Is Joint Liability Lending More Efficient than Individual Lending?: A Theoretical and Experimental Analysis

by

Sujiphong Shatragom

A thesis submitted in partial fulfillment for the degree of Doctor of Philosophy

School of Economics

University of Adelaide

July 2012

Contents

List of Tables

List of Figures

Abstract

This thesis aims to compare loan repayment decisions under individual and joint liability lending schemes using game theoretical models and laboratory experiments. We find that even under the most unfavourable circumstances joint liability still gains significantly higher repayment rates than individual liability.

We also examine an alternate joint liability scheme that reduces transaction costs We find that there are potential benefits from adopting this scheme, as it does not undermine the high repayment rates achieved under the traditional scheme.

Lastly, we find that reducing the cost of repayment, allowing for communication and monitoring can improve the repayment rates.

Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Sujiphong Shatragom and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968.

I also give permission for the digital version of my thesis to be made available on the web, via the University is digital research repository, the Library catalogue, the Australasian Digital Theses Programme (ADTP) and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

Signature of Author

Acknowledgements

Writing this thesis has been my most challenging but valuable experience. It would not have been possible without the help of many people.

I am deeply grateful to my supervisor, Associate Professor Ralph-C Bayer, for his encouragement, support, and patience throughout my PhD study. His advice is always constructive and his encouragement is invaluable.

I also would like to thank Mickey Chan for his technical support in programming and conducting the experiments, as well as his friendship and encouragement through the difficult time. My appreciation also goes to Cecilia Kamel who gave me a permission to use her experimental data as well as proof reading one of my first drafts. I appreciate Cecilia and Lachlan Deer's help in conducting some of the experiments.

I am also grateful to the University of Adelaide and the Adelaide Laboratory For Experimental Economics for their generous financial support without which I would not be able to carry out my research.

I thank all the friends and colleagues I have met in Adelaide. In particular, John Snelling who has shown me how to be a good teacher and taught me invaluable lessons in life; Changxia Ke, Pataporn Sukontamarn, and Nopphawan Photphisutthiphong for their helpful inputs and companionship.

Finally, I dedicate my thesis to my family for their love and ongoing support.

Chapter 1

Introduction

Moral hazard is a problem that plagues lending businesses. The problem is more intense when lending to the poor than when lending to large companies. This is because the amount lent is often very small but the transaction costs are large compared to the size of the loans. Additionally, it is often hard to require collateral from the poor to safeguard against defaults. These are the main reasons why the formal lending sector often neglects the poor.

In recent years, many microfinance institutions have been using joint liability lending schemes to reduce the transaction costs and default rates. A general feature of joint liability lending schemes is that a bank lends to a group and all members of that group are responsible for their partners' loan repayment. This means that if one group member defaults, the other members will be cut off from future access to funding for their businesses. Joint liability creates an incentive for partners to help each other repay the loans. If a group is well coordinated and is able to overcome a free-riding incentive, then joint liability schemes can improve social welfare.

It is often claimed that joint liability lending schemes thrive in a society with well-endowed social capital (Stiglitz (1990); Besley and Coate (1995); Wydick (1999)). This does not mean, however, that joint liability lending schemes cannot improve social welfare when borrowers do not have any social connection. The advantage of group members acting as mutual guarantors still exists and this is called an "insurance effect". An insurance effect always exists; if members are willing to help each other, a group will only default on their loan when all members of the group have no income.

Unlike previous studies by others, our research does not assume any form of social capital. We mainly focus on whether humans are able to coordinate with their peers and benefit from an insurance effect under joint liability lending schemes. In this thesis, we examine the following questions: (i) Can joint liability lending outperform an individual liability lending under the most unfavourable circumstances?; (ii) Is there an alternate joint liability lending scheme that can further improve social surplus?; (iii) How is a group repayment decision affected by changes in cost of loan repayment, monitoring, and level of communication?

In Chapter two, we compare welfare under joint liability lending with welfare under an individual lending scheme. We use a simple game theoretical framework to model the strategic repayment decision. Initially, we assume that each group member can monitor their partner's ability to repay. In other words, we implicitly assume that borrowers had informational advantage over the bank. Our initial theoretical results show that the joint liability lending scheme suffered from a free-riding incentive, however it still benefits from an insurance effect and can potentially improve borrowers' social surplus. We then relax the assumption on borrowers' informational advantage. We find that once the information on their partner's income become private, the incentive to free-ride vanishes. This is because there is a risk that once a borrower defaults on her loan, her partner may not be able to repay the loan.

We then design an experiment to answer our first research question. There are only a few experiments that compare joint liability to an individual lending scheme and focus on borrower's decision to repay. In Abbink et al. (2006), the individual liability lending repayment rates used to compare with their joint liability lending scheme were hypothetical. They also had an ex ante limited number of rounds in which group members contributed. Our experiment includes an individual liability lending treatment and has an ex ante infinite number of rounds in which group members contributed. We improve upon Kono (2006)'s experiment by developing a clear theoretical framework and predictions for our experiment and only allowing each subject to participate in one treatment.

We set up our joint liability treatment within an environment that makes it difficult for subjects to coordinate their loan repayments. Specifically, we set our parameters such that our theoretical framework predicts an immediate default, while it predicts a unique repayment equilibrium for individual liability lending. Our results contradict the theoretical predictions and show that the joint liability treatment outperformed individual liability. Subjects were able to take advantage of an insurance effect.

Consequently, the results give strong support for using joint liability lending schemes to improve loan repayment rates and social welfare.

