# SIGNALLING THROUGH JOINT-LIABILITY: AN ADVERSE SELECTION MODEL

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*Abstract*: Joint-liability is maybe the most distinctive feature of microfinance contracts in developing countries. Yet, very little evidence exists on the impact of joint-liability contracts as compared to individual lending contracts. On the one hand, theory claims that joint-liability plays a key role in mitigating agency problems and thus enhancing repayment rates, especially when borrowers lack collateral. On the other, experimental evidence has shown mixed, sometimes contradictory results, highlighting major pitfalls like harsh social sanctions and peer pressure. We contribute to the debate on the relative merits (and weaknesses) of joint-liability by showing that, under certain conditions, joint-liability may not be able to solve adverse selection problems. We build a model in which a risk-neutral lender offers both individually and jointly-liable contracts, but has limited funds and limited knowledge about borrowers' quality. In this case, joint-repayments can be used as a signalling device of borrowers' type. Our model shows that if the lender allows for competition among borrowers, risky borrowers may have an incentive to reveal a higher joint-repayment level than safe borrowers. In other words, joint-liability may increase adverse selection. We test our predictions in a small experimental environment.

*Keywords*: Joint-liability Lending, Microfinance, Adverse Selection.

*JEL classification*: D82, G20, O12, C92.

## 1. *Introduction*

Group lending is doubtless one of the most distinctive characteristics of microfinance contracts in developing countries. In a group lending-type of contract, microfinance borrowers may simply share regular meetings in order to repay their loan obligations, or, rather, they may also be mutually responsible for the loan repayment. While in the former case group members only share the social aspects of the repayment activity (e.g. sitting and discussing together about their business activities, or handling money, as reported in Larance 2001; see also Feigenberg *et al.* 2013), in the latter bor-

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rowers are jointly-liable for the loan received by the members of the group, and share defaulting partners' repayment obligations. Despite its enormous success during the early years of the «microfinance revolution», joint-liability has now lost most of its past attractiveness: it is striking that, since 2002, also the Grameen Bank (Grameen II) has formally eliminated joint-liability from its contracts. Indeed, although joint-liability has been widely celebrated as a powerful instrument to increase repayment rates, possible downsides include social pressure and social sanctions exerted by the group, as well as high costs related to weekly meetings at the MFI. The early theoretical literature on microfinance has highlighted the key role of joint-liability in raising repayment rates by mitigating agency problems; at one end of the spectrum, adverse selection models by Ghatak (1999) and Van Tassel (1999), as well as Ghatak (2000) and Armendariz and Gollier (2000), have stressed the importance of self-selection based on borrowing members' riskiness; in his paper, Ghatak (1999) shows that joint liability leads to positive assortative matching in the process of group formation, and his result contributes to explain why joint liability contracts may lead to high repayment rates even if borrowers lack of collateral. Along the same line, Van Tassel (1999) studies a group formation game where loan sizes are variable. His main result is that by deviating from the pooling interest rate, the lender is able to offer the group lending contract only to high-ability borrowers. Elsewhere, Ghatak (2000) studies group-lending contracts and peer selection and demonstrates that joint-liability can be used as a screening device of borrowers' riskiness. At the other end, peer monitoring and loan repayment enforcement represent possible channels to overcome moral hazard problems (Stiglitz 1990; Banerjee *et al.* 1994; Wydick 2001). In particular, Besley and Coate (1995) study the impact of joint liability on repayment rates, finding both positive and negative results: on the one hand, successful borrowers have an incentive to repay also for their unsuccessful partners; on the other hand, their model shows that group lending may increase peer pressure.

On the empirical ground, when testing the impact of group lending versus individual lending, the recent experimental evidence shows mixed results. Using two randomized field experiments in the Philippines, Giné and Karlan (2011) have shown that, when comparing borrowing groups with and without joint-liability, there is no impact in change in default rates across treatments. On the contrary, Attanasio *et al.* (2011), who test the impact of group versus individual lending in Mongolia, find that group lending increases entrepreneurship and food consumption. Besides, a series of laboratory and artefactual field experiments[1] have tried to uncover the determinants underlying

[1] Experiments which study real-world subjects' choices in a laboratory setting, see Cassar *et al.* (2007) and Cassar and Wydick (2010) for a comprehensive literature review.

the choice between individual versus joint-liability. The results of the lab experiment by Abbink *et al*. (2006) seem to confirm the theoretical predictions that joint-liability increases repayment rates. However, other experiments also pointed out that joint-liability may favour borrower's risk-taking behavior: by conducting a set of games with Peruvian microfinance borrower, Giné *et al*. (2010) find that group lending increases risk-taking, although to a lower extent in self-selected groups. Along the same line, Fischer's experiments (2012) in India reveal that risk-tolerant individuals are more likely to choose riskier projects under joint-liability. In a similar spirit, Barboni *et al.* (2013) find that Bolivian borrowers exogenously endowed with a risky project are more likely to choose jointly-liability contracts over individually-liable contracts. In contrast with what theory predicts, they show that joint-liability may favour adverse selection, rather than mitigating it, and this might explain the recent shift from group to individual lending contracts offered by microlenders.

