the collateral requirement on people's borrowing and effort diversion choices, consider the transition matrix of choices between game 3 and game 4 (Table 4). Again, number of farm days represents the average across all rounds and has been rounded to the nearest integer. Two immediate patterns emerge. First, those people who chose to borrow in both rounds generally increased their number of farm days under the collateralized contract. Only a small fraction of borrowers reduced their level of farm effort between game 3 and 4. Second, 35

Table 4: Transition matrix showing the percentage of participants who made the given choices (on average across all rounds, rounded to nearest integer) between game 3 and game 4

		Joint liability lending WITH collateral						
			Farm days					
		Not borrow	1	2	3	4	5	**Total**
Joint liability lending WITHOUT collateral	Not borrow	77%	2%	0%	2%	8%	11%	**62**
Farm days	1	11%	33%	11%	22%	22%	0%	**9**
	2	40%	0%	20%	20%	0%	20%	**5**
	3	17%	0%	2%	44%	27%	10%	**52**
	4	20%	0%	2%	7%	29%	43%	**56**
	5	10%	0%	0%	2%	7%	80%	**122**
	Total	**83**	**4**	**4**	**34**	**46**	**135**	**306**

out of 244 borrowers in game 3 (14%) self-select out of borrowing when the collateral requirement is added, and thus is a crude estimate of the number of people who are risk-rationed. Third, 14 out of the 62 non-borrowers in game 3 (23%) switch to borrowing under the collateralized contract. These are likely people who were concerned about the cost of joint liability, but who believed the collateral requirement would help partially offset this cost.

The next sections provide a more rigorous statistical approach to analyze the effect of the collateral requirement.

4.3 Empirical specification and results

4.3.1 Econometric model

In this section, I develop an empirical approach for estimating the effect of the collateral requirement under joint liability group lending. Since all participants played all the games, I can uniquely identify the effect of dynamic incentives, joint liability and the collateral requirement. Consider first a simple OLS model of number of farm days on dummies for the various treatments:

$$\tilde{D}_{git} = \alpha_0 + \alpha_1 DI_g + \alpha_2 JL_g + \alpha_3 C_g + \alpha_4 S_{gi} + \alpha_5 X_i + R_t + \epsilon_{git} \tag{14}$$

Here, $\tilde{D}_{git} \in 1, 3, 5$ is defined as the number of farm days chosen in game g by individual i in round t for borrowers only. DI_g is a dummy variable that equals 1 in the games with dynamic incentives (games 2, 3 and 4), JL_g is a dummy for joint liability treatment (games 3 and 4), and C_g is a dummy equaling 1 for the collateral requirement game (game 4). S_{gi} is an index of the level of social collateral in the group, as indicated by participant i in game g. It is calculated as participant i's average number of "positive" network links towards to other group members minus the number of "negative" links in game g. A "positive" link means answering "yes" to either of the first 6 questions of the social network survey, while a negative link means answering "yes" to the last question. A listing of the social networks questions can be found in Appendix A.2. Finally, X_i is a vector of individual characteristics, such as age, gender and land holdings, and R_t is a round fixed effect.

This specification has several issues. First, the number of farm days chosen is only observed for those participants choosing to borrow, which introduces a potential selection problem. In particular, I estimate $\mathbb{E}[\tilde{D}_{git}|B_{git} = 1]$ where B_{git} is a dummy variable indicating whether the person chose to borrow. One possibility would be to argue that non-borrowers essentially choose zero farm days, which would allow me to estimate the model on the full sample. However, this idea assumes that the same latent variable drives both the borrowing decision and the effort diversion decision. While this is likely to be true in the individual lending game with no dynamic incentives, it is probably a false assumption in games with dynamic incentives, joint liability or collateral. This is due to the fact that moving from borrowing with a high level of effort diversion to not borrowing is discontinuous in the probability of success. Hence, factors that are affected directly by the probability of success, such as the ability to borrow in the future, and loss of social or monetary collateral will affect the effort diversion decision differently than the borrowing decision. For example, a person with a strong sense of social responsibility may be less likely to borrow under a joint liability contract because she is concerned about imposing a cost on the other group members. However, if the same person chooses to borrow, she may be less likely to divert effort away from her farming activities as doing so will increase the chance that other members have to cover her loan repayment.