In Chapter three, we explore if we can further improve a traditional joint liability lending scheme. In practice, one of the main concerns in microlending is the high transaction costs. Even if a bank is able to sustain high repayment rates, it may still struggle to stay profitable due to the high transaction costs per borrower. A common joint liability lending practice where if a group member fails to repay the loan a borrower is asked to cover for her partner not only encourages free-riding but can potentially be costly when group members live far apart. This is because when a group member knows that her partner is able and willing to cover for her, it is in her best interest to strategically default. The bank then incurs an extra cost of collecting the repayments. We propose an alternate scheme where group members are only allowed to contribute once and if there is overpayment, the overpayment is redistributed equally within the group. The loan only continues if the contribution is sufficient. By removing a second chance to cover for their partner, this alternate scheme reduces the free-riding incentive. We show this in our theoretical framework. Unlike Tedeschi et al. (2006), Rai and Sjöström (2004) or Bhole and Ogden (2010), we do not aim to find an optimal lending scheme. We clearly show that our alternate joint liability lending scheme can either improve or worsen borrowers' surplus. Our main focus is on how humans react to the alternate scheme and if there is any gain from using it.

Our experimental design in the third Chapter closely follows the design in Chapter two. We leave all parameters and the communication environment unchanged. This allows us to investigate if there is any significant difference to subjects' repayment decisions. The results show that there is no significant difference in the performance of the two joint liability lending schemes.

Lastly, we explore how changes in cost of loan repayment, monitoring, and level of communication affect repayment decisions. Changes in these factors may have a great impact on borrowers' ability to coordinate and therefore on their social welfare. It is of great interest to find out how these changes can improve or deteriorate the repayment rates.

Knowing how borrowers react to changes in cost of loan repayment is important for a bank to determine an appropriate interest rate which in turn can greatly affect borrower's welfare. We show in the third Chapter that as cost of loan repayments increase, borrowers have stronger incentives to strategically default. In the forth Chapter, we decrease the cost of loan repayment. Our theoretical framework predicts that as the cost of loan repayment decreases, repayment rates increase. Our experimental results confirm this prediction.

Most literature identifies social capital as the main reason for the success of joint liability lending (Stiglitz (1990); Besley and Coate (1995)). In our theoretical framework, we inherently assume a form of social capital among group members when they could monitor their partner's income. Our theoretical results show that having knowledge of their partner's income may resolve the coordination problem within a group. We vary the ability for each member to monitor their partner's income in our experiment. The results show that changes in information among group members only significantly affect the repayment rates when the cost of loan repayment is high while there is no significant advantage when the cost is low. These results suggest that changes in the monitoring environment can improve the repayment rates under certain environment.

Although communication does not affect the final outcome in our theoretical prediction, there are a number of experiments that show that pre-play communication can improve cooperation within a group (Cooper et al. (1992); Charness and Grosskopf (2004); Ben-Ner and Putterman (2009)). We vary the way group members communicate from a free-form communication to no communication. We expect that pre-play communication will help group members to coordinate their repayment and thus increase repayment rates. Our experimental results show that pre-play communication is only effective in improving loan repayment when there is lack of information on their partner's income. This may be because communication is used as a substitute for monitoring as suggested by Ben-Ner and Putterman (2009).

Chapter five summarises the findings of this thesis and concludes.

Chapter 2

A Comparison of the Performance of Joint and Individual Liability Lending Schemes

2.1 Introduction

The business of lending is subjected to moral hazard. The problem is more critical in developing countries where it is costly to enforce loan repayments. Formal lending institutions often find it hard to make profits from lending to the poor. This is due to the high monitoring costs as well as the the inherent moral hazard and adverse selection problems involved. With these costs, it is difficult for low income borrowers to obtain a loan from a formal lending sector. Usury seems the inevitable option for poor people who need start-up capital for a small business. For the poor who want to start a business, there seems to be no other option but to pay exorbitant rates of interest on their loans.

In the past, governments in developing countries attempted to intervene by providing cheap loans through government sponsored credit programs. However, Braverman and Guasch (1986) reported that the rate of defaults in these programs in Africa, the Middle East, and Latin America were high - ranging from 40 to 95 percent. Moreover, most of the money ended up in the hands of the local elite instead of poor borrowers in need (Banerjee et al. (2011)). These failures are perhaps due to the inefficiency of market intervention and hidden political motives that drive the lending program. Armendariz de Aghion and Morduch (2007) and Banerjee et al. (2011) suggested that other reasons might include informal credit providers having extra information or more effective means of enforcing the contract than the state-owned bank.

Lenders often ask for collateral to protect themselves against the misuse of funds and strategic default. For example, it is hard to get a loan if you do not own land. Unfortunately, the very poor often do not have any marketable assets to use as collateral (Armendariz de Aghion and Morduch (2007)). Lenders might therefore use a borrower's reputation as collateral. Stiglitz and Weiss (1983) showed that lenders do not need collateral and can induce borrowers to commit to their investment by promising a new loan if they are able to repay the current loan. This can cause problems when borrowers are unable to repay the loan due to misfortunes and not because of moral hazard. Indiscriminately punishing borrowers who defaulted in the past may lead to inefficiency since a potentially profitable project might not be funded.

Joint liability is useful in reducing transaction costs as well as the rate of defaults. Borrowers will form a group and the loan will be distributed to individuals under this scheme. Members in the same group are jointly liable for their partners' repayment. If a member fails to repay, the other group members are considered as defaulting and will lose access to future loans. By taking advantage of lending in bulk and an insurance effect where borrowers act as mutual guarantors, joint liability lending schemes can potentially improve the welfare of the society. The Grameen Bank and its founder, Muhammad Yunus, have demonstrated that lending to the poor can be self-sustainable and can also change lives. For example, the Grameen Bank has repayment rates of 98 percent[1] with some branches achieving 100 percent repayment rates in 2008[2]. However, many lenders that use joint liability lending schemes fail to replicate Grameen Bank's success. Kenya's Jehudi scheme and the Good Faith Fund in Arkansas were among some of the failures (Ghatak and Guinnane (1999)). The obvious main causes of failure are coordination problems and, in many circumstances, a free-riding incentive inherent within the joint liability lending scheme.

