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Cost Efficient Joint Liability Lending

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Abstract

Traditional micro-lending schemes suffer from high transaction costs relative to the loan size, which renders many small loans uneconomical. This paper proposes an alternative lending protocol with lower transaction costs and shows that in theory repayment rates are not compromised. We then use laboratory experiments to confirm this finding. Finally we conclude that our lending protocol if implemented could improve social welfare by reducing transaction cost.

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1 Introduction

Joint liability lending is one of the most recognised features in micro-credit and it allows many people to borrow where they otherwise would not be able to on their own. Joint liability often implies high repayment rates.

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Unfortunately, the traditional joint liability lending protocols suffer from high transaction cost, which threaten the financial sustainability of lending institutions despite of high repayment rates. On these grounds, this paper sets out to search for a different lending protocol that on the one hand reduces transaction cost without on the other hand reducing repayment rates.

At its best, joint liability lending allows borrowers to insure one another against default risk and through this channel improves social welfare. The incentive to cover for the defaulting member in the group comes from the fact that the bank will only renew the loan if all loans are repaid. If one of the group members fails to repay, the entire group will be cut off from borrowing. Over the years, many micro-credit institutions have successfully used joint liability to improve the loan repayment rates. Ghatak (1999) showed that joint liability lending is a solution to the adverse selection problem if borrowers have more information about each other than the lenders. The result is that through assortative matching, borrowers of the same type will be in the same group. Sorting occurs because although lenders charge the same interest rates for each borrowing group, the effective interest rates for each type of borrower will be different. Joint liability lending can also create an incentive for borrowers to monitor each other (Stiglitz (1990)). For the case where there are social penalties for delinquent partners, Besley and Coate (1995) and Armendariz de Aghion (1999) demonstrated that if the penalties are high enough, repayment rates will be higher for joint than for individual lending.

Unfortunately, micro-credit institutions only give small loans which means they face high transaction costs relative to the loan volume, since the main component of the transaction cost is fixed. In fact, transaction cost is the most important cost of lending for micro-credit institutions (Shankar (2007)). Transaction costs include group formation cost, cost of appraisal, documentation cost, cost of time spent in field work and cost of monitoring. There is also the additional cost of avoiding default that arise from field staff spend extra effort with a group when there is a problem. If one of the members fails to repay, then the bank will have to ask the non-default members to cover for their partner, which can be especially costly if group members are geographically separated and if groups are large. Thus, even though micro lending institutions such as the Grameen Bank can achieve high repayment rates, these high repayment rates do not necessarily lead to financial sustainability of the bank (Armendariz de Aghion (1999)).

In what follows, we propose a mechanism where borrowers still can benefit from an insurance effect but with lower transaction costs for the lending institution. In our protocol, once the loan is due a loan officer will collect the repayment from each group member according to what they are willing to contribute. There is no "second chance" in matching the repayment required for the bank to continue lending to the group. Any overpayment from a group will then be redistributed equally among group members. By removing the additional steps of having to go back to group members multiple times reduces after some individuals fail to repay, the collection cost can be considerably reduced. These savings are particularly large if borrower groups have many members. Our theoretical results show that our proposed protocol has the potential to lead to repayment rates as high as those predicted for the traditional lending protocol. As there are multiple equilibria under both lending schemes, the theoretical prediction is not conclusive though. Moreover, we know that in similar environments, actual behaviour often deviates from theoretical predictions (see e.g. Ledyard 1995, Zelmer 2003 and Chaudhuri 2011 for behavioural regularities in voluntary contribution games). Thus, we use experimental methods to settle the question if our proposed scheme achieves repayment rates as high as the conventional lending scheme.

Currently, there exist only a few laboratory experiments that compare the effectiveness of individual and joint liability lending. Abbink et al. (2006) conducted an experiment comparing individual and joint liability lending where subjects played a game similar to a voluntary contribution mechanism for public goods. They varied the group sizes and how the group was formed to test the effect of group size and social ties in joint liability lending. Their results showed that joint liability lending outperformed individual lending in all of their treatments. Cason et al. (2008) compared individual and joint liability lending by varying the cost of monitoring for both peer monitoring and lender monitoring. In their treatment there was one player in a group who acted as a bank and made lending decisions. The authors' setup excluded strategic default by assumption and consequently the effectiveness of each lending scheme was assessed by comparing the lending rate by the bank and the average level of monitoring across schemes. The study found that if monitoring costs among borrowers were lower than those of the banks, then joint liability lending outperformed individual liability lending.

Werner (2010) measured the efficiency of different lending schemes (joint and individual) by the level of effort players put into their projects to isolate the effect of moral hazard in joint liability lending from other factors. The result showed that even though joint liability lending outperformed individual liability, a moral hazard problem still exists. Gine et al. (2010) used data from a natural experiment in the Philippines where loan centres gradually converted joint liability loan contracts into individual liability loan contracts, while all other aspects stayed the same. They found that there was no change in loan repayment rates after the conversion. Their results implied that joint liability itself does not improve the loan repayment rates. However, prior to removing the joint liability contracts, the bank had already reissued loans to borrowers in good standing even if someone in the same group had defaulted. This seems to suggest that the joint liability lending contracts used earlier had already provided the necessary screening for project quality.