Another possibility is to correct for the potential selection bias by estimating a Heckman (1979) selection model. In particular, I estimate the following two-stage model:

$$B_{git} = \beta_0 + \beta_1 JL_g + \beta_2 C_g + \beta_3 GS_i + \beta_4 X_i + \beta_5 \hat{\gamma}_i + R_{1t} + u_{git} \quad (15)$$

$$\tilde{D}_{git} = \alpha_0 + \alpha_1 JL_g + \alpha_2 C_g + \alpha_3 S_{gi} + \alpha_4 X_i + \alpha_5 \hat{\gamma}_i + R_{2t} + \alpha_\lambda \lambda_{git} + \epsilon_{git} \quad (16)$$

where λ_{git} is the inverse mills ratio from the first stage regression. The exclusion restriction, GS_i, is a measure of the expected social collateral across all the session participants, as viewed by participant i. It is defined as in the same way as S_{gi}, except that the index is averaged across all session participants instead of just the group members in the game. Since participants only observe average social collateral in the session when making the borrowing decision while the actual social collateral is revealed once groups are formed, GSC_i should be a valid instrument. In particular, GSC_i affects the decision to borrow, but does not influence the level of effort diversion, except through the inverse mills ratio. Finally, $\hat{\gamma}$ is an estimated measure of risk aversion based on game 1. In particular, I first convert the number of farm days chosen in each round in game 1 to a level of CRRA risk aversion, using the middle point of the risk aversion range associated with each particular choice and assuming that the lower bound is $RA = 0$ and the upper bound is $RA = 3.5$. Hence, the associated levels of risk aversion for 0, 1, 3 and 5 farm days are 3, 1.705, .63 and .185, respectively. I then compute participant i's average level of risk aversion across all three rounds as:$\hat{\gamma}_i = \mathbb{E}[RA_{it}]$. This also implies that equations 15 and 16 must be estimated using data from games 2 through 4 only.

A second potential problem with specification 14 is that the effort diversion variable is not continuous but rather a discrete representation of latent effort. I therefore also estimate an ordered probit model in the second stage. While the interpretation of the coefficients is less straightforward than in a linear model, I will report the marginal effects on the probability of choosing 5 farm days.

Finally, the models presented so far assume that the error terms for the different games are drawn from the same distribution. To allow for the possibility that the error terms come from different distributions, I estimate separate models for each game, and then calculate the implied effect of the joint liability and collateral treatments. This approach has the advantage of being more flexible, but comes at a cost of less efficient estimates. In particular, I estimate:

$$B_{2it} = \beta_{2,0} + \beta_{2,1}X_i + \beta_{2,2}\hat{\gamma}_i + R_{2,1t} + u_{2it} \tag{17}$$

$$\tilde{D}_{2it} = \alpha_{2,0} + \alpha_{2,1}X_i + \alpha_{2,2}\hat{\gamma}_i + R_{2,2t} + \alpha_{2,\lambda}\lambda_{2it} + \epsilon_{2it} \tag{18}$$

for game 2, and

$$B_{git} = \beta_{g,0} + \beta_{g,1}X_i + \beta_{g,2}\hat{\gamma}_i + \beta_{g,3}GS_i + R_{g,1t} + u_{git} \tag{19}$$

$$\tilde{D}_{git} = \alpha_{g,0} + \alpha_{g,1}X_i + \alpha_{g,2}\hat{\gamma}_i + \alpha_{g,2}S_{gi} + R_{g,2t} + \alpha_{g,\lambda}\lambda_{git} + \epsilon_{git} \tag{20}$$