Literature supporting the virtue of joint liability lending schemes often focus on social capital within the community that the formal lending sector lacks. Ghatak

[1] http://www.grameen-info.org/index.php?option=com_content&task=view&id=665&Itemid=685 [28 November 2009].

[2] http://www.grameen-info.org/index.php?option=com_content&task=view&id=669&Itemid=671[28 November 2009]

(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. This is because everyone prefers to be matched with borrowers who are more likely to succeed rather than with borrowers who are more likely to fail. The effect is that, although lenders charge the same interest rates for each borrowing group, the effective interest rates for each type of borrower will be different. This is the case as in equilibrium, borrowers with less risky projects will be less likely to have to bail out their partners than borrowers with risky projects.

A bank can also use joint liability lending to create an incentive for borrowers to monitor each other in cases where the partners can costlessly observe each other's activities (Stiglitz (1990)). Joint liability causes the expected utility of the borrowers to depend on the ability of their partners to repay which leads to more monitoring among partners. Besley and Coate (1995) and Armendariz de Aghion (1999) allowed for social penalties and demonstrated that if the social penalties are high enough, these penalties will lead to improvement in loan repayment rates compared to individual liability lending.

Rai and Sjöström (2004) suggested that the best outcome can be achieved by using cross-reporting. They assumed that the bank cannot observe borrowers' income, while borrowers can observe each other's income. The bank can ask borrowers to report on the income of any borrower in the partnership and only punish borrowers who falsely under-report their income. This will induce mutual insurance among borrowers whereby a more successful borrower has an incentive to help out their partners.

The success of the Grameen Bank has shown that joint liability can outperform individual liability lending under specific settings. Unlike the papers cited above, we do not assume any kind of social capital among borrowers since we intend to focus on the insurance effect. The insurance effect is always present whenever there is more than one party who is responsible for the loan. This is because the probability that all group members' projects fail, p^i (where p is the probability that the project is successful and i is the number of people in a group), is always lower than the probability that one individual project fails, p. When there is at least one successful project in a group, the more fortunate group members can help out their unlucky partners and ensure that all members obtain loans for their future projects. Joint liability lending automatically creates the insurance effect and can potentially improve the repayment rates. Our aim is to examine under which circumstances using joint liability lending can lead to higher social welfare.

In traditional joint liability lending, the bank lends to group members simultaneously. If the loans are repaid on time, then the lending process continues. When group members fail to repay, loan officers may pressure the other group members to repay on behalf of the defaulted members (Armendariz de Aghion and Morduch (2007)).

Our theoretical results show that a joint liability lending scheme can potentially improve social welfare even when group members do not have information about each other's income. However, it is unclear whether it actually improves social welfare since there are multiple equilibria, some of which are less efficient than individual lending. If group members fail to coordinate on a good equilibrium the social welfare can be lower than under an individual liability lending scheme.

We use experiments to test if humans can coordinate in such a way that the joint liability scheme improves social welfare. Our results show that even under circumstances least favourable for joint liability to be successful, welfare is much higher under the joint liability lending scheme.

The organisation of this Chapter is as follows. We first set up a simple game theoretical model capturing the main features of a lending situation without collateral. We then compare the equilibrium resulting from an individual liability lending with the equilibria under a joint liability lending scheme. With a particular focus on the differences in predicting social welfare, we design our experiments to test if joint liability lending actually improves welfare. Lastly, we report our experimental results and discuss their implications.

2.2 Setting

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

Lender: There is only one benevolent lender, the bank, who issues loans under both an individual and a joint liability lending scheme. The objective of the bank is to recover the opportunity cost of the funds.

We assume that the cost of funds is constant and equal to c per borrower. Therefore, to recover the cost of lending, the bank requires an individual borrower to repay at least c.

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, $\theta_i = 0$. In order to demonstrate the insurance effect we will also assume that if only one investment is successful, the resulting return will be sufficient to cover for their partner if needed (i.e. $\pi > 2c$).

We assume that the probability of success is independent across projects and that borrowers are risk neutral. To focus on the strategic default problem, we also assume that borrowers use all income at the end of each period such that they do not accumulate assets over time. Borrowers have no source of income other than the return of their investment.

The bank and borrower interaction

We analyse the interaction between bank and borrowers using a repeated game framework. The timing is as follows.

1. The bank lends to the borrowers.

2. Borrowers invest in projects with success probability p.

3. Nature independently draws the project outcomes. The borrowers observe the project outcome.

4. Borrowers then make their repayment decision.

5. If the repayment is sufficient to cover the bank's cost of funds, then the bank continues to lend and the process returns to (1). If only one partner has repaid, then the bank asks this borrower to cover for the other borrower. If the amount repaid is still insufficient to cover the debt, lending ceases for all members in the group and the game ends.

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 probabilities of progressing from t to $t+1$ are constant (υ), 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.

2.3 Individual liability versus joint liability lending: a theoretical comparison

2.3.1 Individual liability lending as a benchmark

As our objective is to determine if joint liability lending can increase social surplus, we compare joint liability lending to the conventional individual liability lending. Under an individual laibility lending scheme each individual borrower is responsible for her own repayment. The bank continues to fund the loans only if the borrower repays at least c. The bank deters delinquent borrowers from strategically default by denying credit to those who have defaulted previously. While this reputation mechanism reduces moral hazard problem, it is inefficient because it also punishes borrowers when they defaulted due to bad luck.

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 $\frac{c}{\pi} \leqslant p$

This means that an individual borrower will always repay the loan whenever possible if the loan repayment costs less than the expected income.