Our experimental design is closest to Abbink et al. (2006) since we also focus on repayment decisions and not on effort or monitoring. However, Abbink et al. model joint liability lending as a one round voluntary contribution mechanism which is repeated if the sum of repayments exceeds a threshold (up to eight times), while our experimental design allowed subjects to explicitly choose if they would like to make an additional repayment for their defaulting partner. Another main difference is that Abbink et al. limited play to a maximum of eight rounds while our experiments implement an infinitely repeated game setting, which only stops if subjects default. In contrast to Abbink et al., our primary question is not if humans are able to cooperate in a setting, where backward induction should theoretically prevent it. We chose an infinitely repeated game setting instead, as we want to compare different joint liability lending schemes using standard theory, which is much simpler in an infinite horizon environment.

In our treatments we vary the repayment protocol in order to be able to compare repayment rates. We find that our transaction cost saving protocol does as well as the conventional protocol, as repayment rates are not significantly different. Thus our protocol, if implemented could save considerable transaction cost for lending institutions without jeopardising low default rates. This wold allow the further extension of micro-lending to people with smaller projects.

The organisation of this paper is as follows. We first set up a simple game theoretical model for individual lending (benchmark), traditional joint liability lending protocol and our proposed joint liability lending protocol. Next, we compare the predicted equilibrium welfare across all three lending protocols. Then we present our experimental design. Finally, we report our experimental results and discuss their implications.

2 Setting

Before we begin to describe our model, we will state our assumptions and the role of lender and borrowers in our environment.

Lender: The bank is a benevolent lender who issues loans under either an individual or a joint liability lending scheme. We assume that the bank's cost of funds is c per borrower. Therefore, the bank requires an individual borrower to repay at least c to recover the cost of funds. We assume that the bank uses a reputation mechanism to induce loan repayment. Delinquent clients will be cut off from future borrowing while it will renew the loans of borrowers who repay on time.

Borrowers under joint liability lending: There are two ex ante identical borrowers who both have a project with the same probability of success, capital requirement and earnings potential. The income from a project is denoted by θ_i. For a successful project, $\theta_i = \pi$ and for an unsuccessful project, $\theta_i = 0$. The probability of success is assumed to be independent across projects. To demonstrate the insurance effect we also assume that the successful project is highly productive such that if only one investment is successful, the resulting return will be sufficient to cover for an unsuccessful partner (i.e. $\pi > 2c$).

We further assume that the probability of success is independent across projects and that borrowers are risk neutral. In order to focus on the strategic default problem, we assume that borrowers use all income at the end of each period such that they do not accumulate assets over time and that they have no other source of income.

Welfare

The expected surplus per borrower for period t is $\upsilon_t p(\theta_i - d_i)$ where υ_t is the probability that period t is reached and d_i is the amount a borrower decides to repay. If under a regime, the probability of progressing from t to $t+1$ (υ) is constant, then the ex ante total expected surplus is $\sum_{t=0}^{\infty} \upsilon^t(\theta - d_i)$ which increases in υ.

Definition 1. *Other things being equal, a regime is more efficient if and only if the probability of reaching a new period (υ) is higher for all periods.*

3 Comparing different lending schemes

3.1 Individual liability lending as a benchmark

We start by establishing the repayment condition under an individual liability lending scheme where each individual borrower is responsible for her own repayment. The bank uses a reputation mechanism and continues to fund the loans only if the borrower repays at least c.

Suppose a borrower i reached a period t and observed the outcome of her own project θ_i but has not yet decided on the amount to repay d_i, then her expected future profit is given by

$$\theta_i - d_i + \phi V$$

where V is the continuation value representing the expected future profits from repaying the loan, $d_i \in [0, c]$ is the amount repaid by borrowers, and

$$\phi = \begin{cases} 1 & \text{if } d_i \geqslant c \\ 0 & \text{otherwise} \end{cases}$$

Proposition 1. *Under individual liability the uniquely optimal plan of action is* $d_i = c$ *whenever* $\theta_i = \pi$ *and* $d_i = 0$ *otherwise iff* $\frac{c}{\pi} \leqslant p$

Proof. In the case of $\theta_i = 0$, the borrower has no means to repay and will default. It remains to check $\theta_i = \pi$. For a strategy to be an equilibrium, we require that a subject has no incentive to deviate from it. The best deviation for a borrower in this case is to "take the money and run". Defaulting on the loan would yield a payoff of π. A borrower's payoff from repaying the loan whenever possible is,

$$\pi - c + V$$

where

$$V = p(\pi - c) \sum_{t=0}^{\infty} p^t$$

Note that a borrower who decides not to repay in the future will never repay today. For this reason, the continuation value is based on repaying whenever possible. Thus, $d_i(\pi) = c$ requires

$$\begin{aligned} \pi - c + V &\geqslant \pi \\ V &\geqslant c \end{aligned}$$

Therefore, a borrower will have no incentive to deviate if $\frac{c}{\pi} \leqslant p$. $\square$

Thus, an individual borrower will always repay the loan whenever possible if the loan repayment costs less than the expected income.