In this paper, I present a theoretical model aimed at studying to what extent joint-liability may represent a signalling device of borrower's quality. We build an adverse selection model in which a risk-neutral lender offers both individual and jointly-liable contracts, but has limited funds and limited knowledge about borrowers' quality. In this case, joint-repayments can be used as a signalling device of borrowers' type. Our model shows that if the lender allows for competition among borrowers, risky borrowers may have an incentive to reveal a higher joint-repayment level than safe borrowers. Our research thus contributes to feed the debate on the impact of joint-liability along two lines: at one end of the spectrum, we show that if both joint-liability and individual contracts are offered by a lender with limited resources, the joint-liability contract may be preferred to the individual liability contract. At the other end, we provide evidence that under certain conditions joint-liability contracts can foster adverse selection, in contrast with Ghatak (1999) and Van Tassel (1999).

The paper thus proceeds as follows: we present the model in section 2, and discuss predictions. In section 3, we show the results of a small laboratory experiment. Section 4 concludes.

## 2. *The Model*

We start with an adverse selection model where a risk-neutral lender faces a pool of borrowers, similar to Ghatak (1999). We assume that there is a unit mass of borrowers, with a fraction $\beta$ of safe borrowers and a fraction $1 - \beta$ of risky borrowers; while $\beta$ is common knowledge, their type, that is the probability of success of their project, is unknown to the lender, but known to the other borrowers. There are two types of projects available in the market, a safe and a risky one, both of which requires an initial outlay $I = 1$ to become productive. The safe project yields $R_s$ with probability $p_s$ and 0 otherwise, while the risky yields $R_r$ with probability $p_r$ and 0 otherwise, where $p_s > p_r$ but $R_s < R_r$. Project outcomes are independently distributed, both for the same types and across types. Furthermore, we assume that the following relationship holds:

$$p_s R_s > p_r R_r > 1$$

that is, the safe project dominates the risky one (in the sense of first-order stochastic dominance), but both have a positive net present value. By assumption, borrowers have zero collateral. We also assume that there is a single lender and excess demand for funds; in other words, the bank can offer up to $\alpha$ amount of funds, where $\alpha < 1$. We also assume that $\alpha > \max\{\beta; 1 - \beta\}$. There are two types of contracts the lender can offer: an individual and a group lending. Under both contracts, borrowers borrow one unit of capital at time 0 and are requested to repay $D$ in the following period. Under group lending, however, borrowers are not only responsible for their own repayment, but they must also repay their partner's loan in case of default. We consider groups of size 2. A joint-liability credit contract is thus characterized by a combination of $(D, q)$ where $D$ is the individual repayment (which comprises principal plus interests) and $q$ the joint repayment in case of partner's default.

## 2.1. *Lending with individual liability*

Under individual liability and symmetric information, and given that is has a limited amount of funds, the bank would first lend to safe borrowers and then lend to risky borrowers until there are funds[2].

Things, however, change in presence of adverse selection. Following the analysis by Bolton and Dewatripont (1995), we assume that the lender can only set a fixed repayment $D$ in exchange of the lent amount, which is due in the following period. Borrowers will apply for funds if and only if $D \leq R_i$. If $D > R_s$, only risky borrowers will enter the contract, and thus setting $D > R_r$ will be optimal for the lender, as it gives the bank a profit of:

$$\Pi^s_{IL} = (1 - \beta)(p_r R_r - 1) \tag{2}$$

[2] We assume that for the bank it is always better to lend than not to lend.

here the subscript *IL* stands for «individual lending» and *s* for separating equilibrium.

Instead, if $D \leq R_s$, both borrowers will apply. Under individual lending, we assume that each applicant has an equal chance of being financed. It will then be optimal for the lender to set $D = R_s$ and he will obtain:

$$\Pi^p_{IL} = \alpha\,[\beta\,(p_s R_s - 1) + (1 - \beta)\,(p_r R_s - 1)] \tag{3}$$

where again the subscript *IL* stands for «individual lending» and *p* for pooling equilibrium. In this case, the lender will use his funds fully, but he is leaving risky borrowers with a rent, as they could repay up to $R_r$ with probability $p_r$. Note that this result holds because we assume that the expected surplus from the risky project is positive. This means that achieved repayment rates are the same as if there was full information. When this assumption doesn't hold, as in the underinvestment problem shown in Ghatak (2000), the individual lending contract fails to achieve full repayment rates.

