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Adverse Selection and Moral Hazard in Joint-Liability Loan Contracts: Evidence from an Artefactual Field Experiment

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We design an artefactual field experiment to study the relationship between joint-liability lending and adverse selection, moral hazard and risk preferences. While theories concerning joint-liability lending have highlighted its ability to mitigate adverse selection in credit transactions, our experimental results indicate that joint-liability lending may actually induce problems of adverse selection. The results of our experiment, carried on in partnership with a Bolivian microlender, show that borrowers exogenously endowed with a risky project are disproportionately likely to choose jointly-liability contracts over individually-liable contracts. This behavior does not appear to be motivated by risk-diversification, but rather by free-riding, as these subjects disproportionally switch from safe to risky projects when exogenously given a joint-liability contract instead of an individual contract. Thus the results of our experiment offer a possible explanation why joint liability loans have

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diminished in popularity in recent years among both borrowers and microfinance lenders.

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1 Introduction

Group lending, or joint-liability lending, is widely used by microfinance lenders to provide microfinance loans to borrowers in developing countries. In a joint-liability lending contract, all members of a borrowing group are jointly liable for the loan granted to each group member. Join-liability lending imbeds a credit transaction in the context of the social network among group members. When individual default would pose a threat to social ties, borrowers have a strong incentive to repay loans. In this way, group lending may be able to replace or reduce the physical capital often used as collateral by harnessing the social capital that exists within traditional societies (Wydick, 1999). In cases where microfinance lenders are able to offer loan terms that are attractive relative to alternative sources of credit, these incentives for repayment are often sufficient to induce nearly 100-percent repayment rates for many lenders.

A number of theories have been proposed seeking to explain why joint-liability lending is able to generate high repayment rates. Some have argued for the self-selection of borrowing groups based on localized information to reduce adverse selection problems (Van Tassel, 1999; Ghatak, 1999). Other theories posit that peer monitoring between jointly liable borrowing group members mitigates the different aspects of moral hazard endemic to credit transactions (Stiglitz, 1990; Banerjee, Besley, and Guinnane, 1994; Wydick, 2001). Joint-liability lending may also allow for risk diversification between group members (Sadoulet, 2000), of potential advantage both to the lender and borrowers. Still other theories contend that joint-liability lending harnesses existing social capital in tightly-knit societies when borrowers have other important relational ties that extend outside of the lending contract (Floro and Yotopolous, 1991; Besley and Coate, 1995). In this way, many believe that group lending allows the poor credit access by substituting social capital for physical capital.

Despite the many celebrated facets of joint-liability lending, in recent years there has been a shift among microfinance lenders from joint-liability loans towards individual liability loans (Giné and Karlan, 2010). As this has occurred, microfinance lenders have often continued to integrate clients into their program in groups to preserve the economies of scale associated with group lending, while dropping the requirement of joint liability. But while the structure of group lending has often remained in place, the trend away from joint-liability loans has occurred across the globe, and included some of the most well-known microlenders, including the Grameen Bank of Bangladesh and BancoSol of Bolivia. As the market for microfinance has become more competitive, the movement away from joint liability loans has been driven by the need to mitigate some of the features of microfinance contracts that have proven unattractive to clients. These negative aspects associated with joint-liability lending include the added costs to borrowers of organizing borrowing groups and borrowing group meetings in order to gain credit access, tensions among group members that arise due to the peer pressure associated with joint liability, the intrusion of peer monitoring, problems of free-riding and opportunism by dishonest borrowers against honest ones, and by riskier borrowers against safer ones.

There are formidable statistical complexities involved with trying to isolate the respective advantages and disadvantages of joint-liability loans in a purely observational setting. Real-world issues of endogeneity and self-selection at multiple levels have made rigorous analyses of the effects of joint-liability lending difficult. As a result, recent work has used a variety of experimental methods to understand the relative merits of joint versus individual liability, including laboratory experiments (Abbink et al. 2006), artefactual field experiments (experiments using real-world subjects in a laboratory setting--Karlan, 2005; Giné et al. 2010; Fischer 2010; Cassar et al. 2007; Barr and Genicot (2008), Cassar and Wydick, 2010), and randomized field experiments (Giné and Karlan, 2010). In particular, our study is closely related to Giné et al. (2010) and Fischer (2010) in the analysis of the dynamics underlying joint-liability. One of the main results of the work of Giné et al. (2010) on microfinance borrowers in Peru is that group lending increases risk-taking, although this effect is mitigated in self-selected groups. Along the same line, Fischer's experiment with Indian microfinance borrowers suggests that, under joint liability with limited information (that is, borrowers only know the final outcome of their partners' project), risk-tolerant individuals are more likely to choose riskier project, as they rely on their partners in case of default.

In line with the cited literature, the research we present in this paper tests the causal relationship between joint-liability lending and moral hazard, adverse selection, and free riding in an experimental setting. We use an artefactual field experiment on a pool of 200 Bolivian subjects involved in either formal or informal microfinance.[2] We implemented four treatments: in two of the treatments, subjects were exogenously given either a relatively safe (TS) or a risky (TR) investment, in random order, and asked to choose between an individual or a joint-liability loan contract. In the other two treatments, the same subjects were assigned an individual (TI) or group (TG) (joint-liability) loan, and then asked to choose between a relatively safe investment and a risky (but potentially high yielding) investment. Each subject participated in all four treatments, which were administered in random order. In addition, each subject participated in a risk aversion elicitation task, so we could get an estimate of each subject risk preferences. This within-subjects design allows us to categorize borrowers and to understand more fully the motives behind their actions.

Comparing the first two treatments, we can get an estimate of adverse selection: whether borrowers are more likely to choose a joint-liability lending contract when endowed with a risky project. Similarly, comparing the second two, we can get an estimate of moral hazard: whether under joint liability subjects are more likely to choose investments that have a higher probability of default than they would take under individual liability.

The experiment is designed as a series of one-shot games. The experimental setting allows us to disentangle the key determinants of investment choices, allowing us to compare behavior under joint-liability to the one under individual liability. By keeping some of the variables exogenous within the microfinance framework (among all, the projects' probability of success), we are able to control

[2] In our sample, 83% of our subjects were current microfinance borrowers and 17% of whom participated in rotating savings and credit associations (ROSCAS).

for strategic default. While in real microfinance experiences monitoring and dynamic incentives play an important role, here we want to focus on just one specific aspect, *ex-ante* moral hazard, so we control for them by keeping them constant across treatments (no monitoring and no repetition).