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

$$\pi - c + V \geqslant \pi$$

$$V \geqslant c$$

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

Because a borrower will repay whenever possible, the probability of reaching a new period is p (the probability of her project being successful). Therefore, joint liability is more efficient than individual lending if it can generate a probability of reaching a new period that is greater than p and less efficient otherwise.

Next we examine if joint liability can improve the efficiency of loan repayment compared to individual liability lending. We show that for a certain subspace of the parameter space, the efficiency achieved under joint liability either improves on or is worse than the efficiency achieved with individual liability lending. We first analyse the case where borrowers know each other's income, i.e. the complete information case. We subsequently examine the incomplete information case where borrowers are only able to observe their own income.

2.3.2 Joint liability under complete information

Under the joint liability lending scheme, the bank lends to each individual member in a group. However, now group members are not only responsible for their own repayment but also for their partners' repayments. If group members are willing to cover for each other when they are unable to repay then the joint liability lending scheme can improve social welfare. 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. The probability of reaching a new period is $2p - p^2 > p$. In a group of two, the bank will continue to lend to each group member only if the group repays at least $2c$, otherwise all group members will lose access to future loans.

Under complete information, group members can costlessly observe each other's project outcome. Thus we implicitly assume that they have some social connection with each other where the bank does not (Stiglitz and Weiss (1983)). We will relax this assumption in the next Section where we analyse the incomplete information case.

In a standard joint liability lending scheme, when some group members fail to repay the loan, the bank asks the remaining group members who have repaid their share to cover for their partners (Armendariz de Aghion and Morduch (2007)). On the one hand, this can potentially improve social welfare, as now group members are acting as each other's guarantors. The group utilises an insurance effect. On the other hand, there is an incentive to free-ride and strategically default on the loan if group members believe that their partners will always cover for them.

Although borrowers can in principle choose to repay any amount from 0 to π, for simplicity we assume that borrowers either default or repay the full amount c. That is, we assume $d_i^r(.) \in \{0, c\} \quad \forall r$ where r refers to a repayment round in a given period. This assumption does not undermine our objective since the purpose of this Section is only to show that there can be multiple equilibria for certain parameters. So restricting the strategy space makes our job harder rather than easier.

The timing for the traditional joint liability lending scheme is as follows.

1. Borrowers observe all θ_i where $\theta_i \in \{0, \pi\} \forall i \in \{i, j\}$
2. Borrowers take their repayment decisions, d_i^1 where $i \in \{i, j\}$ and $d_i^1 \in \{0, c\}$.
3. 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,
4. Borrower i with $d_i^1 = c$ takes a second repayment decision, d_i^2 where $d_i^2 \in \{0, c\}$
5. 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 1) her income from her investment, 2) her repayment decision d_i^1, 3) her decision to cover for her partner d_i^2, and 4) 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 $s_i = \{d_i^1(\theta_{it}, \theta_{jt}, H_t, t), d_i^2(\theta_{it}, \theta_{jt}, H_t, t, d_i^1(\cdot), d_j^1(\cdot))\}$
$\forall t, H_t, \theta_{it}, \theta_{jt}$ and $Eu_{it}(s_i, s_j) = \theta_i - d_i^1 - \alpha d_i^2 + \phi V$.

Of the potentially many equilibria we exemplarily establish three of particular interest. These three equilibria are labelled: free-ride, default, and cover with trigger strategy. There is a combination of the parameters where all three equilibria can occur.

A free-ride equilibrium is the equilibrium where one borrower always covers for her partner whenever her project is successful while her partner (the free-rider) only repays when the project of the other player fails.

A default equilibrium is the equilibrium where both borrowers never repay the loans.

A cover equilibrium with trigger strategy is the equilibrium where initially both borrowers always repay whenever they can. Once either partner deviates from repaying the loan whenever possible, they will choose to indefinitely play a default equilibrium.

A default equilibrium is less efficient than individual liability, while the others are more efficient by providing maximum insurance. In the case of the latter, one equilibrium is symmetric (cover with trigger strategy), where the borrowers share the expected surplus equally, while the other (free-ride) leads to a very unequal distribution of surplus.

Since there are welfare increasing and welfare decreasing equilibria, the question of whether joint liability theoretically improves welfare for the parameter space discussed is one of equilibrium selection. This question is answered empirically by using experiments.

Since a group necessarily defaults if both their projects are unsuccessful, we only need to focus on the critical states of the world. These states of the world are when either both or at least one of the projects are successful.

One of the problematic characteristics of joint liability lending is the potential for moral hazard within a group. When both group members observe that both projects are successful, they may be tempted to default. This is the case if one of the borrowers anticipates that her partner will cover for her since the punishment of never getting a loan again is too strong. In what follows, we will formalise this idea and show that it is a severe problem. This preliminary step will be helpful for deriving the above mentioned equilibria later on.

We concentrate on strategies that depend only on the current period's type drawn but are independent from history. Thus, we can simplify our notation and drop time indexes and history. So denote the repayment decision of player i in round r for given types θ_i, θ_j as $d_i^r(\theta_i, \theta_j) \in \{0, c\}$ with $\theta_i, \theta_j \in \{0, \pi\}$.

Proposition 2. There is no stationary equilibrium where $d_i^1(\pi_i, \pi_j) = c \quad \forall i$.

Proof. 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]

$$s_i^c = (d_i^1(\pi, \pi) = c, d_i^2(\pi, \pi) = 0, d_i^1(\pi, 0) = c, d_i^2(\pi, 0) = c, \cdot)$$

$$s_i^d = (d_i^1(\pi, \pi) = c, d_i^2(\pi, \pi) = 0, d_i^1(\pi, 0) = 0, d_i^2(\pi, 0) = 0, \cdot)$$

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

$$\pi - 2c + V^c \geqslant \pi, \text{or}$$

$$V^c \geqslant 2c$$

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

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

$$\pi - 2c + V^c \leqslant \pi - c, \text{or}$$

$$V^c \leqslant c$$

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

[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.

$$V^d = c.$$

Observe that when both players play s_i^d then

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

and

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

which is ruled out by assumption.