### 2.2. *Lending with group liability*

In his model, Ghatak (1999) shows that for any joint-liability contract offered by the bank, borrowers will select themselves into groups of homogenous riskiness. This result moves from the intuition that, for any given type, borrowers prefer to form a group with a safer type, and the safer they are, the higher value they will place on a safer partner. In a population of borrowers that is balanced by group size, and assuming groups are made of two borrowers, this thus ensures that any borrower will find a partner of the same type to form a pair. Taking this result as a starting point, our analysis of the group liability contract assumes that joint-liability enhances positive assortative matching. It follows that if the lender offers the group liability contract, borrowers will form homogeneous groups (in this case, pairs) in terms of riskiness. Given that borrowers have no initial wealth, the sum of the individual and joint repayments must not exceed the borrower's project return. This assumption is expressed through the limited liability constraint:

$$D + q \leq R_i,$$

where $D$ and $q$ represent the individual and the joint liability repayment, respectively, while $R_i$ is the project return, where $i = \{r; s\}$. In other words, $q$ represents the share of profit a borrower must sacrifice in order to cover her partner's loss, assuming the former is successful while the latter defaults[3]. In analyzing the group lending contract, Ghatak (1999) assumes the lender chooses both the interest rate and the joint repayment in order to solve his optimization problem. On the contrary, we design a group liability contract where the joint repayment is endogenous and set by borrowers. This is related to the fact that the lender is funding constrained, and he will use the joint-liability repayment as a signal of borrower's quality[4]. Therefore, when the lender offers the contract, he will first announce $D$ and will then ask borrowers to decide which share of their project's return, $q_i \geq 0$, they are willing to sacrifice in order to cover their partners' default, provided that their project is successful. To our knowledge, this is the first model to study the implications of letting borrowers choose their preferred degree of joint liability[5]. For the limited liability constraint, borrowers' won't be able to offer $q_i > R_i - D = \bar{q}_i$. For simplicity, we assume that $q_i$ is unique across pairs. Under group lending with joint-liability, the borrower's expected utility will be:

$$EU(D, q_i) = p_i[(R_i - \mathrm{D}) - (1 - p_i)q_i] \tag{4}$$

where $i = \{r; s\}$. Expression (4) can be re-written as:

$$p_i[(R_i - \mathrm{D}) - (1 - p_i)\, q_i] = u$$

where $u$ is a constant. As shown by Ghatak (1999), this means that, for a certain level of utility, the slope of an indifference curve of a type $i$ borrower in the $(D, q_i)$ plane is:

$$\left.\frac{dq_i}{dD}\right|_{U=u} = -\frac{1}{1-p_i}$$

As $p_s > p_r$, it follows that the absolute value of $dq_i / dD$ is higher for safe borrowers than for risky. This means that, for small reduction in $D$, safe borrowers are willing to offer a higher joint repayment than risky borrowers. Thus, being funding constrained, the lender wants to give priority to safer borrowers. Therefore, we assume that the bank takes his funding decisions upon the observation of $q_i$, and in particular it will finance projects starting

[3] Therefore, individual lending contracts can been seen as a special case of joint-liability contracts, with $q = 0$.

[4] On the contrary, Ghatak (1999) assumes that the bank faces a perfectly elastic supply of funds, so that loan demand can be fully satisfied.

[5] However, this issue has already been explored under the form of «cosignature» of firms' loans by Spallone (2008).

from the highest values of $q_i$, as it expects that safe borrowers will propose a higher value of $q_i$ than risky ones.

If the joint repayment is exogenous and set by the bank, the lender's problem becomes similar to the one analyzed in section 2.1. In this case, the bank has to decide which values of $D$ and $q$ should be offered in the joint-liability contract. Recall that the limited liability constraint applies: therefore, if the lender sets $D > R_s - q$, the safe type will be excluded from the pool; thus, it will be optimal to set $D = R_r - q$, and he will end up with the following profit[6]:

(5) $$\Pi^s_{GL} = (1 - \beta)\{p_r[D + (1 - p_r)q] - 1\}$$

where the subscript $GL$ stands for «group lending» and $s$ for separating equilibrium. On the contrary, if $D \leq R_s - q$, both borrowers will apply and it will be optimal for the lender to set $D = R_s - q$ His profit will thus be:

(6) $$\Pi^p_{GL} = \alpha\{\beta p_s[D + (1 - p_s)q] + (1 - \beta)p_r[D + (1 - p_r)q] - 1\}$$

where again the subscript $GL$ stands for «group lending» and $p$ for pooling equilibrium.

## 2.3. *Comparing individual and group lending contracts*

Let us now assume that the lender offers both the individual and the group lending contract at the same time. Both contracts can be described by the pair $(D, q)$, where $q = 0$ for the individual lending contract. Recalling expression (2):

$$\Pi^s_{IL} = (1 - \beta)(p_r D - 1)$$

And expression (3):

$$\Pi^p_{IL} = \alpha[\beta(p_s D - 1) + (1 - \beta)(p_r D - 1)]$$

being the separating and the pooling equilibrium under individual lending, respectively, and assuming $D$ is the same for both contracts, where $D$ is such that the limited liability constraint is satisfied and holds also for the individual lending contract[7], we can compare the two lending strategies. Therefore,

[6] Recall that $R_s < R_r$ by assumption.