separately for $g \in 3, 4$. Then, to estimate the effect of adding joint liability (β_4 and α_4, on selection and farm days, respectively) and collateral, (β_5 and α_5) I compute $\beta_4 = \mathbb{E}[\hat{B}_{3it}] - \mathbb{E}[\hat{B}_{2it}]$, $\beta_5 = \mathbb{E}[\hat{B}_{4it}] - \mathbb{E}[\hat{B}_{3it}]$, $\alpha_4 = \mathbb{E}[\hat{D}_{3it}] - \mathbb{E}[\hat{D}_{2it}]$, and $\alpha_5 = \mathbb{E}[\hat{B}_{4it}] - \mathbb{E}[\hat{B}_{3it}]$ and then perform a t-test on the difference in means to test for significance.

4.3.2 Results

Table 5 shows the results of estimating equations 15 and 16 assuming that the dependent variable is either continuous or a multinomial ordered choice variable. Consider first the effect on the decision to borrow. The primary coefficient of interest is that on the collateral requirement, which is negative and significant in all three specifications, implying that a collateral requirement pushes people out of lending. This finding suggests that the risk rationing effect is stronger than the effect of reduced joint liability within groups, and may be driven by the fact that people have a

Table 5: Heckman and Heckman ordered probit regression results. Cluster robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Dep. var is farm days	Heckman [1]	Heckman [2]	Heckman Ordered Probit [3]
Joint Liability	0.0876	0.0390	-0.00870
	(0.0697)	(0.0700)	(0.0989)
Collateral Req't	0.168***	0.171***	0.199**
	(0.0541)	(0.0525)	(0.0775)
Risk Aversion	-0.530***	-0.548***	-0.595***
	(0.103)	(0.108)	(0.167)
Social Collateral Idx	0.166***	0.185***	0.254***
	(0.0549)	(0.0607)	(0.0844)
Constant	4.494***	4.383***	
	(0.0841)	(0.326)	
Rho	0.067342	.0845816	.0735642
	(.0858193)	(.0495694)	(.0513248)
Sigma	1.159181	1.148468	1.147562
	(.0357872)	(.0356506)	(.0358963)
Lambda	.0078061	.0971393	.0956234
	(.0994342)	(.0569501)	(.0613246)
First stage, dependent var. is Borrow(1/0)			
Grp Social Coll Idx	0.626**	0.423	0.396
	(0.259)	(0.265)	(0.300)
Joint Liability	-0.465***	-0.436***	-0.437***
	(0.0971)	(0.101)	(0.101)
Collateral Req't	-0.200**	-0.212**	-0.212**
	(0.0822)	(0.0849)	(0.0848)
Risk Aversion	-0.443***	-0.470***	-0.476***
	(0.0926)	(0.0939)	(0.101)
Constant	1.318***	1.618***	1.628***
	(0.150)	(0.502)	(0.502)
Ind'l covariates	NO	YES	YES
Round FEs	NO	YES	YES
Observations	4,696	4,664	4,664

strong negative aversion to losing their collateral. In particular, adding collateral to a joint liability contract reduces the probability of borrowing by between 6 and 10 percentage points, depending on the specification. As expected, the coefficient on the imputed risk aversion variable is negative and highly significant. More risk averse borrowers, i.e. those who are more likely to not borrow or to divert effort in the first game, are less likely to borrow in all the other games. Next, the coefficient on the expected social collateral of the group, which was used as the instrument in the first-stage regression, is positive but only significant in the individual fixed effects model. Hence, a higher level of perceived social collateral in the session increases the probability of borrowing. This is consistent with the idea that people are reluctant to entering into groups with people whom they either do not know or do not trust. It may well also be a manifestation of their concerns about their actual real-world credit groups. For example, a VFT credit group member who perceives the social collateral in the VFT group as being low may also have concerns about entering into a joint liability contract in the game with a subset of these members. Finally, the addition of joint liability to a contract significantly reduces the probability of borrowing. Again, this indicates that people perceive joint liability as a cost and is consistent with previous findings suggesting that joint liability contracts are prone to free-riding and collusion (Gine et al., 2009; Laffont and Rey, 2003). However, as I demonstrated above, this negative effect can be partially offset by the prospects of sufficient social collateral within the group.