□

Our proof shows that once the borrower decides to repay in the first repayment round and the expected income is higher than the cost of repayment, then she will always cover for her partner if asked to. Due to this, there is always an incentive to free-ride for the other group member. This free-riding incentive makes it difficult for partners to collaborate and to secure the benefits from insuring each other. Despite this, the joint liability lending scheme can still perform better than individual liability lending through an insurance effect.

The following Proposition shows that there is a stationary equilibrium where one borrower free rides while the other borrower covers. The "free rider" only contributes if the "sucker's" project is unsuccessful in order to prevent defaulting.

Proposition 3. There exist an equilibrium with the strategy profile $s_i^* = (s_i, s_j)$ where

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

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

iff $\frac{c}{\pi} \leqslant \frac{p}{2(1-p+p^2)}$.[5]

Proof. We first consider player i. We will show the condition where s_i^* is optimal when player j plays s_j. Note that given that player j plays s_j, $d_i^1(\pi, .) = c$ always implies the subgame-perfect continuation $d_i^2(\pi, .) = c$ since otherwise the game ends with certainty.

The condition for $d_i^1(\pi, .) = c$ to be optimal requires

$$\pi - 2c + V_i \geqslant \pi$$

$$V_i \geqslant 2c$$

[5]The $\cdot$ represents the remaining part of the strategy, which is trivial.

where V_i is the expected continuation payoff for player i when s_i and s_j are played by player i and j.

Observe that when s_i and s_j are played then

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

Thus player i will play $d_i^1(\pi, .) = c$ iff $\frac{c}{\pi} \leqslant \frac{p}{2(1-p+p^2)}$.

Now consider player j. Note that if s_i^* is played, it is optimal for j to play $d_j^1(\pi,\pi) = 0$, since the game will continue regardless of her action. Also, $d_j^1(\pi, 0) = c$ always implies the subgame-perfect continuation $d_j^2(\pi, 0) = c$. We will show the condition required for player j to play $d_j^1(\pi, 0) = c$.

Observe that $d_j^1(\pi, 0) = c$ requires

$$\begin{aligned} \pi - 2c + V_j &\geqslant \pi \\ V_j &\geqslant 2c \end{aligned}$$

When s_i and s_j are played then

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

Thus the condition required for s_j^* to be optimal is $\frac{c}{\pi} \leqslant \frac{p}{2(1-p)}$.

Since the condition for s_i^* to be optimal is always stricter, the free-ride equilibrium exist iff $\frac{c}{\pi} \leqslant \frac{p}{2(1-p+p^2)}$.

$\square$

This equilibrium is more efficient than that under individual liability lending. The probability of reaching a new period in the free-ride equilibrium is $1-(1-p)^2$ while it is only p under individual liability lending. The efficiency gain comes from an insurance effect. In the free-riding equilibrium, the loan can be repaid even if the project of one of the group members fails. However, the free-riding equilibrium is disadvantageous for one of the borrowers since the surplus is not shared equally. The free-rider ex-ante expected surplus for the next period is $p^2\pi + p(1-p)(\pi-2c)$ in each period, while her partner's surplus is only $p(\pi-2c)$.

Unfortunately, for some parameter values, a socially harmful equilibrium exists. We call this equilibrium the default equilibrium where borrowers never repay any loan and the probability to get to a second period of loans is zero.

Proposition 4. There exist 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

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

$$\frac{c}{\pi} \geqslant \frac{p}{2}$$

□

In this equilibrium, the probability of reaching a new period is zero. We have multiple equilibria and thus a coordination problem whenever $\frac{p}{2} \leqslant \frac{c}{\pi} \leqslant \frac{p}{2(1-p+p^2)}$. Whether joint or individual liability is more efficient depends on the equilibrium selected by the players. If they can resist the free-riding incentive and coordinate, then they will be able to reach a higher total surplus than they would have achieved under individual liability lending. Only when the cost of repayment per unit of income ($\frac{c}{\pi}$) is low enough, then the traditional joint liability lending scheme is undoubtedly welfare improving.

We have seen so far that joint liability has a potential to improve the total surplus in an equilibrium where the division of surplus is very skewed (a free-ride equilibrium). Next, we show that there exists a symmetric equilibrium in trigger strategies that both improves welfare and also leads to an equitable surplus distribution. We will show that by threatening to default, the trigger strategy can induce higher levels of cooperation among group members.

First we define a stage game strategy which represents covering for the other player if possible. Player k plays covering in the stage game if $s_k^c = (d_k^1(\pi,\pi) = c, d_k^2(\pi,\pi) = c, d_k^1(\pi,0) = c, d_k^2(\pi,0) = c, \cdot)$.

Proposition 5. There exist an equilibrium with

$$s_{it}^* = \begin{cases} s_i^c \quad \text{if } s_{j(t-n)} = s_j^c \quad \forall n > 0 \\ d_i^r(\theta_i,\theta_j) = 0 \quad \forall \theta_i,\theta_j \quad \text{otherwise} \end{cases} \qquad \forall \quad i \in \{i,j\}$$

iff $\frac{p}{2} \leqslant \frac{c}{\pi} \leqslant p^2(2-p)$.

Proof. Note that from Proposition 4 we know that the trigger action after a deviation from s_k^c is a subgame-perfect continuation iff $\frac{c}{\pi} \geqslant \frac{p}{2}$. It remains to show that action s_k^c is optimal when s_i^* is played by the other player.