[7] In order to reach the separating equilibrium, the condition $D = R_r - q < R_s$ must be satisfied, that is $q < R_r - R_s$.

by comparing equations (2) to (5), and (3) and (6), it is easy to see that, if the lender cannot seize borrower's collateral under individual lending, he will be always better-off under group lending.

It follows:

**Proposition 1**: *If the lender offers both the individual and the group lending contract, and sets the same repayment obligation D across the contracts, he will always be better-off with the group lending than with the individual lending contract.*

Assuming that the lender sets $D < R_s - q$ such that both types can borrow, if no other contractual feature is specified, borrowers will prefer the individual to the group lending contract as long as the following equation holds:

$$p_i(R_i - D) \geq p_i[(R_i - D) - (1 - p_i)q] \tag{7}$$

It is straightforward to see, however, that under our assumptions borrowers will always prefer the individual contract, $\forall q$. From Proposition 1 it immediately follows that the lender ends up with a lower profit than what he potentially may achieve.

Therefore, in order to try to get a higher profit, the lender has two alternatives: either he only offers a group lending contract or, instead, he may set a «rule»: that is, as he can fund borrowers up to $\alpha$, he will first select jointly-liable borrowers and then borrowers under individual lending. We assume therefore that the model will proceed as follows: first, borrowers will decide which contract they want to sign; second, in case they opt for the group lending contract, they will be asked to set the value of $q_i$ they intend to grant for their partner; last, based on the ranking of $q_i$[8], the lender will proceed and fund borrowers. In this model, therefore, borrowers have two choices to make: first, they have to decide which contract to undertake; second, they have to choose $q_i$, conditional on having chosen the group lending contract.

## 2.4. *The borrowers' decision*

Let us consider a situation in which $n$ borrowers of homogeneous riskiness have to simultaneously take the decision on whether to apply for $\alpha$

[8] Recall that the individual lending contract can be seen as a special case in which $q_i = 0$.

TAB. 1. *Normal-form representation, opponent of the same type*

| | *IL* | *GL* |
|---|---|---|
| *IL* | $\rho_{IL,IL} p_i(R_i - D)$,<br>$\rho_{IL,IL} p_i(R_i - D)$ | $\rho_{IL,GL} p_i(R_i - D)$,<br>$\rho_{GL,IL} p_i(R_i - D)$, |
| *GL* | $\rho_{GL,IL} p_i[(R_i - D) - (1 - p_i)q_i]$,<br>$\rho_{IL,GL} p_i(R_i - D)$ | $\rho_{GL,GL} p_i[(R_i - D) - (1 - p_i)q_i]$,<br>$\rho_{GL,GL} p_i[(R_i - D) - (1 - p_i)q_i]$ |

funds individually or jointly[9]. We assume that their participation constraint is satisfied, so that all borrowers will apply. If both opt for the individual lending strategy or for the group lending strategy, they have equal chances to get funded, that is $\rho_{IL,IL} = \rho_{GL,GL} = \frac{\alpha}{n}$[10], being $\rho_{j,k}$ the probability that the borrower is funded by the lender, $j$ and $k$ stand for the strategy adopted by the borrower and her opponent[11], respectively, whereas the subscripts *IL* and *GL* identify Individual Lending and Group Lending contracts. For instance, $\rho_{IL,IL}$ identifies the probability for a borrower $j$ to get funded when both herself and her opponent $k$ have opted either for the Individual Lending strategy. On the contrary, if a borrower deviates and opts for a different strategy than her opponent, the following relationship holds:

$$\rho_{GL,IL} > \rho_{IL,IL} = \rho_{GL,GL} > \rho_{IL,GL}$$

The normal-form representation of the game is displayed in Table 1, where $i = \{s, r\}$.

The game represented above is anything but a Prisoner's Dilemma between the borrowers. The game has a unique pure-strategy Nash Equilibrium which is to both opt for the Group Lending strategy, for:

$$q_i \leq \min\left(\frac{\rho_{GL,IL} - \rho_{IL,IL}}{\rho_{GL,IL}} \frac{R_i - D}{1 - p_i}, \frac{\rho_{GL,GL} - \rho_{IL,GL}}{\rho_{GL,GL}} \frac{R_i - D}{1 - p_i}\right) \tag{8}$$

**Proposition 2**: *For values of $q_i$ which satisfy (8), assuming that the lender has limited funds, borrowers will opt for the group lending rather than the individual lending strategy, thus reaching a sub-optimal equilibrium.*

[9] We assume that if they opt for the group lending strategy they will set the same value of $q_i$ so that the probability of being funded doesn't depend on $q_i$.

[10] Because in the case of group lending each pair would need 2 units of capital.

[11] Who belongs to another pair.