Next, consider the effect on effort diversion. As predicted by the theoretical model, the coefficient of the collateral requirement is positive and significant across all specifications. In particular, the addition of a collateral requirement to a joint liability contract increases the number of farm days by .17 assuming a linear model. Not surprisingly, the effect of risk aversion is negative and highly significant, as risk averse borrowers are more likely to choose the safer borrowing options which coincide with a higher level of effort diversion. The joint liability coefficient is not significant in any of the specifications, and is slightly positive in the linear model and slightly negative in the ordered probit model. This result suggests that joint liability by itself does not incentivize great effort. Instead, the level of social collateral within the group is what determines the expected level of effort diversion that borrowers will choose, as indicated by a positive and significant coefficient on the social collateral index variable. This result is consistent both with the theoretical findings in this paper and with those in Besley and Coate (1995), who show that social collateral among group members can mitigate the negative effect of joint liability on repayments.

Finally, table 6 shows that results of estimating separate models for each game. While the standard errors are slightly higher due to the efficiency loss, the results are mainly the same, and the key coefficients are both significant and similar in magnitude.

Table 6: Regression results, separate models for each game. Cluster robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Heckman estimates, dep. var is farm days	Game 2 [1]	Game 3 [2]	Game 4 [3]	Implied cross-model par. [4]
Joint Liability				.091799***
				(.0109282)
Collateral Req't				.195412***
				(.0088029)
Risk Aversion	-0.764***	-0.513***	-0.440***	
	(0.131)	(0.133)	(0.116)	
Social Collateral Idx		0.172**	0.209***	
		(0.0827)	(0.0669)	
Constant	4.399***	4.758***	4.250***	
	(0.396)	(0.438)	(0.391)	
Rho	.1556843	.0590269	.0234309	
	(.035114)	(.0676562)	(.0924431)	
Sigma	1.216274	1.185577	1.033261	
	(.041773)	(.0419329)	(.0494775)	
Lambda	.1893548	.069981	.0242102	
	(.045132)	(.0803266)	(.0953179)	
First stage, dependent var. is Borrow(1/0)				
Grp Social Coll Idx		0.240	0.640*	
		(0.315)	(0.342)	
Risk Aversion	-0.742***	-0.460***	-0.363***	
	(0.102)	(0.119)	(0.118)	
Constant	1.997***	1.699**	0.650	
	(0.715)	(0.736)	(0.654)	
Ind'l covariates	YES	YES	YES	
Round FEs	YES	YES	YES	
Observations	1,027	1,850	1,904	

Table 7: Heckman regression results with collateral/social collateral interaction. Cluster robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Dep. var is farm days	Heckman	Heckman
	[1]	[2]
Joint Liability	0.0839	0.0404
	(0.0708)	(0.0709)
Collateral Req't	0.158**	0.161**
	(0.0681)	(0.0661)
Risk Aversion	-0.533***	-0.551***
	(0.101)	(0.107)
Social Collateral Idx	0.144*	0.166**
	(0.0786)	(0.0815)
SCI * Coll. Req't	0.0431	0.0321
	(0.0884)	(0.0883)
Constant	4.495***	4.398***
	(0.0835)	(0.316)
Rho	.0076732	.0848233*
	(.0852449)	(.0494412)
Sigma	1.159119	1.148443
	(.0357695)	(.0356401)
Lambda	.0088942	.0974148
	(.0987569)	(.056802)
First stage, dependent var. is Borrow(1/0)		
Grp Social Coll Idx	0.593**	0.386
	(0.257)	(0.263)
Joint Liability	-0.417***	-0.397***
	(0.0966)	(0.100)
Collateral Req't	-0.241***	-0.248***
	(0.0810)	(0.0837)
Risk Aversion	-0.443***	-0.470***
	(0.0921)	(0.0934)
Constant	1.330***	1.636***
	(0.149)	(0.500)
Ind'l covariates	NO	YES
Round FEs	NO	YES
Observations	4,813	4,781