Observe that when all players follow a cover equilibrium with defaulting as trigger strategy, $d_i^1(\pi,\pi) = c$ always implies the subgame-perfect continuation of $d_i^2(\pi,\pi) = c$. Also, note that $d_k^1(\pi,0) = c$ always implies the subgame-perfect continuation of $d_k^2(\pi,0) = c$ since otherwise, the game ends immediately and the initial payment is lost. In what follows we will show the conditions under which playing $d_i^1(\pi, \pi) = c$ and $d_i^1(\pi, 0) = c$ is optimal for all players $i \in \{i, j\}$.

For $d_i^1(\pi, \pi) = c$ to be optimal we require

$$\begin{aligned} \pi - c + V_{it}^c &\geqslant \pi + p\pi \\ V_{it}^c &\geqslant p\pi + c \end{aligned} \tag{2.1}$$

while for $d_i^1(\pi, 0) = c$ to be optimal requires

$$\begin{aligned} \pi - 2c + V_{it}^c &\geqslant \pi \\ V_{it}^c &\geqslant 2c \end{aligned}$$

.

where $V_{it}^c = \sum_{t=0}^{\infty}(1-(1-p)^2)^t(p^2(\pi - c) + p(1-p)(\pi - 2c))$.

Our assumption implies $c \geqslant p\pi$. Therefore, the condition for $d_i^1(\pi, \pi) = c$ is stricter. It follows that s_k^c is optimal iff Equation 2.1 holds, which requires $\frac{c}{\pi} \leqslant p^2(2-p)$.

$\square$

Note that this equilibrium is not only more efficient than that under individual liability lending but also gives players an equitable income. The probability of reaching a new period under this trigger strategy is $1-(1-p)^2$ which is higher than p in individual liability lending. Also, note that the parameter space where this cover equilibrium with trigger strategies exists is larger than that where the free-riding equilibrium can be supported. Trigger strategies increase the space where joint liability is more efficient than an individual liability lending scheme.

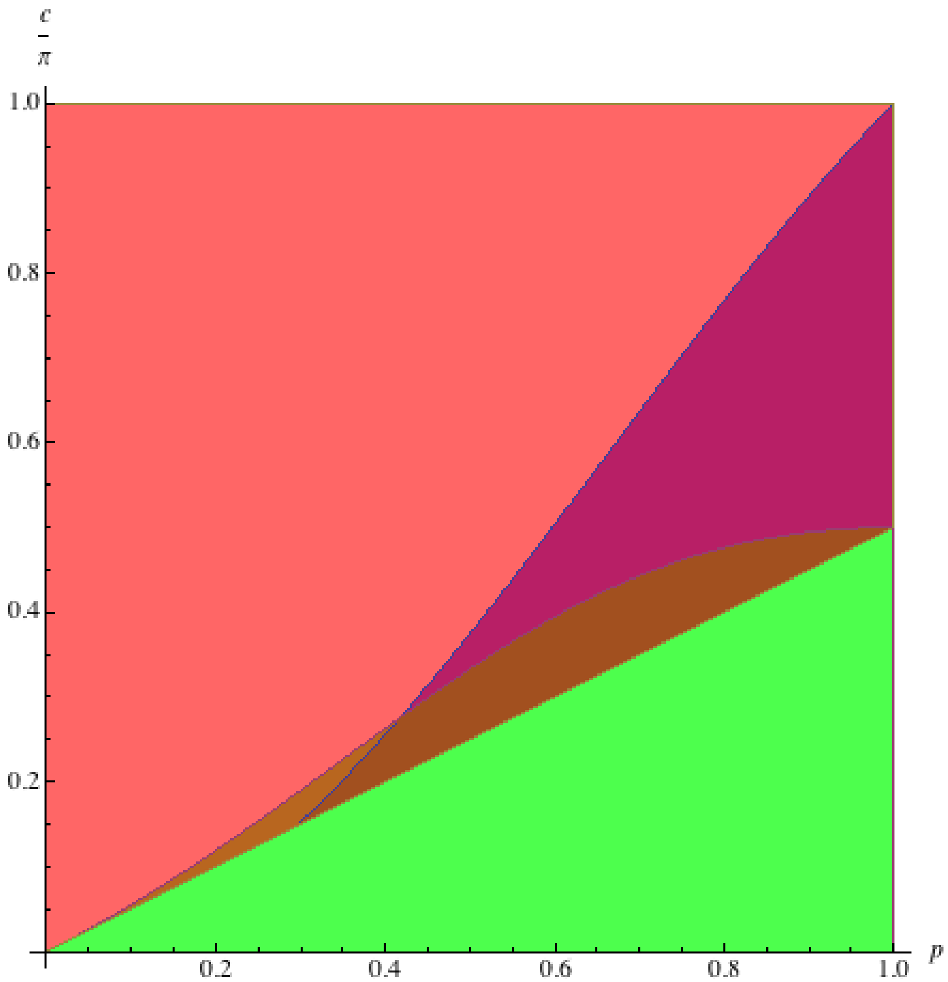

FIGURE 2.1: Joint liability under complete information

Figure 2.1 summarises the equilibria we have shown so far. We show $\frac{c}{\pi}$ (the cost of repayment per unit of income) on the vertical axis and p (the probability that the project is successful) on the horizontal axis. The cost of loan repayment is equal to the expected income on the 45° line. Assuming that borrowers are rational, they will not be willing to repay the loan in the space above the line. We only select three possible equilibria as an example. There can be many more equilibria that can achieve full efficiency. However, our main interest is to show that there can be many equilibria with different welfare consequences for the same parameters. In the green and orange areas, the free-ride equilibrium exists. The default equilibrium exists in the space above the green area. Note that the default equilibrium can also exist in an area below the 45° line. This means that for some parameters, a joint liability lending scheme might lead to immediate default where individual lending does not. In the magenta area, we have a cover equilibrium with trigger strategies. Note that when the probability of success is very low, the threat is ineffective since the player would rather deviate in the current period. Thus, there is a space where the free-riding equilibrium exists but the cover equilibrium does not exist. The Figure also shows an overlapping area(dark brown area) where all the equilibria described above can occur. In this overlapping area, the resulting social welfare depends on the borrower's equilibrium selection.