The second decision concerns the value of $q_i$: the lender will fund projects starting from the highest values of $q_i$. This means that the probability of being funded now depends on the chosen value of the degree of joint liability. The choice of $q_i$ also takes into account borrower's own and her partner's riskiness[12]: the higher is the $q_i$ borrowers are committed to grant, the lower their final payoff will be. Moreover, for a given $q_i$, we assume that it is always better for the lender to finance a safe borrower than a risky one, as the probability to be repaid is higher in the former than in the latter case. This means that it may be optimal for a borrower who undertakes the group lending contract to give the impression that she is a safe type in order to increase her chances to get funded. Assuming that $q_i$ satisfies the values in (8), s.t. all borrowers will choose the group lending contract, each borrower will choose $q_i$ which maximizes:

$$\rho_{GL,GL}(q_i)p_i[(R_i - D) - (1 - p_i)q_i] \tag{9}$$

## 2.5. *Equilibrium*

In the previous section, we have seen that for values of $q_i$ which satisfy (8) all borrowers will opt for the group lending contract. We now analyze under which conditions borrowers' projects will be financed. We build the model as a game of incomplete information between the lender and the borrowers. In the following analysis, I will compute the perfect Bayesian equilibrium of the game. The borrower's only concern is whether her offer of $q_i$ will be accepted by the lender and thus her project will be financed. Given $D$ arbitrarily set by the lender, borrowers will choose the value of $q_i$ which satisfies their participation constraint:

$$p_i[(R_i - D) - (1 - p_i)q_i] \geq 0$$

The risky borrowers will thus offer $q_r$ which satisfies their limited liability constraint, that is $q_r \leq R_r - D = \bar{q}_r$. Similarly, safe borrowers will offer $q_s \leq R_s - D = \bar{q}_s$. As, by assumption, $R_r > R_s$, it follows that risky borrowers are able to offer a higher joint repayment than safe borrowers. The lender's strategy[13] then will be:

[12] Recall that groups have homogenous riskiness.

[13] Assuming that (8) holds.

(10) $$\rho^*(q_i) = \begin{cases} 1 & \text{if } \; q_i = R_r - D \\ 1 - \dfrac{1-\alpha}{\beta} & \text{if } \; q_i < R_r - D \end{cases}$$

Therefore, risky borrowers, who can offer up to $\bar{q}_r = R_r - D$, will be funded with certainty; on the contrary, safe borrowers, who can offer up to $\bar{q}_s = R_s - D < R_r - D$ will be funded with probability $1 - \dfrac{1-\alpha}{\beta}$[14].

The risky borrower's profit will thus be:

(11) $$p_r[(R_r - D) - (1 - p_r)(R_r - D)]$$

while safe borrowers' profit will be:

(12) $$\left(1 - \frac{1-\alpha}{\beta}\right)\{p_s[(R_s - D) - (1 - p_s)(R_s - D)]$$

The lender's profit will then be:

(13) $$\begin{aligned} &(1-\beta)[p_r D + p_r(1-p_r)(R_r - D) - 1] + \\ &+\beta\left(1 - \frac{1-\alpha}{\beta}\right)[p_s D + p_s(1-p_s)(R_s - D) - 1] \end{aligned}$$

On the contrary, if only risky borrowers' participation constraint is satisfied, safe borrowers won't apply for funds, and the lender's profit will be:

(14) $$(1 - \beta)[p_r D + p_r(1 - p_r)(R_r - D) - 1]$$

### 2.6. *Discussion of theoretical predictions*

We build an adverse selection model where safe and risky borrowers compete for a limited amount of funds. Furthermore, we assume that the lender, who cannot screen out risky borrowers, offers both an individual and a group lending contract. As the lender's profit is higher under joint-liability contracts than under individual liability ones, he will first fund jointly-liable borrowers and then, if funds are still available, those under individual lending. By increasing competition among borrowers, we expect all borrowers to ask for a group lending contract for values of the joint repayment which satisfy condition (8), which represents the pure-strategy Nash

[14] By assumption $\alpha < 1$.

Equilibrium of the game. When the value of the joint repayment is endogenous and the lender is funding constrained, our model predicts that the value of the joint repayment increases and, in particular, risky borrowers will offer a higher joint repayment than safe borrowers. As a consequence, safe borrowers may be screened out, or at least funded with a lower probability than risky borrowers. Our model thus shows that, under certain conditions, joint liability may foster adverse selection rather than mitigate it. With respect to the existing literature on the topic, we introduce some novelties in our theoretical framework. In particular, compared to Ghatak's model (1999), our design differs along several dimensions: first, we let joint repayments be endogenous and arbitrarily set by the borrowers in the joint liability contracts; second, we assume the lender to be funding constrained; third, we allow for competition among borrowers, showing that this will be not beneficial to the lender, since he will not be able to distinguish among borrowers' types. Under these assumptions, our model predicts that joint-liability contracts increases the adverse selection problem faced by the lender.