4.4 Complementarities between social and monetary collateral

While social collateral and monetary collateral may separately have a positive effort on effort, it is possible that one might simply substitute for the other. For example, if transferring some of the risk back to each individual makes borrowers less concerned about having the other group members cover their loans, the full effect of the monetary collateral may not materialize. This was indeed the hypothesis suggested by the theoretical model. In particular, the model shows that the positive effect of collateral on effort decreases as the social collateral in the group grows stronger.

To test this hypothesis, I add an interaction term between the social collateral index and the collateral requirement dummy to equation (15). A negative coefficient on this interaction term would suggest that social collateral and monetary collateral are substitutes, while a positive sign would indicate that there are complementarities between the two.

Table 7 shows the results of estimating equations 15 and16 with this interaction term. Contrary to the predictions of the theoretical model, the coefficient on the interaction term is positive, although not significantly different from zero. This surprising result suggests that monetary collateral does not crowd out social collateral but may instead complement it. One possible explanation for this result is that the disutility borrowers derive from having other group members cover their loans is nonlinear in the amount covered. In particular, simply the idea that someone else in my group would have to repay part of my loan, regardless of the amount, is a sufficient incentive for me to divert less effort.

4.5 Effects on repayments

While the effects of collateral and joint liability on effort diversion are interesting from a theoretical perspective, these numbers are less useful to microfinance practitioners. Lenders are mostly concerned with repayments and may be deterred from lending altogether if expected defaults are sufficiently high. Moreover, increasing repayment rates could also help reduce interest rates in the long run, especially if banks operate in a competitive environment. This, in turn, would increase expected incomes for borrowers and could enhance credit market participation.

To empirically test the effect of a collateral requirement on repayments, I estimate the following set of equations, where R_{git} is a dummy indicating loan repayment for individual i in game g and round t.

$$B_{git} = \beta_0 + \beta_1 JL_g + \beta_2 C_g + \beta_3 GS_i + \beta_4 X_i + \beta_5 \hat{\gamma}_i + R_{1t} + u_{git} \tag{21}$$