3.2 Traditional joint liability protocol

We now compare this result with that from the traditional joint liability lending scheme. Under joint liability lending, the bank lends to each individual member in a group. Group members are not only responsible for their own repayment but also for their partners' repayments. If they are willing to cover for each other whenever possible, the probability of reaching a new period is $2p - p^2 > p$. Recall that under individual liability the probability of reaching the new period is p. If the members of a group of two cover for each other, then joint liability only stops if both are unsuccessful. So if group members can overcome the free-riding incentive, joint liability lending can improve social welfare. While there might be many equilibria, we concentrate on those that are stationary. The two candidate equilibria are 1) A cover equilibrium, where everybody pays if possible and also covers if possible with the continuation probability of $2p - p^2$. 2) A default equilibrium where nobody ever repays and the continuation probability is zero. Given that these equilibria span the full possible spectrum of efficiency from the highest to the lowest possible efficiency, concentrating on these equilibria is sufficient, as non-stationary equilibria are time-variant mixtures of the stationary ones.

In reality it is hard to verify other's income so we assume that project outcomes are private information. After observing their own returns, borrowers simultaneously send a message about their project's outcome, $m_i(\theta_i)$, to their partner. Without loss of generality we assume that messages are restricted to either "my project is successful"' or "my project is unsuccessful", denoted by π and 0 respectively. Borrowers then form a belief about their partner's income from the project and simultaneously decide on the amount they want to repay. The bank will only keep lending to the group if eventually a repayment of 2c has been made.

The timing of the game is as follows:

1. Borrowers observe θ_i where $\theta_i \in \{0, \pi\} \forall i$.

2. Borrowers simultaneously send a message $m_i(\theta_i)$ where $m_i(\theta_i) \in \{0, \pi\} \forall i$.

3. Borrowers then make a repayment decision, d_i^1.

4. If $d_i^1 + d_j^1 \geqslant 2c$, loans are renewed and the process returns to (1). However, if $d_i^1 + d_j^1 < 2c$, borrower i whose $d_i^1 = c$ will be asked to contribute for her partner. In that case, there is a second loan repayment decision that is,

5. Borrower i with $d_i^1 = c$ takes a second repayment decision, d_i^2

6. If $\sum(d_i^1 + d_i^2) \geqslant 2c$, loans are renewed and the process returns to (1). Otherwise, the game ends.

Borrower i's expected payoff is $\theta_i - d_i^1 - \alpha d_i^2 + \phi V$ where V is the continuation value and

$$\alpha = \begin{cases} 1 & \text{if } d_i^1 + d_j^1 < 2c \\ 0 & \text{otherwise} \end{cases}$$

$$\phi = \begin{cases} 1 & \text{if } d_i^1 + d_i^2 + d_j^1 + d_j^2 \geqslant 2c \\ 0 & \text{otherwise} \end{cases}$$

A borrower's expected payoff depends on her income from her investment, her repayment decision d_i^1, her decision to cover for her partner d_i^2, and her expected future income from reinvestment if the loan is renewed.

Formally, we consider the strategic game $G =< N, (S_i), (u_i) >$ in which $N \in \{i, j\}, s_i \in S_i$ where $s_i = \{m_{it}(\theta_{it}), d_i^1(\theta_{it}, m_{jt}(\theta_{jt}), H_t, t), d_i^2(\theta_{it}, m_{jt}(\theta_{jt}), H_t, t, d_i^1(.), d_j^1(.)\} \quad \forall t, H_t, \theta_{it}, \theta_{jt}$ and $Eu_i(s_i, s_j) = \theta_i - d_i^1 - \alpha d_i^2 + \phi V$.

The main problem with the case where borrowers cannot monitor each other's project outcome is that both group members have an incentive to lie when they are successful. If it were possible to make the partner believe that the own project failed, then in the case of the partner being successful, profitable free riding could occur. Free-riding behaviour might prevent group members from taking advantage of an insurance effect. In what follows, we will formalise this idea and show that it is a severe problem.[1]

3.2.1 Separating equilibrium

Because we are interested in determining if joint liability can improve social welfare compared to individual liability lending, we only consider the case where a separating equilibrium can potentially improve social welfare.

[1] We ignore the case where players lie when their project is unsuccessful since in that case, players cannot repay and will immediately default.

Proposition 2. *There is no stationary equilibrium where $m_i(\pi) \neq m_i(0) \quad \forall i$ and the probability of reaching a new period is greater than p.*

Proof. Please see the proof in the appendix. □

Proposition 2 shows that borrowers have an incentive to lie and free-ride on their partner when their project is profitable. Thus, incomplete information hinders cooperative behaviour among group members and may result in lower social welfare.

Next, we consider the case where borrowers do not send a truthful message. We will demonstrate that there is a welfare-improving equilibrium, a "cover equilibrium" but there is also a welfare-worsening equilibrium, a "default equilibrium". We will also show that in the case of private information, a parameter space exists where both equilibria can be sustained.