2.3.3 Joint liability under incomplete information

We relax the assumption that group members can costlessly observe each other's project outcome, such that the results in this Section do not rely on social capital in the lending community. In this Section, θ_i is known to only borrower i but not to others. After observing their own returns, borrowers then simultaneously send a message about their project's outcome, $m_i(\theta_i)$, to their partner. 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 to be repaid. Borrowers can either reveal their true type or lie when they send out their messages.

We have shown in the previous Section that the structure of joint liability lending encourages free-riding, so it cannot necessarily take advantage of the insurance effect. Without any information, it will be even harder for group members to cooperate.

The lending scheme is the same as described in the previous Section. However, since borrowers do not have information on each other's income, the timing of the game is changed. For this game, the timing is:

1. Borrowers observe only 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.

The borrower's payoff is identical to the case of complete information.

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 $Eu_i(s_i, s_j) = \theta_i - d_i^1 - \alpha d_i^2 + \phi V$.

We will concentrate on the socially best and worst equilibria, a cover and a default equilibrium. We will also show that in the case of private information, a parameter space exists where both equilibria can be sustained. The default equilibrium is less efficient than the unique equilibrium under an individual liability lending scheme, while the cover equilibrium is more efficient as partners take advantage of an insurance effect.

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. This might prevent group members from taking advantage of an insurance effect. When a borrower anticipates that her partner will cover for her, she always has an incentive to lie and free-ride. In what follows, we will formalise this idea and show that it is a severe problem.[6]

Separating equilibrium

Because we are interested in determining if joint liability can improve social welfare compared to individual liability lending, we first consider the case where a separating equilibrium can potentially improve social welfare. In what follows we show that borrowers have an incentive to lie to their partner when their project is successful.

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

Proposition 6. 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. First note that under complete information, Proposition 2 has shown that there is no stationary equilibrium where $d_i^1(\pi,\pi) = c \quad \forall i$. Thus any strategy that contains $d_i^1(\pi,\pi) = c \quad \forall i$ cannot be part of an equilibrium where $m_i(\pi) \neq m_i(0) \quad \forall i$. Recall that in any separating equilibrium, the messages lead to certainty about the state of the world (the returns from the projects).

Note that Proposition 4 shows that the default equilibrium exists whenever $\frac{c}{\pi} \leqslant \frac{p}{2}$ regardless of the realised type profile. So there is a stationary equilibrium where $m_i(\pi) \neq m_i(0) \quad \forall i$. However, under the default equilibrium, the probability of reaching a new period is $0 < p$.

The remaining potential non-stationary separating equilibrium is the equilibrium containing the actions outlined in Proposition 3 where one player is a "sucker" and the other is a "free-rider". 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.

□

Proposition 6 shows that borrowers have an incentive to lie and free-ride on their partner when their project is profitable. Because their partner cannot verify the message, coordinating to mutually improve their welfare is harder with incomplete information.

Next, we consider the case where borrowers do not send a truthful message.

Pooling equilibrium

In this case, the belief after observing a message is equal to the prior belief, $\mu(\pi|m_j) = p \quad \forall m_j$ since updating is not possible. Although there is no separating equilibrium that is more efficient than the individual liability lending scheme, we will show that for a certain parameter space there exists a pooling equilibrium that is more efficient than the individual liability lending.

Proposition 7. There exist 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

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

□

This equilibrium generates higher surplus per borrower than the individual liability lending. The probability of reaching a new period is $1-(1-p^2)$ which is greater than p. Note that the incomplete information does not have a free-riding problem found when borrowers have complete information. Since it is now uncertain whether the potential "sucker" will be able to repay, there is less incentive for borrowers to deviate from repaying c whenever they can. This is because lending only ceases when both borrower's projects are unsuccessful. Thus they benefit from the insurance effect. Despite this positive point, there exists a coordination problem since a default equilibrium exists. This is established in the following Proposition.

Proposition 8. There exist 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. As the borrowers never repay independent of the realised type profile, the proof is analogous to that of Proposition 4. □

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

Figure 2.2 shows the parameter spaces where the two equilibria exist. Of the many possible equilibria, we concentrate on the cover and the default equilibrium. The