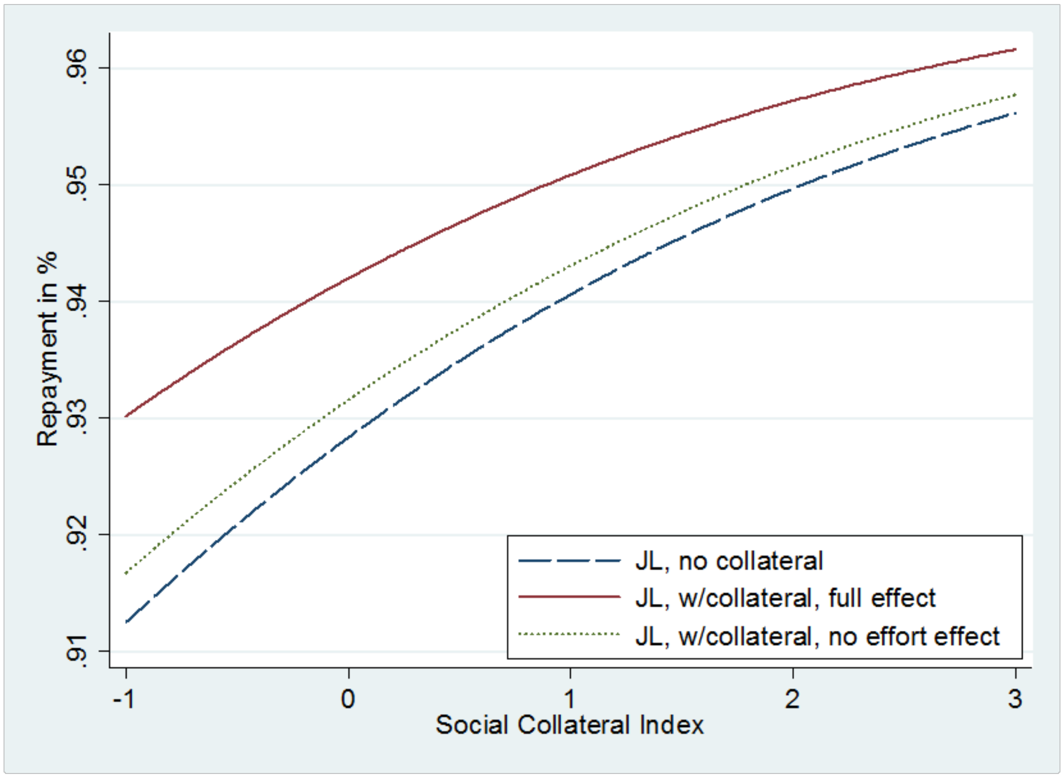
$$R_{git} = \alpha_0 + \alpha_1 JL_g + \alpha_2 C_g + \alpha_3 S_{gi} + \alpha_4 X_i + \alpha_5 \hat{\gamma}_i + R_{2t} + \alpha_\lambda \lambda_{git} + \epsilon_{git} \tag{22}$$

Table 8 shows the results of estimating this model assuming a probit structure. As expected,

Table 8: Heckman regression, effects on repayments. Cluster robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Dep. var is repayments(1/0)	Heckman Probit [1]	Heckman Probit [2]
Joint Liability	1.054***	0.998***
	(0.0860)	(0.127)
Collateral Req't	0.116	0.114
	(0.0935)	(0.118)
Risk Aversion	-0.0608	-0.0716
	(0.0952)	(0.154)
Social Collateral Idx	-0.0435	-0.0401
	(0.0636)	(0.0636)
Constant	0.650***	0.343
	(0.0693)	(0.217)
Rho	-.0761448	.0368214
	(.4220456)	(.6903516)
First stage, dependent var. is Borrow(1/0)		
Grp Social Coll Idx	0.577**	0.374
	(0.251)	(0.265)
Joint Liability	-0.422***	-0.401***
	(0.0967)	(0.101)
Collateral Req't	-0.236***	-0.240***
	(0.0807)	(0.0832)
Risk Aversion	-0.447***	-0.474***
	(0.0920)	(0.0945)
Constant	1.340***	1.672***
	(0.145)	(0.506)
Ind'l covariates	NO	YES
Round FEs	NO	YES
Observations	4,804	4,772

Figure 2: Simulated repayment rates based on estimates from ordered probit model results from table 5



joint liability has a large, positive effect on repayments; however, neither the collateral requirement nor the level of social collateral has statistically significant coefficients. While this may seem surprising given the previous findings, recall that in the current experimental setup, repaying a loan is not a choice but rather an indirect consequence of effort diversion and contract features. In particular, repayments are determined by the random draws of each group member and by the presence of joint liability or a collateral requirement. Although individuals can affect the probably of default through their effort diversion choices, the realized repayments will be a noisier signal and the coefficients on the covariates will have larger standard errors. However, given the estimates from the effort diversion model and knowledge of the contract features for each game, it is possible to simulate expected repayment rates.

Figure 2shows how expected repayments vary with the level of social collateral in the group for a joint liability contract without collateral (blue dashed line) and with collateral (red solid line). This graph makes it clear that the collateral requirement indeed increases repayments, and that order of magnitude is roughly one to two percentage points. While this may seem small, it could potentially have large impacts on an MFI's portfolio at risk. For example, a one-percentage point increase in repayment rates could reduce the portfolio at risk by as much as 20% if repayment rates are currently around 95%.