3.2.2 Pooling equilibrium

In a pooling equilibrium the belief after observing a message is equal to the prior belief since messages are not informative. In this section, we will show that for a certain parameter space there exists a pooling equilibrium that is more efficient than the individual liability lending, the "cover equilibrium." Under this cover equilibrium, borrowers always repay in the first round if they have successful projects and repay for their partner if needed. This equilibrium generates higher welfare than individual lending because the group will only default if both borrowers projects fail. The probability of reaching a new period under this equilibrium is $2p - p^2$ which is greater than p under individual lending.

Proposition 3. *There exists an equilibrium with the strategy profile $s_i^* = (d_i^1(\pi, .) = c; d_i^2(\pi, d_j^1 = 0) = c, d_i^2(\pi, d_j^1 = c) = 0, \cdot) \quad \forall i$ iff $\frac{c}{\pi} \leqslant \frac{p}{2-p}$.*

Proof. First note that $d_i^2(\pi, d_j^1 = 0) = \pi$ is subgame-perfect following $d_i^1(\pi) = c$ since otherwise the game ends with certainty and player i loses her initial repayment. Secondly, when $d_j^1 = \pi$, it is always in player i's best interest to take $d_i^2(\pi, d_j^1 = \pi) = 0$. It remains to show the condition required for $d_i^1(\pi, .) = c$, which is

$$\begin{aligned} p(\pi - c) + (1-p)(\pi - 2c) + V_i &\geqslant \pi + pV_i \\ V_i &\geqslant \frac{(2-p)c}{1-p} \end{aligned}$$

where V_i is the expected continuation value for player i. When both players play s_i then

$$\begin{aligned} V_i &= \sum_{t=0}^{\infty}(1-(1-p)^2)^t(p^2(\pi-c)+p(1-p)(\pi-2c)) \\ &= \frac{p^2(\pi-c)+p(1-p)(\pi-2c)}{(1-p)^2}. \end{aligned}$$

Thus, $d_i^1(\pi,.)=c$ is optimal when

$$\begin{aligned} \frac{p^2(\pi-c)+p(1-p)(\pi-2c)}{(1-p)^2} &\geqslant \frac{(2-p)c}{1-p} \\ \frac{c}{\pi} &\leqslant \frac{p}{2-p}. \end{aligned}$$

□

Unfortunately, there also exist a welfare worsening equilibrium under joint liability lending where the probability of reaching a new period is zero. This is established in the following Proposition.

Proposition 4. *There exists an equilibrium with the strategy profile* $s_i^* = (d_i^1(\theta_i,\theta_j) = d_i^2(d_i^1(\theta_i,\theta_j)=0) \quad \forall\theta i,\theta_j\}\forall i$ *iff* $\frac{c}{\pi} \geqslant \frac{p}{2}$.

Proof. Note that the best deviation from this default strategy is to always repay, $d_i^r(\pi,\pi)=c$. Also, note that $d_i^1(\pi,\pi)=c$ implies the subgame-perfect continuation of $d_i^2(\pi,\pi)=c$, since otherwise the initial repayment is lost. Thus the condition required for $(d_i^1(\theta_i,\theta_j)=d_i^2(d_i^1(\theta_i,\theta_j))=0)$ to be optimal is

$$\begin{aligned} &\pi \geqslant \pi - 2c + \sum_{t=0}^{\infty} p^t p(\pi-2c) \\ &\frac{c}{\pi} \geqslant \frac{p}{2} \end{aligned}$$

□

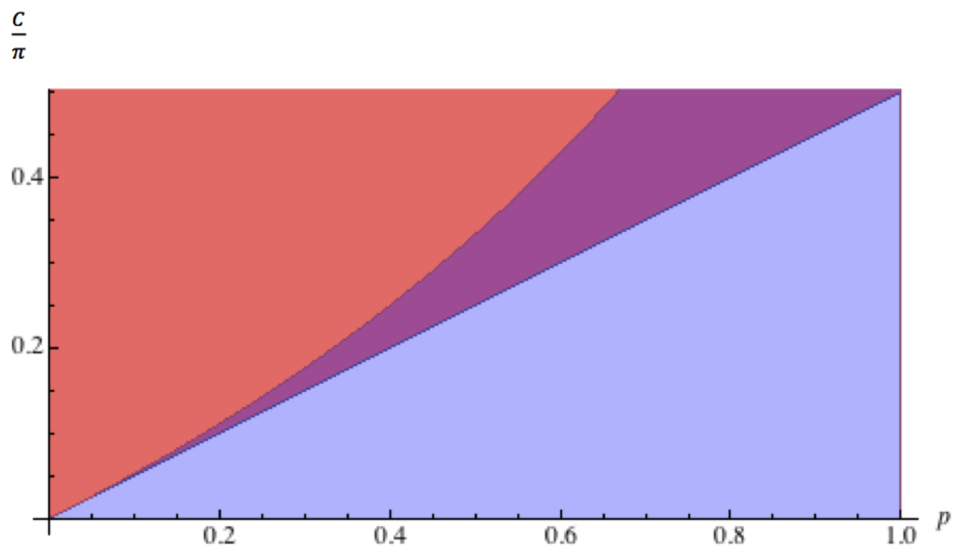

Figure 3.1: Joint liability under incomplete information

In this case, lending will end after the first round. Therefore, if borrowers select to play this equilibrium, they will obtain the lowest possible surplus.