Moreover, having one observation per subject for all four treatments allows us to take this analysis one step further. If subjects are more likely to choose a joint-liability contract when they are endowed with a risky project (and we find that they do), it could be for two reasons, which are important to distinguish. The joint-liability contract may be chosen by subjects with risky loans in order to diversify this risk. Conversely, subjects with a risky project may choose the joint-liability loan in order to free-ride on the intra-group insurance provided by the group, since group defaults and not individual defaults are punished by the lender under joint liability. Through our experimental design, we can therefore ascertain whether a statistically significant fraction of the switch into joint-liability loans by subjects with risky projects was made up of subjects who switched from safe to risky projects when given individual and joint-liability contracts respectively. These subjects we identify as free-riders.

In summary, our results show that joint-liability lending appears to attract a riskier pool of investments than individual lending. When individuals are endowed with a risky project (instead of a safer project), the percentage of those who prefer a joint-liability contract to an individual contract nearly doubles from 31% to 59%. Secondly, we find that this movement of risky projects into joint-liability loans is significantly more likely to occur among subjects who switched from safe to risky investments when moving from individual to joint liability. These subjects thus appear to have motives of free-riding rather than risk-diversification since they choose the risky project only under joint liability. In this respect, our results show that some of the potentially beneficial properties of joint-liability lending are counteracted at least partially by creating a context for free-riding. This may help explain why, in practice, most microfinance clients appear to prefer individual-liability contracts. As the competition between microfinance lenders over potential clients grows, lenders respond by moving away from joint-liability and toward individual liability loans.

The remainder of the paper proceeds as follows. Section 2 describes the protocol and the design of our experiment. Section 3 presents the results. These findings are further analyzed in the concluding remarks of Section 4. Theoretical predictions linking individual risk aversion with contract choice is provided in the Appendix. The experimental instructions are available on the web.[3]

2 Experimental Design

Our artefactual field experiment consists of four treatments and a risk elicitation task administered in random order (except for the risk task, which was always last) to each one of our 200 experimental subjects (two subjects couldn't stay for the duration, so we drop them from the analysis). The payoffs from the experiments were displayed in experimental bolivianos converted at rate of 100 exp. bolivianos per actual boliviano. This was done so that we could use integer numbers in the experiment to make it easier for subjects. The subjects were informed about this conversion rate at the beginning and were reminded of this through the session.

In general, under all four treatment conditions, each subject-borrower was given 500 exp. bolivianos, which would serve later as partial collateral on loans of 1000 exp. bolivianos. The loan subsequently had to be repaid at 20 percent interest for a total repayment of 1200 exp. bolivianos. In a joint-liability contract these conditions would create a group obligation with a principal of 5000 exp. bolivianos and a repayment of 6000 exp. bolivianos. For the different treatments, each subject had to decide on either the type of *project* or the type of *contract* under which they would invest their "loans." Depending on their own decisions and on chance, subjects could earn between 0 to 43 real bolivianos (USD $0 to $6) in addition to the 30 real bolivianos given as a show-up fee. To ensure saliency, actual payoffs were calibrated so that average earnings corresponded to about a one day labor wage.

The first two treatments, Treatment Safe (or TS for short) and Treatment Risky (or TR) are developed to test for the presence of adverse selection. In our study, adverse selection occurs if borrowers are more likely to choose a joint-liability-lending contract when endowed with a riskier project than when endowed with a

[3] http://sites.google.com/site/cassar

safer one. Comparing the behavior from the same subject given both TS and TR allows us to understand if different levels of preexisting risk impact the choice for joint liability.[4]

Under TS, the subjects were endowed with a relatively *safe* project that generated either a profit of 3000 experimental bolivianos in the positive state with 5/6 probability, or zero profit in the negative state with probability 1/6. Under TR, the subjects were endowed with a relatively *risky* project that, if successful, resulted in a higher profit of 5000 experimental bolivianos with a probability of success of only ½, and a corresponding ½ probability of zero profit in the negative state. After seeing their type of project, the subjects were then asked whether they preferred an individual or a joint-liability contract.

The success (or failure) of the investments was determined randomly with a roll of a six-faced die after the subjects had made their contract decisions, and only for the task randomly selected for payment. For joint-liability contracts, group size was set at five members. If less than five subjects opted for the joint-liability contract, the project success or failure for the missing subjects was generated by computer.

Our experimental design allows us to test for adverse selection under joint liability. Adverse selection is given by the propensity for subjects to choose an individual-liability contract when endowed with a safer project, but a joint-liability contract when endowed with a riskier one.

The second two treatments, Treatment Individual (TI) and Treatment Group (TG), test for moral hazard. Under TI, each subject was given an individual-liability contract, while under TG the subject was given a joint-liability contract. In either case, the subject had to choose between the risky project and the relatively safe one.

Under TG, since the *project* decision was made at individual level and subjects' choices were not disclosed to the others, groups could be made up of all possible combinations of *safe* and *risky* projects where $n_i = 5$, with $i = \{s, r\}$. In particular, the *risky* project (which had the same expected value as the *safe* project) influenced group repayment in two contrasting ways: First, a higher share of risky projects in the group implied a higher probability of group loan default and the resulting need for collateral seizure. However, if only one borrower's project succeeded, the

[4] While in practice microfinance loan risk is unlikely to originate from intentional investment in risky projects *per se*, imposing the structure of risky versus safe project in an experimental setting captures important issues related to adverse selection and moral hazard in credit transactions.

collateral of the rest of the group would be spared only if the uniquely successful borrower had undertaken a risky project.

Moral hazard arises in our study if subjects are more likely to choose investments that have a higher probability of default under joint liability than they would undertake under individual liability. Again, since our experimental design yields observations for each subject under both TI and TG, it provides a test for moral hazard in joint-liability lending: the added propensity for subjects to choose a risky project when given the joint-liability contract relative their choice under individual lending.

The final part of the experiment consists of a risk elicitation task to estimate the risk preferences of each individual, which serves as an important control in our empirical estimations. Each experimental session was then followed by a survey designed to collect individual and group-level characteristics.

One objection to our setup could be that our experiment is not able to incorporate many aspects of real-world microfinance lending such as dynamic incentives and information dynamics between borrowing group members. Our treatments are purposefully one-shot games. But we choose instead to incorporate the elements of group lending that are most germane to our focus of study: whether joint liability increases adverse selection and moral hazard in microfinance lending.

2.1 Experimental Protocol

Each session consisted of either 10 or 15 subjects. To ensure that the subjects understood the procedure, the experimenters read the instructions aloud with the help of visual aids. Afterward, the subjects practiced three directed test runs (to avoid uncontrolled framing and instructional cuing) for each individual treatment exploring possible outcomes. After each trial run, subjects were asked questions to assess their understanding of the experimental procedure. If doubts remained about subject comprehension, the experimenters continued re-reading the instructions and administering practice runs. Moreover, in order to facilitate subjects' understanding of the tasks, along with the instructions in each treatment we provided visual aids displaying the current payoffs. A total of 17 sessions were conducted between July and August 2009. Sessions were run with the support of a mobile lab device.[5]

Our within-subject experimental design requires each subject to participate in all treatments. While increasing the power of the tests, this may introduce sequencing effects and dependence across treatments. For this reason, the final payments were based on only one randomly chosen task.[6] In addition, for the group tasks individual decisions were never disclosed to other subjects unless that task was the one chosen for payment. For the same purpose of avoiding dependence across treatments, the resolution of uncertainty--the actual rolling the die to determine if an individual project was successful--was left to the very end, and only for the task randomly selected for payment.