It is further possible to decompose the total effect of a collateral requirement into a "contract effect" and an "incentive effect". The "contract effect" represents the direct impact on repayments due to the transfer of a portion of the liability from the lender to the borrower, but given the same level of effort. This effect is represented by the green dotted line, which shows that only a slightly larger fraction of groups are able to repay as a direct consequence of having a "collateral cushion". The difference between the red solid line and the green dotted line is the "incentive effect", which represents the increase in repayments due to higher induced effort. As is clear from the graph, the incentive effect largely accounts for the increase in repayments due to a collateral requirement.

5 Conclusion

Joint liability group lending has been viewed as a solution to several problems in microfinance, including high monitoring costs, moral hazard and adverse selection. Yet, empirical evidence has failed to demonstrate a clear advantage of group lending contracts relative to individual contracts. In this paper, I propose an alternative contract design which aims to combine the incentive effects of an individual contract with the social collateral and insurance effects of a joint liability contract. In particular, I demonstrate both by the help of a theoretical model and the use the data from a framed field experiment that adding a modest collateral requirement to a joint liability group lending contract reduces effort diversion among borrowers and helps increase repayments without compromising the effect of the social collateral in the group. However, such a requirement also results in increased risk rationing, as for some people, the risk of losing their collateral outweighs the potential reduction in joint liability cost of borrowing.

A collateral requirement in group lending is not a new idea. Microfinance lenders commonly ask borrowers to pledge personal belongings or land as collateral, and some, including VisionFund Tanzania, require that borrowers post a modest (10-20%) monetary savings collateral in order to qualify for a loan. Despite this, no research has studied the effect of such a collateral requirement in a group lending context. While the effect of a collateral requirement is individual lending is straightforward, it is far more complex under group lending due to the effect on the cost of joint liability and its possible interaction with social collateral. To my knowledge, this is the first paper to analyze the effect of collateral in a group lending context.

If true, the findings of this paper may have important implications both for social welfare and for microfinance practitioners. Since greater effort is associated with higher expected returns for borrowers and lower default rates for the lender, a full-effort equilibrium is optimal both from a social perspective and from the bank's standpoint. Although this is a result of the experimental setup, it is also likely to be the case in a real-world lending environment, as farming is considered a high-risk high-return activity. Hence, the reduction in effort diversion due to the collateral requirement is likely to have a positive effect on social welfare. My results thus suggest that MFIs should consider introducing a modest savings collateral requirement is areas where people can afford to do so and in cases where the MFI is facing capacity constraints. In areas where people are too poor to post collateral, I would expect a collateral requirement to result in a modest increase in rationing.

Finally, while these results hold in a framed field experiment, the external validity of these results has yet to be confirmed. Hence, further research should focus on how to test whether my hypotheses hold true in a real micro-finance setting. This may be done for example through a randomized control trial.