Figure 3.1 shows the parameter spaces where the two equilibria exist. The cover equilibrium exists in the blue area. In the red area, the default equilibrium exists. Both equilibria exist in the overlapping area (purple area). The coordination problem exists in the parameter space where the red and the blue areas overlap. That is, there is a coordination problem when $\frac{p}{2} \leqslant \frac{c}{\pi} \leqslant \frac{p}{2-p}$; on these parameter values both the most and least efficient equilibrium exist and the outcome depends on borrowers' equilibrium selection.

3.3 Transaction cost reducing protocol

The main transaction cost saving feature of our proposed protocol is that only on payment decision has to be made and that no following up on borrowers with defaulted partners is necessary. Since transaction costs are the main cost of running micro-finance institutions, this may help improve the financial viability of micro-finance as long as it does not reduce the repayment rates. Our protocol works as follows: The bank asks the borrowers to repay as much as they can of the total loan. Then if the total repayment of the group exceeds the total debt lending will continue and potential over-payment will be returned to the individual group members. If the total repayment does not cover the group debt a default is declared and lending stops without any additional rounds of asking for payments.

We will show that the "cover equilibrium" still exists for the same parameter space as for the traditional joint liability protocol. To keep the analysis consistent, we will again assume private information on project outcomes.

With the alternative protocol, the timing of the game has changed to:

1. Borrowers observe their own θ_i where $\theta_i \in \{0, \pi\} \forall i$.
2. Borrowers simultaneously send a message $m_i(\theta_i)$ where $m_i(\theta_i) \in \{0, \pi\} \forall i$.
3. Borrowers then make a repayment decision, d_i.
4. If $(d_i + d_j) \geqslant 2c$, loans are renewed and the process returns to (1). Otherwise, the game ends. The bank redistributes $\frac{1}{2}(d_i + d_j - 2c)$ back to each member if $d_i + d_j > 2c$.

Borrower i's expected future profit is given by $\theta_i - d_i + \phi V + \frac{1}{2}\lambda(d_i + d_j - 2c)$ where V is the continuation value representing the expected future profits from repaying the loan and

$$\phi = \begin{cases} 1 & \text{if } d_i + d_j \geqslant 2c \\ 0 & \text{otherwise} \end{cases}$$

$$\lambda = \begin{cases} 1 & \text{if } d_i + d_j > 2c \\ 0 & \text{otherwise} \end{cases}$$

Borrower's expected payoff depends on her income from her investment, her repayment decision d_i, and the amount her partner repaid.

Formally, we consider the strategic game $G =< N, (S_i), (u_i) >$ in which $N \in \{i, j\}, s_i \in S_i$ where $s_i = \{m_{it}(\theta_{it}), d_i(\theta_{it}, m_{jt}, H_t, t), H_t, t, d_i(.), d_j(.)\}$ $\forall t, H_t, \theta_{it}, \theta_{jt}$ and $Eu_i(s_i, s_j) = \theta_i - d_i + \phi V + \frac{1}{2}\lambda(d_i + d_j - 2c)$.

The alternate protocol faces the same problem as the traditional protocol with private information in that borrowers will always have an incentive to lie when they have a successful project. Therefore, there is no welfare-improving separating equilibrium. The proof is analogous to the proof for the traditional scheme in the previous Section.

3.3.1 Pooling equilibrium

Even though there is no separating equilibrium that is more efficient than an individual liability lending scheme, group members can still take advantage of an insurance effect and improve their surplus. We will show that there exists an equilibrium where borrowers always repay $2c$ whenever they can regardless of their partner's signal. Under such equilibrium, the group will continue borrowing with the probability of $2p - p^2$ which is greater than the probability of loan renewal under individual lending.

Proposition 5. *There exists an equilibrium with the strategy profile* $s_i^* = (d_i(\pi, .) = 2c, \cdot) \quad \forall i$ *iff* $\frac{c}{\pi} \leqslant \frac{p}{(2-p)}$.

Proof. Note that the best deviation from $d_i(\pi, .) = 2c$ is to always default given that player i's partner is playing this cover equilibrium. The condition required for s_i^* to be optimal is

$$\pi - 2c + pc + p(\pi - 2c + pc)\sum_{t=0}^{\infty}(1-(1-p)^2)^t \geqslant \pi + \frac{p^2\pi}{1-p}$$
$$\frac{c}{\pi} \leqslant \frac{p}{(2-p)}$$

□

Note that the condition for this equilibrium is the same as the condition for a cover equilibrium under the traditional joint liability protocol. This equilibrium achieves the highest expected surplus.

Unfortunately, there exists welfare-worsening equilibrium under this alternate protocol.

Proposition 6. *There exists an equilibrium with the strategy profile* $s_i^* = (d_i(\theta_i, \theta_j) = 0 \quad \forall \theta_i) \quad \forall i$ *iff* $\frac{c}{\pi} \geqslant \frac{p}{2}$.