2.1.1 Protocol for Adverse Selection Treatments

For each of the adverse selection treatments, TS and TR, each subject had to choose an *individual-liability* contract or a *joint-liability* contract under which to place their loan. Earnings for these two treatments depended on the type of contract and on the project's success. With the TS or TR treatment under an individual contract, the investment's gross profits were 3000 or 5000 exp. bolivianos, respectively, if the project was successful. If a subject opted for a joint-liability contract, her payoff depended on the number of successful projects within her group, including her own. Table 1 illustrates the possible outcomes for each treatment. For example, if a subject were to choose a joint-liability contract with TR and her investment was successful, her gross profit would be 5000 exp. bolivianos. However, since she has chosen a joint-liability group contract, her final earnings would depend on the number of other successful projects in the group.[7] If all group members had successful projects, the subject's payoff would remain unchanged. But if any of the other projects were unsuccessful, her payoff would then be reduced through her joint-liability obligations.

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[5] The mobile lab processed subjects' choices and stored the data in excel format.

[6] We assigned to every task a number and we put as many slips of paper – each with a number corresponding to one task – as the number of played games in a bag. At the end of the experiment, one subject was randomly selected to extract a slip of paper from the bag and read aloud the number on it. We thus proceeded with the payment of the final outcomes of the corresponding treatment.

[7] To maintain payoffs based on borrowing groups of five, when less than five subjects chose the joint-liability contract, the project success or failure for the missing subjects was generated by computer using the appropriate probabilities (since the riskiness of the project was exogenously given).

Table 1: Adverse Selection Treatment Conditions (Probabilities at the Individual Level)

Contract Choice	Gross Profit	Event Probability	# Successful Projects in Group	Net Profit
TS Exogenous Condition: Safe project				
Individual	3000 Bs.	5/6		2,300 Bs.=500+3,000-1,200
	0 Bs.	1/6		0 Bs.
Group	3000 Bs.	5/6	5	2,300 Bs.=500+3,000-1,200
			4	2,000 Bs.=500+3,000-1,500
			3	1,500 Bs.=500+3,000-2,000
			2	500 Bs.=500+3,000-3,000
			1	0 Bs.
	0 Bs.	1/6	4	500 Bs.
			3	500 Bs.
			2	500 Bs.
			1	0 Bs.
			0	0 Bs.
TR Exogenous Condition: Risky Project				
Contract Choice	Gross Profit	Event Probability	# Successful Projects in Group	Net Profit
Individual	5000 Bs.	5/6		4,300 Bs.=500+5,000-1,200
	0 Bs.	1/6		0 Bs.
Group	5000 Bs.	5/6	5	4,300 Bs.=500+5,000-1,200
			4	4,000 Bs.=500+5,000-1,500
			3	3,500 Bs.=500+5,000-2,000
			2	2,500 Bs.=500+5,000-3,000
			1	300 Bs.=500+5,000-5,200
	0 Bs.	1/6	4	500 Bs.
			3	500 Bs.
			2	500 Bs.
			1	300 Bs.=500-(1,000/5)
			0	0 Bs.

In the case that a subject's project fails, under an individual-liability contract, she would earn zero profit, including the loss of the initial collateral of 500 exp. bolivianos. Under a joint-liability contract, however, earnings would not necessarily be zero as would be the case under an individual-liability contract. As before, the final payoff would depend on the number of successful projects within the group. With at least two successful projects, a subject would keep her 500 exp. boliviano collateral (more if additional projects were successful) and the rest of his group would repay that subject's loan. [8]

Comparing individual behavior under both treatments, we can isolate the cases of adverse selection. Adverse selection occurs when a subject chooses the individual contract when faced with a safe project (TS) but chooses the joint-liability contract when faced with higher risks (TR). Here the borrower may either be risk-pooling or disseminating the potential negative externalities of her own riskiness onto her peers. The following two treatments will help us to disentangle these two motives.

2.1.2 Protocol for Moral Hazard Treatments

The moral hazard component of the experiment consisted of randomly assigning either an *individual-liability loan* (Treatment Individual, or TI) or a *joint-liability loan* (Treatment Group, or TG) and asking the subjects to choose between a risky project or a relatively safe project, with payoffs identical to those in the adverse selection treatments: Investing in the safe project would generate a gross profit of 3000 exp. bolivianos with 5/6 probability, while investing in the risky project would generate a gross profit of 5000 exp. bolivianos with 1/2 probability. Net profit depended on whether the subject was initially given an individual or a joint-liability loan contract.

Under TI, a subject was assigned an individual loan, and risk was borne solely by the subject; the final payoff depended only on the individual choice of project and chance. If the subject chose the safe project and it was successful (5/6 probability), the final payment was 2,300 exp. bolivianos (initial 500 + gross return 3,000 – loan and interest 1,200). If the project was unsuccessful (1/6 probability), the final payment was zero. If the subject chose the risky project, with ½ probability she would receive net earnings of 4,300 (500 + 5,000 -1,200), and with ½

[8] While a subject's decision could be influenced by her expectations about the behavior of other subjects, given that our experimental design holds the subject group constant for each subject, any influences of expectations about other members are netted out in our analysis.

probability a return of zero. Under TG, the final payoff depended on the entire group's choices and the success or failure of her own project as well as the number of successful projects within the group. Again, every subject was endowed with 500 exp bolivianos to use as collateral for a 1000 bolivianos loan. Therefore, the whole group received 5000 exp bolivianos, with an overall collateral of 2500 exp bolivianos. The total amount to repay under joint-liability was 6000 bolivianos (principal plus interests). As Table 2 shows, if all 5 members succeeded (again, irrespectively of which project they had undertaken), each subject had to repay 6000/5=1200 exp bolivianos. In this case, the collateral remained untouched, and subjects had a net profit of: 500 + x_i - 1200 exp bolivianos (where x = 3000 if $i = s$ or x = 5000 if $i = r$). On the contrary, if one project in the group failed, the liability of the defaulting borrower was split among the four successful members (that is, 300 exp bolivianos each). As successful clients could still cover the extra-burden with their revenue, their collateral was also unaffected. In this case, the amount to be repaid by each borrower became: 500 + x_i - 1200 - 300 exp bolivianos (where x = 3000 if $i = s$ or x = 5000 if $i = r$).