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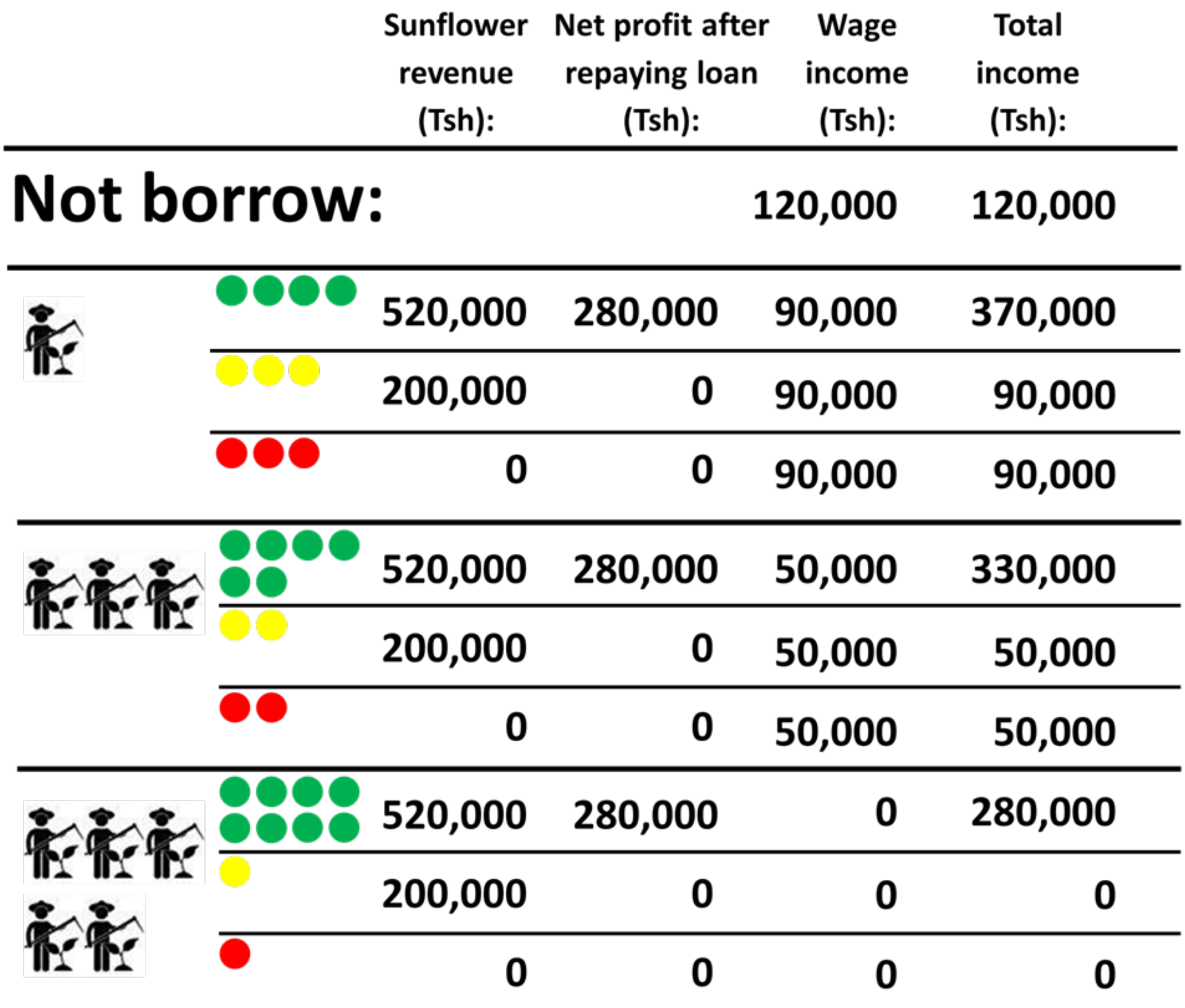
Appendix A.1: Posterboard



	Sunflower revenue (Tsh):	Net profit after repaying loan (Tsh):	Wage income (Tsh):	Total income (Tsh):
Not borrow:			120,000	120,000
	520,000	280,000	90,000	370,000
	200,000	0	90,000	90,000
	0	0	90,000	90,000
	520,000	280,000	50,000	330,000
	200,000	0	50,000	50,000
	0	0	50,000	50,000
	520,000	280,000	0	280,000
	200,000	0	0	0
	0	0	0	0

Appendix A.2: Social networks questions

1. Are any of these people in your closest family (spouse, children, parents)?
2. Are any of these people a close relative (aunt/uncle, cousin, niese/nephew)?
3. Which of these people do you consider to be your close friends?
4. Which of these people have you spoken to in the past week (except for today)?
5. Which of these people would you feel comfortable leaving your child with?

6. Which of these people did you NOT know well before joining the credit group?