Proof. As the borrowers never repay independently from the realised type profile, the proof is analogous to that of Proposition 4. □

The condition under which both "cover equilibrium" and "default equilibrium" exist under this alternate protocol is identical to the condition where both equilibria exist under the traditional protocol. However, as our new protocol reduces the number of repayment steps, transaction cost saving can be made. Next, we will formally compare the potential welfare under each lending scheme.

4 Welfare comparison

In the previous section, we proved that both joint liability lending protocols can be welfare-improving, i.e. they can achieve higher probability of reaching a new period. In this section, we will show the condition under which this is possible.

Proposition 7. *Joint liability lending under both protocols can improve the maximum expected total surplus if* $\frac{p}{2} \leqslant \frac{c}{\pi} \leqslant p^2(2-p)$.

Proof. Definition 1 states that a regime is more efficient if and only if the probability of reaching a new period is greater. If the condition above is satisfied, the most efficient equilibrium yields a probability of reaching a new period of $2p - p^2 > p$ which is the probability of reaching a new period under an individual liability lending equilibrium.

□

Proposition 8. *The alternate protocol can potentially achieve the same social welfare as the traditional protocol.*

Proof. The condition where a traditional joint liability lending protocol performs best is $\frac{c}{\pi} \leqslant \frac{p}{2-p}$. This is the same condition required for borrowers under the alternate regime to be able to fully take advantage of the insurance effect.

□

5 Comparing the performance of the two protocols

We have seen theoretically that joint liability under the alternate protocol can reach the best possible social welfare just as traditional protocol. In this Section, we use an experiment to verify our theoretical results.

5.1 Experimental design

The experimental design follows the theoretical framework. We set the probability of a successful project to $p = 0.6$ and the successful project revenue to $\$E100$.

The timing of the game under the traditional protocol is as follows.

1. Subjects learn their project outcome. If their project is successful, they earn $\$E100$. Otherwise, they do not earn anything and cannot make a repayment.

2. The partners can communicate with each other before reaching their repayment decision of either 0 or $\$E45$ by choosing one of the following three messages: "I do not want to talk"; "My project is successful"; "My project is unsuccessful."

3. If the total repayment of the group is equal to $\$E90$, the game continues to the next round. If no one repays, then the game ends. If the total repayment is $\$E45$, the subject who repaid will be asked to make up for the rest of the group's liability. Subjects can either choose to repay an extra $\$E45$ or to default.

4. Once the repayment decision is final, we reveal the amount each subject contributed, profits for the round, and if the repayment is sufficient for the game to continue.

The timing and setup for the alternative protocol treatment is identical up to step three which becomes:

1. If the total repayment of the group is at least $\$E90$, the game continues to the next round. Otherwise, the game ends. Any overpayment is redistributed equally among subjects in that group.

We start our experimental investigation by using parameter values that theoretically do not allow for any welfare improving effects from joint liability lending. So we chose $p = 0.6$, $\pi = 100$ and $c = 45$. At first sight this choice seems strange. The rationale is the following. Knowing that humans often cooperate in situations where standard theory would not predict it, this is the right starting point. Then if we achieve close to full repayment in this situation we do not have to test the case where the parameters are more favourable for cooperation. On the other hand if theory is confirmed and repayment rates are close to zero then in a next step one would repeat the test with parameters that theoretically allow for repayment equilibria. Our hypotheses are:

Hypothesis 1. *The estimated probability of reaching a new period under both joint liability lending treatments is lower than that of individual liability lending ($p = 0.6$).*

Hypothesis 2. *There is no statistical difference between the estimated probability of reaching a new period of the alternate and the traditional joint liability lending protocol.*

5.2 Experimental procedures

We used the computer program 'z-Tree' (Fischbacher (2007)) to conduct our experiment in AdLab at the University of Adelaide, Australia. Subjects were recruited using ORSEE (Greiner (2004)). Most of the subjects were university students from various disciplines. There were four sessions with 84 participants. There are 5 games in a session and each game consisted of an undetermined number of rounds. Two subjects were randomly paired to form a group. Each subject remained anonymous throughout the session. To get a greater number of observations, we changed the group composition after each game such that subjects would not be matched with the same partner twice. Subjects were given context-free instructions outlining the game at the beginning of each session.

For the traditional protocol, after subjects had realised their project outcome, each subject could chose to send one message out of the three described above or choose not to send any message. Then they could choose to either repay $\$E45$ or to pay nothing. If the group's total repayment was $\$E90$, profits were shown and the game continued to the next round. If the group's total repayment was $\$E45$, the subject who decided to repay $45 was asked if she wanted to make up for the rest of the loan repayment. If she did, profits were revealed and then the game continued to the next round. In the default case (both failed to repay when asked in the first repayment round or someone refused to cover), the game ended and profits for the round were displayed.

For the alternate protocol, subjects were asked to enter the amount they would be willing to contribute as they realised their project's outcome. If the group's total repayment was at least $\$E90$, profits were revealed and the game continued to the next round. If the total group's contribution was higher than $\$E90$, then the excess amount was redistributed equally within that group. Otherwise, the game ended. Since a new game did not start until all groups in the session had completed the current game, we allowed subjects to do other quiet activities.