Table 2: Moral Hazard Treatment Conditions

Project Choice	Gross Profit	Event Probability	# Successful Projects in Group	Net Profit
TI Exogenous Condition: Individual Liability Loan				
Safe	3000 Bs.	5/6		2,300 Bs.=500+3,000-1,200
	0 Bs.	1/6		0 Bs.
Risky	5000 Bs.	1/2		4,300 Bs.=500+5,000-1,200
	0 Bs.	1/2		0 Bs.
TG Exogenous Condition: Group Liability Loan				
Safe	3000 Bs.	5/6	5	2,300 Bs.=500+3,000-1,200
			4	2,000 Bs.=500+3,000-1,500
			3	1,500 Bs.=500+3,000-2,000
			2	500 Bs.=500+3,000-3,000
			1	0 Bs.
	0 Bs.	1/6	4	500 Bs.
			3	500 Bs.
			2	500 Bs.
			1	300 Bs, or 0 Bs[†]
			0	0 Bs.
Risky	5000 Bs.	1/2	5	4,300 Bs.=500+5,000-1,200
			4	4,000 Bs.=500+5,000-1,500
			3	3,500 Bs.=500+5,000-2,000
			2	2,500 Bs.=500+5,000-3,000
			1	300 Bs.=500+5,000-5,200
	0 Bs.	1/2	4	500 Bs.
			3	500 Bs.
			2	500 Bs.
			1	300 Bs, or 0 Bs[†]
			0	0 Bs.

[*]If successful project is risky, then 5000 Bs return from risky project is used to pay loan + 1000 Bs from collateral leaving 500-(1,000/5) = 300 to each borrower.

The repayment rule thus functioned as described, with the successful borrowers bearing the repayment burden of the unsuccessful ones. In the case of only one successful borrower, the type of the project chosen by the successful borrower became crucial for the whole group. That is, if she had chosen the safe project, she and her partners would end up with a payoff of zero. But if she had opted for the risky project with the correspondingly higher payoff, this would mean a sacrifice of only 40% of her and her partners' collateral (200 out of 500 exp bolivianos each). In this case, everybody would receive 300 exp bolivianos. According to this repayment rule, unsuccessful borrowers would be able to keep their collateral (that is, 500 exp bolivianos) as long as at least two group members could repay. Table 2 shows the possible payoff outcomes for TI and TG respectively.

It is the contrast in subject behavior between these two treatments that allows us to identify (*ex ante*) moral hazard over investment choice, which occurs when a subject chooses the safe project when assigned an individual loan (under TI) but changes her strategy to a risky project when assigned to a group (under TG). In this case a subject imposes additional risk (with potential negative externality) on her peers, risk that she would not choose to bear in an individual loan. In the Appendix, we derive the conditions under which some agents will switch to a risky project under with joint-liability borrowing. We demonstrate that this will occur when the individual rate of risk aversion is low, the probability of success of in the good state is low, and the protection from joint-liability is high.

2.1.3 Risk Task

To elicit individual risk preferences we concluded the experiment with a risk task based on the MPL (Multiple Price List) procedure of Holt and Laury (2002). This procedure allows us to estimate a subject’s coefficient of risk aversion based on a CRRA specification of the utility function, in addition to giving us a rougher ordinal measure.

The MPL protocol consists of presenting the subjects with two different lotteries, Lottery A and Lottery B, whose payouts are constant but whose probabilities of success change from one round to the other (see Table 3). In our experiment, Lottery A offers the subjects an opportunity to gain either 2000 exp. bolivianos or 1600 exp. bolivianos. Lottery B offers a larger gain of 3850 exp. bolivianos in its high state, but only a 100-exp. boliviano gain in its low state. The actual payment received by subjects depends on two factors: (1) the lottery they have chosen for the actual round randomly selected for payment; (2) the result of the lottery. To play the lottery, we used a bag filled with 10 balls of different colors selected in the proportion corresponding to the round probabilities: Green balls represented the higher payoff in each lottery (2000 and 3850 exp. bolivianos for Lottery A and B respectively) while red balls represented the lower figure (1600 exp. bolivianos for Lottery A and 100 for B).

Table 3: Risk Aversion Elicitation Game

			Lottery A		*Lottery B*					
	Green	Red	If	If	If	If	EV	EV	Risk Av. Index	Risk Av.
Round	Balls	Balls	Green	Red	Green	Red	(A)	(B)	(if B Chosen)	Coef. Interval
1	1	9					1640	475	1	(-inf, -1.71)
2	2	8					1680	850	2	[-1.71, -0.95)
3	3	7					1720	1225	3	[-0.95, 0.49)
4	4	6					1760	1600	4	[-0.49, -0.14)
5	5	5	2000	1600	3850	100	1800	1975	5	[-0.14, 0.15)
6	6	4					1840	2350	6	[0.15, 0.41)
7	7	3					1880	2725	7	[0.41, 0.68)
8	8	2					1920	3100	8	[0.68, 0.97)
9	9	1					1960	3475	9	[0.97, 1.37)
10	10	0					2000	3850	10 (or 11 if A)	[1.37, inf)

For this last task, the subjects had to decide which one of the two lotteries they preferred, one choice for each one of ten rounds. Lottery probabilities were explained to subjects in terms of frequencies (since probability is an abstract concept known to be very difficult to understand for non-college educated subjects) and always with the help of visual aids, in our case colored balls. The frequencies of green and red balls in the bag were displayed to the players before they made their lottery-choice for each round. In round one, for example, subjects were shown that the bag from which the ball was to be drawn contained one green ball and nine red balls. In the second round, subjects saw that one green ball was added to the bag while a red one was taken away. In the third round, a third green ball was added to the bag while a red one was taken away, and so on. This pattern continued until the last round when the bag contained only 10 green balls. In this scenario, there is of course a 100% probability of getting the high prize, with all subjects expected to choose Lottery B (since 3850 bolivianos is higher than 2000 bolivianos). This last round is usually included to test for subject understanding. In our experiment, only one subject out of 200 chose Lottery A in the last round.

Depending on the round in which a subject switches from Lottery A to Lottery B, we can infer individual risk preferences. During the ten rounds, the probability of getting the high prize under both lotteries increases from 0.1 to 1, with the expected value of Lottery B increasing at a much higher rate than Lottery A. Until round four, lottery A gives a higher expected value than lottery B. From round five on, Lottery B yields a higher expected value. A subject who chooses Lottery A until round four and then switches to B would be classified as risk neutral, since he simply prefers the lottery that offers the highest expected value. Subjects who stay with Lottery A longer than five rounds display increasing levels of risk aversion. Subjects switching to Lottery B in the earlier rounds would display increasing levels of risk-loving behavior. A first estimation of risk aversion is provided by the round at which a subject switches from Lottery A to Lottery B (column 1 in Table 3) with 1 indicating the least risk aversion to 10 indicating the most risk aversion.[9] In case a subject switched back to Lottery A after having switched to Lottery B, we use the first time she switched to B as measure of her risk aversion. (Using either this first switch time or an average of switching times does not make a significant difference in our results).