## 3. *The Experiment*

In order to test our hypothesis, we implemented a small-scale laboratory experiment in the same spirit as Abbink *et al.* (2006) with undergraduate students at LUISS University in Rome, Italy[15]. The experiment was carried out in June 2008 and consisted of a one-shot game[16]. It was made up of two parts. In the first part, 20 subjects were first randomly assigned to one type (safe and risky, in the experiment identified by the red and blue color, respectively) and were then asked to move into two different rooms based on their type. In the second part of the game, an investment game (Berg *et al.* 1995) was played, where subjects had the possibility to implement an investment opportunity. In particular, subjects who were exogenously assigned to the safe type could implement a project which yielded 42 euros with probability 5/6 and 0 otherwise. Risky borrowers, on the contrary, had the possibility to implement an investment opportunity which yielded 60 euros with probability 1/6 and 0 otherwise. In the second part of the experiment, subjects were told that the bank (whose role was played by the experimenters) had only a limited amount of funds, and that they could choose whether to

[15] Recruitment was made anonymously by sending an invitation email to students' university account.

[16] The instructions, translated from Italian, are reported in the Appendix.

ask for a loan individually or jointly with a person in the same room[17]. Moreover, they were told that in case both individual and group-lending contracts were formed, the lender would have lent to jointly-liable borrowers first, and then, if funds were still available, he would have lent to single borrowers. Last, if borrowers were to opt for group-lending contracts, they had to fill a form where they had to indicate which share of their profit $q$ they were willing to guarantee in case of their partner's default. Furthermore, it was clearly stated that, in giving loans, the lender would have started from the highest levels of $q$[18]. The experiment was implemented in paper form. In the second part of the experiment, where groups had eventually to be formed, borrowers were allowed to talk with the other in the same room. However, once a pair was formed, the value of $q$ was not disclosed to the other subjects in the room. All choices made in the other room were kept unkown. After all subjects had made their decisions (which contract to choose, and which $q$ in case they opted for the group lending one), all borrowers were asked to go back to the common room. At that point, the funding requests were evaluated by the lender, who decided which projects would have been financed. Funded investment opportunities were then implemented and subject received their final payments. All participants also received 5 euros as show-up fee.

### 3.1. *Predictions*

In line with the theoretical predictions discussed in Section 2.5, we expect two main results from the experiment: first, borrowers should opt for the group lending contract instead of the individual lending one, although their utility is higher under the latter than in the former. Second, we expect the values of the joint repayment set by risky borrowers to be higher than safe borrowers' ones. Therefore, the main variables of interest in our experiment are borrowers' choice between the individual and the group lending contract (the variable *choice*, a dummy which takes the value of 1

[17] Consistent with the model setup, groups consist of two borrowers of the same type.

[18] As our main focus in the experiment was to study which values of $q$ borrowers were willing to set, and given their limited liability constraint $D + q \leq R_i$, we set $D = 0$ as parametrization in all contracts, in order to have $q \in [0; R_i]$ in the group lending contract. We believe results should not be distorted by this condition, as it still ensures that the individual lending contract is preferred to the joint liability contract. Moreover, this allows subjects to express $q$ as a share of their entire project return. A possible downside is that $q$ may be upward biased with respect to $D > 0$; however we don't have any reason to believe that there would be differences *between* types driven by our parametrization.

if the borrowers opted for the group lending contract, and 0 otherwise) and, conditional on having opted for the joint liability contract, the amount of joint repayment ($q$, here expressed as a share of borrower's project return).

### 3.2. *Results*

Despite its very low power, our experimental evidence provides some interesting results. First of all, as it is shown in Table A1 in the appendix, 90% of the pool of subjects opted for the group lending strategy despite borrowers' utility was higher under individual lending (mean of *choice* is equal to 0.90), thus confirming the Nash Equilibrium we have previously analyzed in Section 2.4. In particular, when we condition by type, all safe borrowers chose the group lending strategy, while only 2 out of 10 risky borrowers asked for an individual lending contract, as it is represented in Figure A2. Second, among those borrowers who opted for the group lending strategy (18 subjects out of 20), the average value of $q$ is 0.373, as reported in Table A1. More specifically, it is worth noticing that, in line with theoretical predictions, when we distinguish by type of borrowers, the average value of $q$ indicated by risky borrowers (0.44) is significantly higher than the one by safe borrowers (0.32), $p < 0.05$, as shown by the paired t-test in Table A2. That is, if borrowers are free to set their joint repayment, risky borrowers have an incentive to act as safe borrowers, thus increasing the adverse selection problem. The distribution of $q$ conditional on borrower's type is displayed in Figure A2. If we exclude the two borrowers who have indicated a value of zero for $q$ (because they opted for the individual lending contract), the minimum value of $q$ under the group lending strategy is 0.30, with an average value of 0.37.

## 4. *Conclusions*

We build an adverse selection model in which a risk-neutral lender offers both individually and jointly-liable contracts, but has limited funds and limited knowledge about borrowers' quality. In this case, joint-repayments can be used as a signalling device of borrowers' type. Our model shows that if the lender allows for competition among borrowers, risky borrowers may have an incentive to reveal a higher joint-repayment level than safe borrowers, thus increasing the adverse selection problem. We also design a small-scale laboratory experiment to test our theoretical predictions: despite its very low power, the experiment supports our theoretical results. Our research contributes to feed the debate on the impact of joint-liability along two lines: at one end of the spectrum, we show that if both joint-liability and individual contracts are offered by a lender with limited resources, the joint-liability contract may be preferred to the individual liability contract. At the other end, we provide further evidence that joint-liability contracts may foster adverse selection.