After each session, the subjects were paid in cash. The subjects were paid a show-up fee of AUD 5 and their earnings during the session. The exchange rate was one Australian Dollar for 50 Experimental Dollars. On average, each session took about one hour and subjects earned about AUD 18.

5.3 Results

In this section, we first use a logistic model to estimate the repayment rates for both joint liability lending protocols. We then use the estimated repayment rates as well as the probability that each state of the world can occur to find the probability of reaching a new period so we can compare social welfare between each lending protocol. The greater the probability of reaching a new period, the higher the welfare.

5.3.1 An overview of loan repayment

We use a logistic regression model to estimate the repayment rates under both joint liability treatments. The dependent variable is 0 if the repayment is insufficient and 1 if the repayment is sufficient for the game to continue.

$$\text{logit}\{Pr(continue = 1)\} = \beta_0 + \beta X_{it} + \varepsilon_{it}$$

Our independent variables consists of a set of dummies: $Joint_i$ means that the observation was taken from the traditional protocol treatment and that i projects where successful. Alt_i indicates that the alternative protocol was used and that i projects were successful. [2]

The left hand side of Table 5.1 shows the estimated log odds that the loans would be repaid. The log odds of repayment rates are positively related to the traditional protocol. The probability that loans were repaid decreases slightly when we switch from a traditional to the alternate protocol.

[2] We omitted the states of the world where there is no success since the subjects will automatically default and there is no decision made.

Table 5.1: Logistic estimation of repayment rates

Variable	**Coefficient**	**Predicted repayment rates**
Constant	1.542***	
	(.320)	
Joint1	.056	.832
	(.222)	(.021)
Joint2	1.553***	.957
	(.348)	(.013)
Alt1		.824
		(.024)
Alt2	1.108***	.932
	(.366)	(.021)
Log likelihood=-346.156; LR chi2(3) = 35.85; Prob>chi2 = 0.0000		
standard errors are shown in parentheses		*** significant at 0.001

The right hand side of Table 5.1 shows the predicted repayment rates under different states of the world. The estimated repayment rates of one means that subjects will always repay the loans. Recall that our theory predicted immediate default. In spite of theoretical prediction, our estimated repayment rates is very close to one when both group members have successful projects. However, when only one group member has a successful project, it is harder to coordinate the loan repayment. Observe that the repayment rates under a single success is approximately 10 percent lower than that under double successes in both treatments.

5.3.2 Comparing different lending schemes

We use our result to test whether there is any statistically significant difference between the traditional and the alternate joint liability treatment under different states of the world. We find no statistical difference between the two treatments in both states of the world ($p \approx 0.801$ when there is one successful project and $p \approx 0.317$ when there are double successes).

We then use the value obtained from Table 5.1 along with the probability that each state of the world can occur to calculate the estimated probability of reaching a new period. The probability that there is one successful project is $2p(1-p) = 0.48$ and the probability that both projects are successful is $p^2 = 0.36$. From the data, the estimated probability of reaching a new period under the traditional joint liability lending scheme is 74.4 percent. Under the alternate protocol, the estimated probability of reaching a new period is 73.1 percent which is only slightly lower than the traditional scheme. Recall that the maximum probability of reaching a new period under individual lending is 0.6. Thus, even though we stack the deck against joint liability lending in our treatments, subjects show that they can overcome the coordination problem such that joint liability schemes are welfare-improving.

In answer to Hypothesis one we can state the following result.

Result 1. *Contrary to our theoretical results, repayment rates under both joint liability schemes are higher than the maximum repayment rate under individual lending.*

We then test if there is any significant difference between the probability of reaching a new period in the two treatments. Formally we test:

$$2p(1-p)(joint1) + p^2(joint2) \gtreqless 2p(1-p)(alt1) + p^2(alt2)$$

where $joint_i$ is the predicted continuation probability (at the mean) under the traditional protocol and alt_i is the predicted continuation probability (at the mean) under the alternate protocol. The i subscript again denotes the number of successful projects.

We cannot reject the null hypothesis that there is no difference between the two treatments ($p \approx 0.473$).

Result 2. *There is no statistically significant difference between the estimated repayment rates under the traditional and the alternate joint liability lending protocol.*

The results conform with our prediction that when there is incomplete information among group members, both joint liability lending protocols can potentially reach the same welfare level. However, the results also contradict our theoretical prediction that when the cost of loan repayment is $\$E45$, the repayment rate should be zero. This result may be due to reciprocal solidarity leading to group members covering for each other and refraining from free-riding.

6 Conclusion

In this paper, we examined an alternative to the traditional joint liability lending protocol that reduces transaction costs. This protocol lowers the transaction cost by reducing the steps the bank needs to take when chasing group members with a defaulted partner.

Most existing papers find the benefits of joint liability lending based on social capital, that is, group members have more information about each other than the bank has (Ghatak (2000), Ghatak (1999), Rai and Sjöström (2004), Bhole and Ogden (2010)). In contrast to these papers we entertained the possibility that our alternate protocol can achieve the same outcome without any assumption on social capital. The benefits of joint liability lending comes from the fact that if group members can overcome the free-riding incentive, they can mutually insure one another against risk of default. Our theoretical results showed that a joint liability lending scheme can potentially improve social welfare even without social capital. Our alternate joint liability lending protocol is also able to reach the same outcome but with potentially significant lower transaction cost.