[9] The only subject that never switched to Lottery B even in the last round was given a value of 11 for the risk index (indicating extreme risk aversion) and a missing value for the CRRA coefficient interval (since in this special case there are no discernible bounds).

The advantage of the MPL procedure is that we can proceed further and estimate for each subject his/her coefficient of risk aversion. Assuming a CRRA specification of the utility function $U = x^{1-r}/(1-r)$ for $r \neq 1$ or $U = ln(r)$ for r = 1, the individual risk aversion coefficient, r, is calculated by finding the r at which the expected value of Lottery A equals the expected value of Lottery B evaluated at the relevant probabilities during the round at which the subject first chooses Lottery B. Figure 3 column 11 shows the interval of the estimated risk aversion coefficients. The difference between the ordinal measure and the interval measure is that while the first one increases by intervals of equal size, the second one does not, where the level of individual risk aversion depends on the curvature of the utility function. Figure 1 offers a depiction of the results among our subjects. The mean for the risk aversion index was 5.8 (σ = 1.7). For the CRRA coefficient interval it was 0.17 (σ = 0.58) indicating that, on average, our subjects were modestly risk averse at a level consistent with most other field studies.

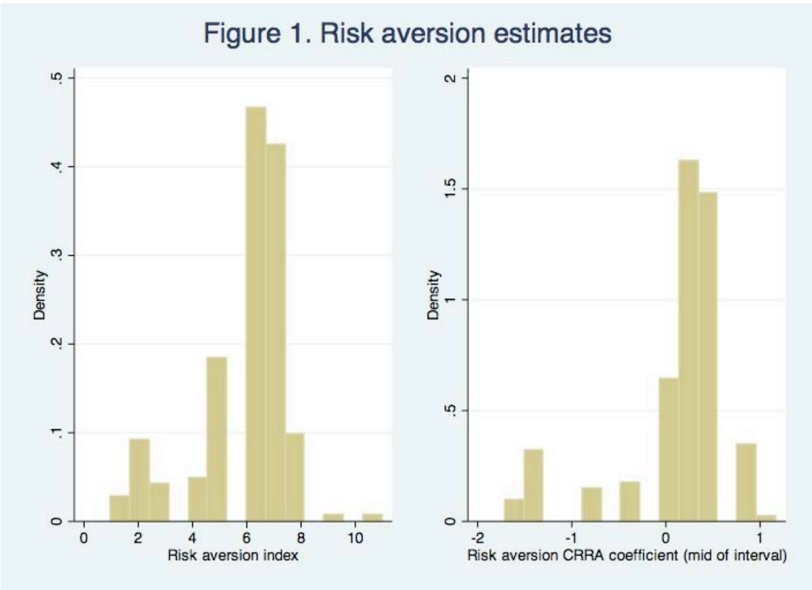

Figure 1: Risk Aversion Estimates

2.2 Survey

After the experiment, subjects were asked to respond to standard questions regarding demographics and other control variables. Two questions intended to measure social capital were included in the survey. Subjects were asked how many members in their experimental borrowing group they would be willing to (1) invite to a social gathering at their house; and (2) assist financially if they faced loan-repayment problems. An index for social capital was constructed by adding the answers to these questions with the purpose of testing whether or not social capital helps in curbing asymmetric information problems.

2.3 Subjects

The experiment was carried out in July-August 2009 among subjects living in and near La Paz, Bolivia. Estimates from 2006 indicate that microfinance institutions reached between 568,000 and 650,000 clients in Bolivia (González-Vega and Villafani-Ibarnegaray, 2007), putting Bolivia at a very high per-capita microfinance coverage relative to other countries (Christen, 2000).

Our subjects were recruited with the collaboration of PORVENIR, a local microfinance institution. The 200-subject sample was comprised primarily of actual microfinance borrowers: 83% were actual microfinance clients of PORVENIR. The remaining subjects were recruited to fit the general profile of PORVENIR microfinance borrowers. Not surprisingly, the subjects fit the standard microfinance borrower profile: average age was 37 years old, 87% were female, formal schooling levels were low (8.5 years on average) and 54% either owned or worked in a family business. Most of the experimental sessions were carried out in poor neighborhoods on the outskirts of the capital city. Average monthly household income was 1350 bolivianos (USD $190) for households that, on average, were formed by five members. Additionally, information about the borrowing groups was collected from credit officers. This information included joint-liability loan sizes (between US$145 and US$571) and group repayment performance (61% of the subjects were members of a group that had experienced some sort of difficulty with loan repayment).

3 Experimental Results

Table 4 shows the summary statistics for the variables used in this study. We begin by analyzing the four treatment conditions (TS, TR, TI and TG) individually and then jointly, by combining individual behavior under all conditions, to understand motives.

Table 4: Summary Statistics

Variable	*N*	Mean (Std. Dev.)	Description
Age	198	37.227 (12.768)	Years of age
Female	198	0.869 (0.339)	1 if female
Married	198	0.652 (0.478)	1 if married
Home Owner	198	0.561 (0.498)	1 if subject owns her house
People Per Room	198	2.899 (1.751)	Num. per sleeping room
Entrepreneur	198	0.535 (0.500)	1 if subject owned or worked in family business
Education	198	8.525 (4.142)	Years of formal education
Real Borrower	198	0.833 (0.374)	1 if subject belongs to real borrowing group
Defaulting Group	198	0.606 (0.490)	1 if credit officer judged insolvent the real group of the borrower
Social Capital	198	4.970 (2.371)	Measure of social connectedness as explained in text (1-8 index)
Risk Aversion	198	5.828 (1.686)	Ordinal index 1-10
RiskCRRAmean	198	0.169 (0.584)	Mean of the CRRA risk aversion coefficient estimated interval
Group|Safe Project	198	0.308 (0.463)	Chooses group in TS
Group|Risky Project	198	0.586 (0.494)	Chooses group in TR
Risky|Individual Loan	198	0.313 (0.465)	Chooses risky in TI
Risky|Group Loan	198	0.354 (0.479)	Chooses risky in TG
Adverse Selection	198	0.348 (0.478)	1 if sj. switches from individual in TS to group in TR
Moral Hazard	198	0.197 (0.399)	1 if sj. switches from safe in TI to risky in TG

Figure 2 and Table 5 show the proportion of subjects choosing a joint-liability contract in the adverse selection treatments (Table 5 panel *a*) and the proportion of subjects choosing the risky project in the moral hazard treatment (Table 5 panel *b*). When endowed with a safe project, 0.308 (std. error 0.033) of the subjects chose the joint-liability contract, roughly half the proportion compared to when they were endowed with a risky project (mean 0.586, std. error 0.035). A paired *t*-test in Table 5 allows us to significantly reject the null hypothesis of no difference between the two treatment conditions, in favor of an alternative hypothesis that given a risky project, the same subject would prefer a joint-liability loan to an individual one. Subject fixed-effect OLS regressions yield essentially identical results. These results thus show that it is not that the borrower is taking riskier actions when in a group, but that she is using joint-liability as a form of "insurance" when faced with riskier projects.