## *Appendix*

TAB. A1. *Descriptive Statistics*

| Variables | Definition | N. | Mean | Median | Std. Dev. |
|---|---|---|---|---|---|
| Choice | = 1 if subjects opted for group lending | 20 | 0.9 | 1 | 0.308 |
| *q* | Amount of joint repayment under group lending | 18 | 0.373 | 0.32 | 0.117 |

TAB. A2. *Mean difference test of the distribution of q*

| *q* by type of borrower | Mean | Std. Error |
|---|---|---|
| *q* ǀ type = risky | 0.437 | 0.0557 |
| *q* ǀ type = safe | 0.322 | 0.0013 |
| *Difference* | 0.1155 | 0.0494 |
| Ha: mean (diff) ! = 0 | *p*-value | 0.0329 |
| Ha: mean (diff) < 0 | *p*-value | 0.0164 |

*Note*: Expressed as a % of the project return.

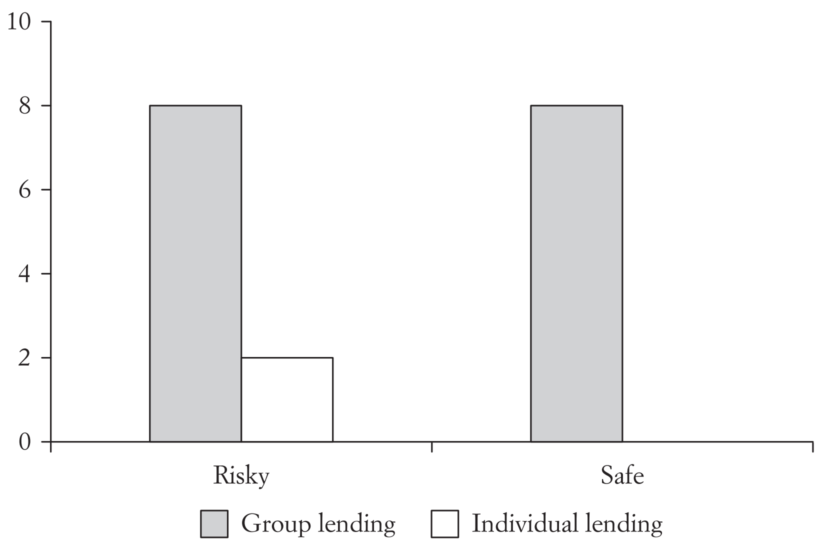


FIG. A1. Mean of choice, by type.

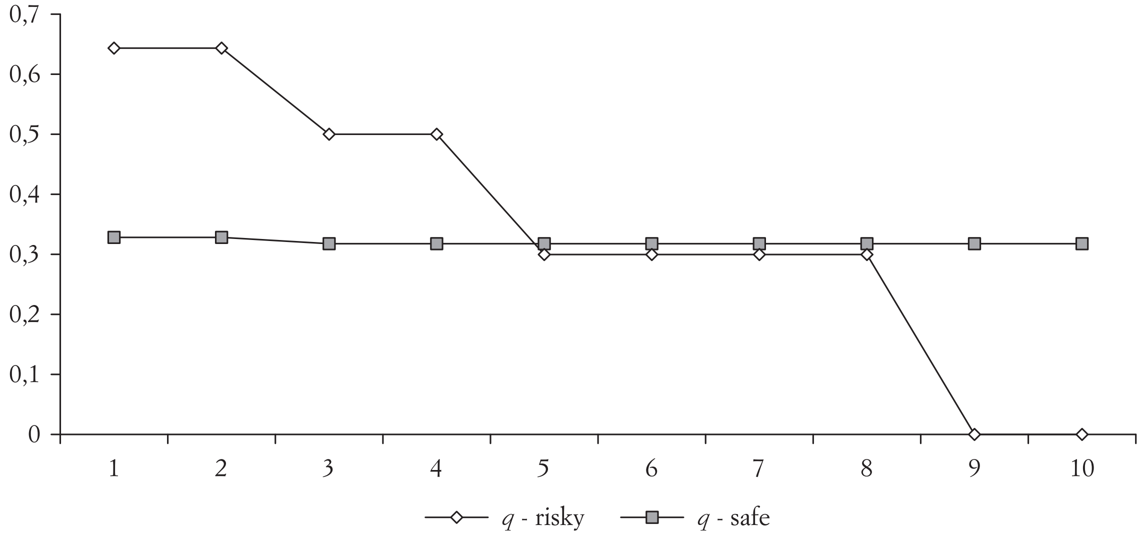


FIG. A2. Distribution of $q$, by type.