Our experimental results revealed that subjects were able to overcome free-riding incentives under both joint liability protocols and the estimated social welfare was higher than the maximum possible with individual lending. Moreover, our alternate joint liability protocol was able to achieve the same social welfare as in the traditional protocol treatment, which implies that our proposed new protocol could – conditional on the external validity of our results – provide substantial savings in transaction cost, without jeopardising the repayment rates.

Appendix

Proof for Proposition 2

Proof. There is a stationary equilibrium where $m_i(\pi) \neq m_i(0) \quad \forall i$ when both borrowers intend to default. The default equilibrium exists regardless of the realised type profile. However, under this separating equilibrium the probability of reaching a new period is $0 < p$. Thus, it is not welfare improving.

Next, we show that a non-stationary strategy where one player is a "sucker" and the other is a "free-rider" cannot be part of the equilibrium where $m_i(\pi) \neq m_i(0) \quad \forall i$. In what follows we will show this set of strategies:

$$s_i^* = (d_i^1(\pi, .) = c, d_i^2(\pi, .) = c, \cdot)$$
$$s_j^* = (d_j^1(\pi, .) = 0, d_j^2(\pi, .) = 0, d_j^1(0, \pi) = c, d_j^2(0, \pi) = c, \cdot)$$

is not compatible with sending a truthful message when the project is profitable. Consider the case where both players would send a truthful message. Observe that for player i to send $m_i(\pi) = \pi$ requires

$$\pi - 2c + V \geqslant \pi - (1-p)2c + V$$
$$(1-p)2c \geqslant 2c$$

Since $(1-p)2c$ is always smaller than $2c$, player i always has an incentive to lie.

Lastly, we show that there is no stationary equilibrium where $d_i^1(\pi_i, \pi_j) = c$ and $m_i(\pi) \neq m_i(0) \quad \forall i$. First note that $d_i^1(\pi, 0) = c$ always implies the subgame-perfect continuation $d_i^2(\pi, 0) = c$, since otherwise the game ends with certainty and the initial payment is lost. Secondly, any strategy that contains $d_i^2(\pi, \pi) = c$ for any i cannot be part of an equilibrium where $d_i^1(\pi, \pi) = c \quad \forall i$. To see this, observe that $d_i^2(\pi, \pi) = c$ implies that the game will continue regardless of $d_j^1(\pi, \pi)$ which makes it optimal for player j to free-ride and choose $d_j^1(\pi, \pi) = 0$. So there are only two strategies remaining that are candidates: a cover strategy s_i^c and a default strategy s_i^d.[3]

[3] We omit i's actions for the case that her project was unsuccessful since the repayment is trivially zero.

$$
\begin{aligned}
s_i^c &= (d_i^1(\pi,\pi) = c, d_i^2(\pi,\pi) = 0, d_i^1(\pi,0) = c, d_i^2(\pi,0) = c, \cdot) \\
s_i^d &= (d_i^1(\pi,\pi) = c, d_i^2(\pi,\pi) = 0, d_i^1(\pi,0) = 0, d_i^2(\pi,0) = 0, \cdot)
\end{aligned}
$$

We first will rule out any player using the cover strategy. Observe that $d_i^1(\pi,\pi) = c$ requires

$$
\begin{aligned}
\pi - 2c + V^c &\geqslant \pi, \text{or} \\
V^c &\geqslant 2c
\end{aligned}
$$

where V^c is the expected continuation payoff for player i playing the cover strategy.[4] This is incompatible with the condition for $d_i^2(\pi,\pi) = 0$, which requires

$$
\begin{aligned}
\pi - 2c + V^c &\leqslant \pi - c, \text{or} \\
V^c &\leqslant c
\end{aligned}
$$

The remaining potential equilibrium entails both players playing s_i^d. In what follows we will show that $d_i^1(\pi,\pi) = c$ and $d_i^2(\pi,\pi) = 0$ are not compatible in a potential defection equilibrium. The condition for $d_i^1(\pi,\pi) = c$ to be optimal is

$$\pi - c + V^d \geqslant \pi,$$

where V^d is the expected continuation payoff. Observe that $d_i^2(\pi,\pi) = 0$ requires that

$$\pi - 2c + V^d \leqslant \pi - c.$$

Combining the two conditions we find that an equilibrium with $d_i^1(\pi,\pi) = c$ can only non-generically exist for

$$V^d = c.$$

Observe that when both players play s_i^d then

[4]Note that V^c also depends on the strategy player j plays. The argument holds regardless of if j plays s_j^c or s_j^d.

$$V_i^d = \sum_{t=0}^{\infty} p^{2t}[p^2(\pi - c) + p(1-p)\pi]$$
$$= \frac{p(\pi - cp)}{1-p^2}$$

and

$$V_i^d = c \rightarrow c = p\pi$$

which is ruled out by assumption.

□

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