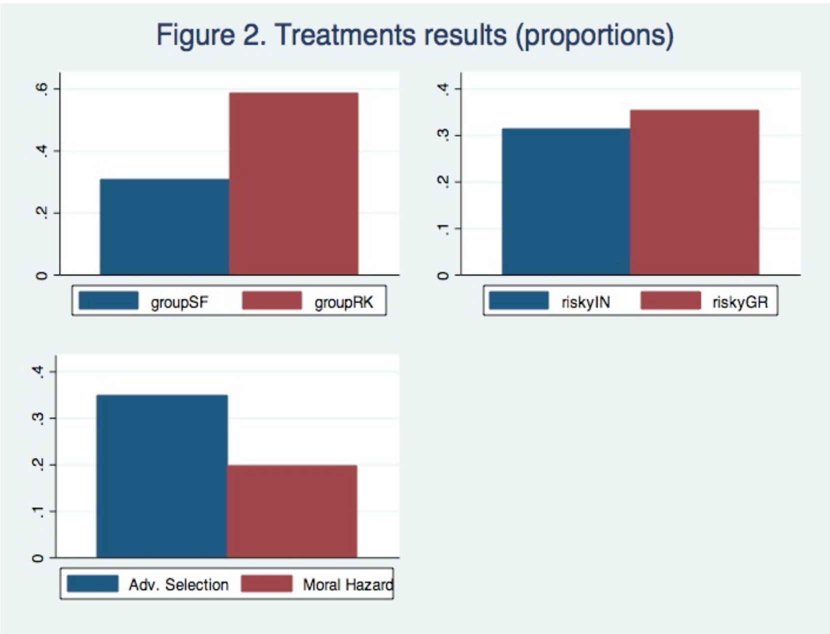

Figure 2: Treatments Results (Proportions)

Table 5: Treatments Results

a) Paired t-test

Adverse Selection Treatment Conditions	Mean	Std. Error
Group|Safe Project	0.3081	0.0329
Group|Risky Project	0.5859	0.0351
Difference	-0.2778	0.0417
Ha: mean(diff) != 0	*p*-value	0.000
Ha: mean(diff) < 0	*p*-value	0.000
Moral Hazard Treatment Conditions	Mean	Std. Dev.
Risky|Individual loan	0.3131	0.0330
Risky|Group loan	0.3535	0.0341
Difference	-0.0404	0.0423
Ha: mean(diff) != 0	*p*-value	0.3403
Ha: mean(diff) < 0	*p*-value	0.1701

b) Fixed-effects regression

Adverse Selection Treatment Conditions	Coef. (Std. Err.)	*t* (*P* >|*t*|)
Treatment (Risky Project=1)	0.2778***	6.6700
	(0.0417)	(0.000)
Moral Hazard Treatment Conditions	Coef. (Std. Err.)	*t* (*P* >|*t*|)
Treatment (Risky Project=1)	0.0404	0.9600
	(0.0423)	(0.340)

Table 6 presents the results of logit estimations for individual behavior for adverse selection, partitioned by treatments TS and TR. Each session was comprised of 15 subjects who were randomly re-matched for the group treatments. To control for within session idiosyncrasies, we cluster our standard errors at the session level (Cameron et al., 2008). To prevent subjects from drawing inferences about other subjects' behavior, we didn't reveal any information to anyone until the very end of the session and only for the treatment that was randomly selected for payment so that subjects had no basis for forming expectations about other participants' behavior (and reacting accordingly).

Table 6: Adverse Selection Treatments

Logistic Regression

Dependent Variable: Subject Chooses the Group Liability Loan	Group|Safe Project				Group|Risky Project			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Risk Aversion	0.082	0.1431			-0.0153	-0.0593		
	(0.089)	(0.132)			(0.089)	(0.079)		
RiskCRRAmean			0.3257	0.4900			0.0719	-0.0218
			(0.262)	(0.396)			(0.251)	(0.212)
Age		0.0027		0.0038		-0.0305*		-0.0293*
		(0.024)		(0.025)		(0.016)		(0.016)
Female		1.0138		0.9444		-0.4364		-0.6007
		(0.683)		(0.691)		(0.358)		(0.403)
Education		-0.1409*		-0.1415*		-0.0102		-0.0102
		(0.072)		(0.072)		(0.059)		(0.059)
Married		-0.4761*		-0.469*		0.3284		0.372
		(0.278)		(0.277)		(0.317)		(0.33)
Home Owner		-0.7304**		-0.7376**		-0.1581		-0.2141
		(0.343)		(0.342)		(0.407)		(0.416)
People Per Room		-0.0816		-0.0776		-0.0277		-0.0163
		(0.118)		(0.118)		(0.096)		(0.096)
Entrepreneur		0.2031		0.2114		0.0763		0.0864
		(0.470)		(0.466)		(0.410)		(0.409)
Social Capital		0.2262		0.2306		0.0195		0.0269
		(0.146)		(0.146)		(0.131)		(0.133)
Real Borrower		0.6802		0.6464		-0.182		-0.298
		(0.748)		(0.755)		(0.343)		(0.354)
Defaulting Group		-0.2496		-0.2444		-0.4627		-0.4639
		(0.563)		(0.566)		(0.464)		(0.47)
Cons.	-1.2905***	-1.8427	-0.8642***	-1.0716	0.4364	2.5965*	0.3471*	2.4138*
	(0.466)	(1.747)	(0.259)	(1.439)	(0.461)	(1.418)	(0.188)	(1.282)
N	198	198	197	197	198	198	197	197

Clustered standard errors at the session level in parentheses, *** p≤0.01, ** p≤0.05, * p≤0.10

In each specification the dependent variable assumes the value of one if the subject chose the joint-liability contract over the individual-liability contract, and zero otherwise. The results indicate that under either treatment, there is no significant correlation at the 10% level between choosing a joint-liability loan and our two estimates of risk preferences. When endowed with a safe project, subjects having lower level of education significantly preferred joint liability, as well as those not owing a house, and with borderline significance, females and those with a higher level of social connectivity. When endowed with a risky project, these variables become insignificant, while younger subjects chose joint liability at a significantly higher rate.