*Instructions – Part A*

*Welcome!*

This is an experiment about investment decisions. In this session, there are 20 people that will play the role of entrepreneurs. The experimenters will participate in the game as the financing bank. In the first part of the experiment, each of you will draw a slip of paper from a bag. Each piece of paper represents an investment opportunity, and it is identified by a number ranging from 1 to 20 and by a colour, red or blue. In order to be started and thus become profitable, each investment activity requires one unit of capital, regardless of its colour. As you can see, the bag contains exactly 10 red investment opportunities and 10 blue investment opportunities. The return of the investment opportunities is determined by throwing a dice at the end of the session. The red investment activity yields a return of 42 euros with probability 5/6 or nothing with probability 1/6. If the die turns out a 2 or a 3 or a 4 or a 5 or a 6, your project is successful and you earn 42 euros plus 5 euros as show-up fee. If instead the die lands on a 1, your project fails and you will only receive 5 euros as show-up fee. The blue investment activity yields a return of 60 euros with probability 1/6 or nothing with probability 5/6. If the die turns out a 6, your project is successful and you earn 60 euros plus 5 euros as show-up fee. If instead the die lands on a 1 or a 2 or a 3 or a 4 or a 5, your project fails and you will only receive 5 euros as show-up fee. Once everybody in the room has drawn the slip of paper from the bag, you will be asked to leave this room and you will be guided into two different rooms, according to the colour of your piece of paper. Once you enter the new room, the second part of the experiment will start. At the beginning of the second part of the experiment, you will receive a new set of instructions. At the end of the experiment, the experimenters will throw the dice for you and will pay you in private.

***

*Instructions – Part B*

*Welcome to the second part of this experiment!*

This is an experiment about investment decisions. In this room, there are 10 people that will play the role of entrepreneurs. In the first part of the experiment, each of you has drawn a slip of paper from a bag. Each piece of paper represents an investment opportunity, and it is identified by a number and by a colour (either red or blue).

*All subjects in the room share the same colour of the project, either red or blue.*

If you drew a red piece of paper, all the other 9 people in this room have a red piece of paper as well; if, instead, you drew a blue piece of paper, all the other 9 people in this room have a blue piece of paper, as well.

In order for your investment opportunity to be started and thus become profitable, regardless of its colour, it is necessary to borrow one unit of capital from the bank. If you don't manage to receive funding, your investment opportunities have no value and your final profit will only be equal to the show-up fee, that is 5 euros. The bank knows that there are 20 investment opportunities in the two rooms, which require a total of 20 units of capital to become profitable. However, the bank has only 16 units of capital, which means it can finance a maximum of 16 investment opportunities. In order to receive funding, you need to make a funding request.

*How can you advance your funding request to the bank?*

You need to fill the «funding request» form you have received with this set of instructions. In particular, you need to specifiy whether you wish to ask for an individual or a group loan. If you ask for an *individual* loan, and your investment opportunity is financed and is successful, you will get the entire profit. If you ask for a *group* loan, you will be part of a group of 2 borrowers who are jointly liable for the entire group loan. Therefore, you first need to identify a partner to form a pair. Second, you need to state which percentage of your project return ($q$ in the form), in case your project is successful but your partner's project is not, you are willing to put as guarantee in order to cover your partner's default.

*Be careful: the value of q must be the same both for you and your partner.*

For example: let's suppose that you have drawn a red slip of paper and you are now asking for a group loan. However, only one out of two investment opportunities of the group is successful. Furthermore, let's suppose that, in advancing the funding request, the group has set $q = 20\%$. This means that the entrepreneur whose project was successful will give back to the bank 8.40 euros (that is, 20% of her profit, 42 euros) in order to cover her partner's default. In this case, the final profit of the successful entrepreneur will be 33.60 euros (42 euros minus 8.40 euros), plus the show-up fee. On the contrary, her partner's return will only be the show-up fee, as her project was not successful. As the bank cannot finance all investment opportunities, the following criterion will be adopted: group loans will be funded first, starting from the highest $q$. Second, if some units of capital will still be available to fund individual loans, these will be randomly chosen untill funding capital will be available. You have now 10 minutes to decide whether to ask for an individual or a group loan and, in the latter case, to form a pair and set the value of $q$. Once everybody in the room has made her choice, the experimenters will collect the «funding request» forms and will bring to the bank. The bank will order the funding requests according to the mentioned criteria. At the end of the experiment, you are requested to go back to the first room, where the outcomes of your investment opportunities will be decided by the roll of a dice. We will then proceed with individual payments.

Do not hesitate to ask for any clarification.

Thank you!

*Funding request form*

| | | |
|---|---|---|
| Project Colour: | Red □ | Blue □ |
| Project Number: | | |
| Your funding request: | Individual loan □ | Group loan □ |

In case you answered «group loan», please specify the share of your profit you are willing to set as guarantee in case your project is successful but your partner's project is not:

$q = \%$

My group's members are:

| | Name | Project Number |
|---|---|---|
| 1 | | |
| 2 | | |

*Note that people in the same group must state the same value of q.*

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