We present similar analyses for the moral hazard treatments, TI and TG, in Figure 2 and Table 5. Our tests for moral hazard indicate that the proportion of subjects choosing a risky project increases, but not significantly, when subjects are given a joint-liability contract (mean = 0.354, std. error 0.034) instead of an individual-liability contract (mean 0.313, std. error 0.033). Subject fixed-effect OLS regressions also find no significant difference in choosing the risky project.

In Table 7 we see that risk aversion has a strong influence over whether a subject chooses the risky or the safe project under either type of loan contract. The association is especially strong with the joint-liability contract. Both estimates of risk aversion produce essentially similar results. Marginal effect calculations reveal that an increase of one unit on the risk-aversion scale reduces the probability of choosing a risky project by about 4.2 percentage points. Other variables display no significant influence on choosing a risky project over a safe project in either the individual or joint-liability treatments.

Table 7: Moral Hazard Treatments

Logistic Regression Dependent Variable: Subject Chooses the Risky Project	Risky Project|Individual Loan				Risky Project|Group Loan			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Risk Aversion	-0.1604	-0.1610			-0.2001***	-0.2203***		
	(0.012)	(0.102)			(0.073)	(0.077)		
RiskCRRAmean			-0.4278	-0.4102			-0.5002***	-0.0218
			(0.304)	(0.297)			(0.251)	(0.212)
Age		0.0101		0.0103		-0.0075		-0.0293*
		(0.013)		(0.013)		(0.018)		(0.016)
Female		-0.3318		-0.3636		-0.1001		-0.6007
		(0.415)		(0.424)		(0.459)		(0.403)
Education		0.0263		0.0263		-0.0151		-0.0102
		(0.052)		(0.052)		(0.037)		(0.059)
Married		0.0809		0.0925		0.0524		0.372
		(0.315)		(0.324)		(0.296)		(0.33)
Home Owner		0.3724		0.3479		-0.1441		-0.2141
		(0.335)		(0.331)		(0.335)		(0.416)
People Per Room		0.045		0.0484		-0.1011		-0.0163
		(0.083)		(0.081)		(0.079)		(0.096)
Entrepreneur		0.1679		0.1686		-0.2179		0.0864
		(0.335)		(0.338)		(0.347)		(0.409)
Social Capital		-0.1556		-0.1554		0.1751		0.0269
		(0.096)		(0.096)		(0.101)		(0.133)
Real Borrower		-0.1421		-0.1745		-0.0053		-0.298
		(0.286)		(0.309)		(0.359)		(0.354)
Defaulting Group		-0.1076		-0.1107		0.0917		-0.4639
		(0.283)		(0.284)		(0.256)		(0.47)
Cons.	0.1575	-0.0069	-0.7155***	-0.8212	0.549	0.8478	0.3471*	2.4138*
	(0.687)	(1.101)	(0.209)	(0.960)	(0.479)	(0.934)	(0.188)	(1.282)
N	198	198	197	197	198	198	197	197

Clustered standard errors at the session level in parentheses, *** p≤0.01, ** p≤0.05, * p≤0.10

We now combine the behavior of the same subject across treatments. We categorize subjects associated with adverse selection as those who switch from an individual to joint-liability loan when the riskiness of the project exogenously increases. We categorize subjects associated with moral hazard as those who switch from a safe to a risky project when their contract exogenously changes from individual to joint liability.

Table 8 reports the results for adverse selection. We present the results in six columns: In Column 1 we only regress for risk aversion level; in Column 2 we including our experimental measure for free riding (*Moral Hazard*) and risk diversification (*Safe in TI and TG*); Column 3 displays the results with all the regressors; Columns 4, 5 and 6 repeat this pattern substituting estimated risk-aversion levels with the CRRA elicited coefficients. Again, risk preferences are not an important determinant in adverse selection.

However, Table 8 indicates that the movement from the safe project under individual liability into the risky project under joint liability appears to be driven by free-riding rather than risk diversification. Because our experiment allows for multiple observations on a single subject, behavior in one treatment helps clarify potential motives of the same subjects in other treatments. Specifically, we find that those who switched from choosing individual liability with a safe project to choosing joint liability with the risky project are disproportionately made up of subjects who switched to the risky project from the safe project when given the joint-liability contract instead of the individual contract (*Moral Hazard*). In contrast, those who chose the safe project regardless of their type of loan contract (*Safe in TI* and *TG*) are not significantly associated with switching to joint liability with the risky project. Indeed if the latter types had been associated with switching to joint liability with the risky project, we would conclude that the phenomenon would have been due to motives of risk diversification. However, because the switch to joint liability under the risky project is associated with those who switched to the risky project from the safe project when given the joint-liability contract, it would appear that the adverse selection observed in the joint liability contract is associated with free-riding behavior.

Table 8: Adverse Selection

Dependent Variable: Adverse Selection (Subject Chose (Individual|Safe) and (Group|Risky))

Logistic Regression	(1)	(2)	(3)	(4)	(5)	(6)
Risk Aversion	-0.0401	-0.0466	-0.1463			
	(0.098)	(0.092)	(0.118)			
RiskCRRAmean				-0.0694	-0.0886	-0.3182
				(0.275)	(0.261)	(0.341)
Moral Hazard		0.4648	0.9955**		0.4614	1.0029**
		(0.416)	(0.480)		(0.415)	(0.482)
Safe in TI&TG		0.2276	0.3851		0.2325	0.4103
		(0.542)	(0.577)		(0.537)	(0.570)
Age			-0.0367***			-0.0366***
			(0.013)			(0.013)
Female			-1.0259**			-1.1734**
			(0.473)			(0.505)
Education			0.1279***			0.1287***
			(0.043)			(0.044)
Married			0.607*			0.6735*
			(0.354)			(0.370)
Home Owner			0.249			0.1956
			(0.421)			(0.427)
People Per Room			0.0635			0.0739
			(0.104)			(0.102)
Entrepreneur			0.174			0.189
			(0.441)			(0.446)
Social Capital			-0.1867			-0.1797
			(0.121)			(0.124)
Real Borrower			-0.5821**			-0.6927**
			(0.246)			(0.285)
Defaulting Group			-0.4563			-0.4532
			(0.289)			(0.287)
Cons.	-0.3924	-0.562	1.3626	-0.6064***	-0.8117**	0.7009
	(0.533)	(0.626)	(1.441)	(0.154)	(0.371)	(1.138)
N	198	198	198	197	197	197

Clustered standard errors at the session level in parentheses, *** p≤0.01, ** p≤0.05, * p≤0.10

4 Summary and Conclusion

Our experimental results highlight several new insights about joint-liability lending contracts. First, theory has posited that joint-liability lending is able to mitigate problems of adverse selection through its ability to screen high-risk borrowers from the lending pool. Our research does not contradict this hypothesis because our experiment is not intended to measure the impact of borrower screening. But using the results from an artefactual experiment, we observe a strong tendency for borrowers with risky projects to prefer joint-liability loan contracts. Whether the positive effects or negative effects of joint liability contracts on adverse selection dominate in practice remains an empirical question that likely depends on the context of microlending.

Second, our experimental results suggest that the principal determinant in choosing to undertake risky investments is a low level of risk aversion, where we measure risk aversion by the Holt and Laury risk-aversion protocol. We find no significant evidence for the effect of social capital on project selection.

Third, we find evidence that the preference among borrowers with risky projects for joint-liability contracts appears to be driven by free-riding rather than a desire to diversify risk. As risky projects may offer a higher expected individual payoff to borrowers, they impose a negative externality on a borrowing group while shielding the borrower from the added risk. We find that the pool of borrowers who switch to joint liability contracts when projects move from safe to risky is disproportionally made up of the pool of borrowers who switch from safe to risky projects as lending moves from individual to joint liability.

The policy implications of these findings do little to contradict what previous research has suggested about factors driving joint-liability lending repayment rates (*e.g.* Ghatak, 1999; Wydick, 1999; Giné and Karlan, 2010). Our results both support and contrast with those of Gine et al. (2010) and Fischer (2010), supporting in the sense that each of these three papers finds that joint liability is associated with increased risk-taking, but contrasting in the sense that we model risky projects as detrimental to the interest of the lender, and where joint liability induces problems of adverse selection. In addition, our experimental results point to the pitfalls of joint-liability contracts if these mechanisms designed to mitigate asymmetric information problems in credit contracts should fail. Joint-liability lending without high levels of borrower screening is likely to attract risky loans. Peer-based screening of credit groups *ex-ante* to group formation should be encouraged and incentivized by microfinance institutions to mitigate adverse selection among joint-liability borrowers. Where these mechanisms are absent, joint-liability lending may induce more problems related to asymmetric information in credit markets than it solves.

We believe our experimental results give some insight into why microfinance borrowers appear to display a preference for individual loans and group loans *without* joint-liability. With competition in the microfinance industry intensifying and microfinance institutions being forced to offer credit contracts that are increasingly appealing to borrowers, market forces have begun to steer microfinance away from joint-liability loan contracts. We would expect joint-liability contracts to remain in place chiefly where social capital and social networks between microfinance borrowers are sufficiently strong that the adverse selection problems associated with joint-liability lending are outweighed by the ability of these social factors to mitigate them.

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Appendix

A Conditions for Borrowers to Choose Risky Projects under Group Lending

Our model is comprised of agents with varying degree of risk aversion who must choose between relatively safe and risky investment projects. The "safe" project yields $\bar{R}$ with certainty, while the "risky" project yields R with probability p or 0 with probability $1-p$. Assume that the risky project has the same expected return of the safe project, that is:

$$\bar{R} = pR .$$

Suppose each borrower has his/her own coefficient of risk aversion,V_i, and that his/her utility function can be expressed as:

$$U_i = E(y) - \frac{1}{2} V_i \sigma_y^2,$$

where *y* represent the project outcome and σ_y^2 its variance.

The lender offers two types of contracts, an individual contract and a group contract. Under individual lending, each borrower is uniquely responsible for the repayment of her loan. Under group lending, borrowers are not only responsible for their own portion of the repayment, but they must also repay their partners' loans in case of their default. To isolate the role of adverse selection, we don't allow for ex-post moral hazard behavior; default occurs only when a project fails.

A.1 Individual Lending Contract

Under individual lending, a borrower's utility depends upon the chosen project. If she decides to invest in the safe project, her utility will be:

$$U_{safe,indiv.} = \bar{R} = pR. \quad (1)$$

If instead the borrower choses the risky project, his utility will be:

$$U_{risky,indiv.} = pR - \frac{1}{2}V_i\sigma_y^2 = pR - \frac{1}{2}V_i[p(R-\bar{R})^2 + (1-p)(0-\bar{R})^2]. \quad (2)$$

By comparing (1) and (2), we can see that under individual lending, all risk-averse borrowers (with $V_i > 0$) would prefer the safe project, risk-neutral borrowers (with $V_i = 0$) are indifferent, while risk-loving borrowers (with $V_i < 0$) would opt for the risky project.

A.2 Group Lending Contract

Assume that the joint-liability contract limits the loss in the bad state to $\hat{R} \in (0, R)$. Suppose, for simplicity, that all the other borrowers in the group choose the safe project. If the borrower choses the safe project, his utility will remain the same as if borrowing individually:

$$U_{safe,group} = pR .$$

If she chooses the risky project, his utility will be:

$$U_{risky,group} = pR + (1-p)\hat{R} - \frac{1}{2}V_i\sigma_y^2. \quad (3)$$

In what follows, we show the conditions under which a risk-averse borrower, who would choose the safe project under individual lending, would switch to the risky project under group lending, *i.e.:*

$$U_{risky,group} > U_{safe,group}$$

$$pR + (1-p)\hat{R} - \frac{1}{2}V_i\sigma_y^2 > pR,$$

which is satisfied if:

$$V_i < \frac{2(1-p)\hat{R}}{\sigma_y^2}, \quad (4)$$

where the variance of the project, σ_y^2, under group lending is:

$$\sigma_y^2 = p(R - \tilde{R})^2 + (1 - p)\left(\hat{R} - \tilde{R}\right)^2, \quad (5)$$

and $\tilde{R}$ represents the expected return of the project under group lending:

$$\tilde{R} = pR + (1 - p)\hat{R}.$$

Substituting the expression for $\tilde{R}$ into (5) we have:

$$\sigma_y^2 = p\left[R - pR - (1 - p)\hat{R}\right]^2 + (1 - p)\left[\hat{R} - pR - (1 - p)\hat{R}\right]^2$$

$$= p\left[(1 - p)(R - \hat{R})\right]^2 + (1 - p)\left[p(\hat{R} - R)\right]^2,$$

and then substituting σ_y^2 into (4) we obtain:

$$V_i < \frac{2(1 - p)\hat{R}}{p(1 - p)^2(R - \hat{R})^2 + (1 - p)p^2(R - \hat{R})^2},$$

which gives the conditions for risk aversion under which a risk-averse borrower would choose the safe project under individuals lending, but a risky project under group lending:

$$V_i < \frac{2\hat{R}}{p(R - \hat{R})^2} = \overline{V_i}.$$

Thus for a certain group of borrowers, those whose $V_i \in (0; \overline{V_i})$, a safer project is preferred under individual lending while a risky one is favored under group lending. Note that this condition for risk aversion is more likely to be fulfilled when the individual rate of risk aversion is low, the probability of success of in the good state is low, and the protection from joint-liability is high.