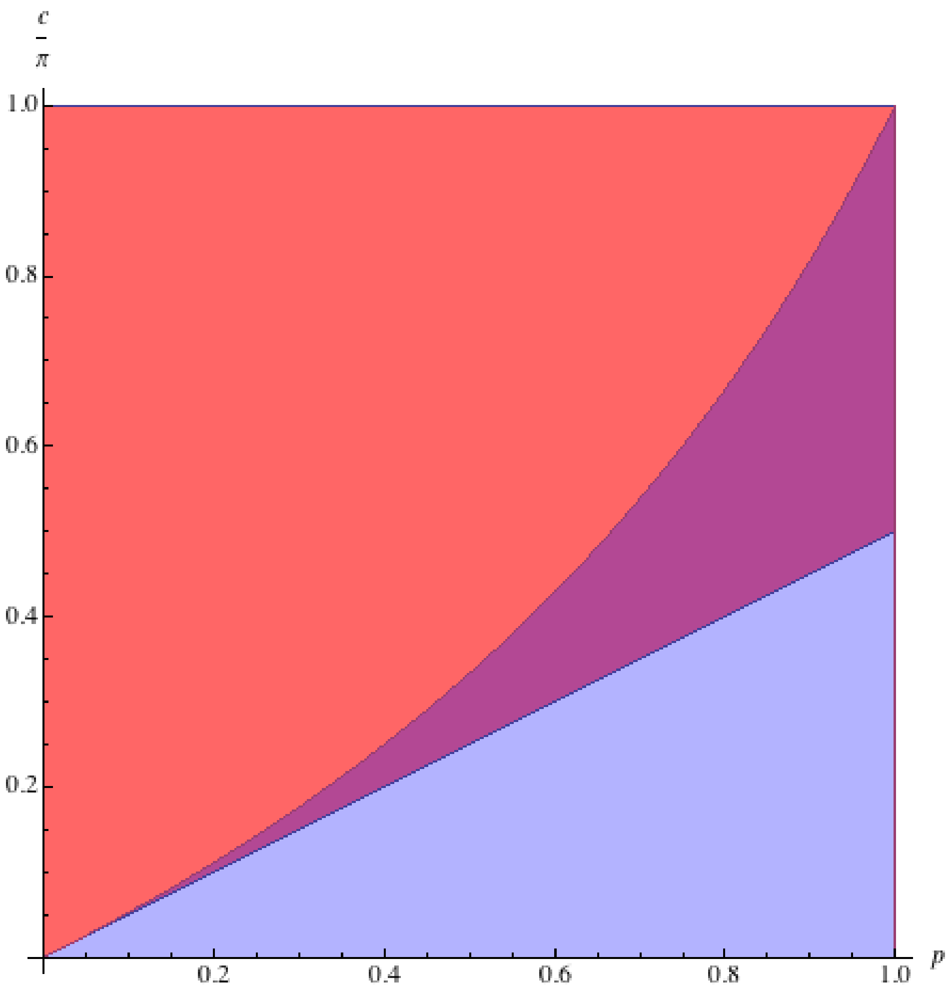

FIGURE 2.2: Joint liability under incomplete information

cover equilibrium exists in the light blue area. In the red area, the default equilibrium exists. Both equilibria exist in the overlapping area (purple area).

2.4 Welfare comparison

The main objective of this Chapter is to compare the maximum expected total surplus between different lending schemes. Specifically, we want to know under which circumstances we can potentially benefit from an insurance effect using a joint liability lending scheme. In this Section, we compare the individual lending scheme and the joint liability lending scheme under both information structures.

Proposition 9. Under complete information, joint liability lending 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 $1-(1-p)^2 > p$ which is the probability of reaching a new period under an individual liability lending equilibrium.

□

Proposition 10. Under incomplete information, joint liability lending can improve the maximum expected total surplus when $\frac{p}{2} \leqslant \frac{c}{\pi} \leqslant \frac{p}{2-p}$.

Proof. The proof is analogous to Proposition 9.

□

2.5 An experimental comparison of joint liability and individual liability lending scheme

For the past few years, many microcredit institutions have moved from joint to individual liability lending. While there are suggestions that this means joint liability is less efficient than individual liability (Armendariz de Aghion and Morduch (2007) and Kono (2006)), it may only mean that institutions and their clients have now matured such that standard debt contracts are able to prevent adverse selection and moral hazard. As shown in the previous Section, joint liability may improve loan repayment rates and efficiency but also has limitations. One limitation of the joint liability lending schemes is that the amount of loans that lenders can distribute depend on the amount that the group members are able and willing to mutually insure for one another. Banks normally only cater for small loans which may not be adequate for a growing business. Madajewicz (2004) showed that individuals with fast growing businesses may prefer individual liability contracts over joint liability. The move from joint to individual lending in some cases may be a result of many clients wanting to break free from their lower income partners. An alternative reason could be that joint liability actually does not increase efficiency. As shown in the previous Section, besides the efficiency increasing equilibria, there are also equilibria that lead to immediate default with a lower surplus. In what follows, we use an experiment to compare welfare of a joint liability lending scheme to that under individual lending. Our results reveal that joint liability lending does have significantly higher repayment rates than individual liability lending schemes. The results explain the observed switch towards individual lending in some countries which do not seem to originate from high default rates under joint liability lending.

Most existing papers that use observational data focus mainly on the factors that make joint liability lending work and on the question of whether social connections have an impact on loan repayment (Ahlin and Townsend (2007); Wydick (1999); Karlan (2007)).

Gomez and Santor (2003) provide the only study to date that directly compares the performance of joint liability lending to that of individual lending using observational data. They used data from two Canadian microfinance institutions and applied a matching approach. They matched individuals that are taking part in group lending with others that are as similar as possible regarding their observable characteristics but are enrolled in an individual lending program. This approach allowed them to estimate the repayment rates conditional on subjects taking part in group or individual lending. Gomez and Santor found that repayment rates under joint liability contracts are better than under an individual lending scheme. The weakness of this study is that there might still be a selection bias. If selection into the programs correlates with an unobservable variable that also has an influence on the probability of repayment, then the results are biased. For example, if we consider social preferences, it is quite possible that borrowers with stronger social preferences are more likely to opt for the joint liability lending scheme and are also more likely to cover for the shortfalls in repayments of their group members. A similar selection bias can come from implicit success probabilities being correlated with the chosen lending scheme.

Experimental methods in the laboratory or the field are ideal to overcome these problems since lending schemes can be assigned randomly. Furthermore, experimenters can ensure causality by using experimental control. By only varying single elements, any behavioural change can clearly be attributed to this change. However, the usual caveat regarding a possible lack of external validity applies.

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 for a limited number of rounds. 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. Their results even held in groups with as many as eight members. However, the design concentrated on the free-riding aspect of group lending and did not investigate the insurance effect.

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. In their setup, the authors 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) isolated the impact of moral hazard in a joint liability lending scheme. The efficiency in each treatment and scheme was measured by the level of effort players put into their projects. Strategic default was excluded by assumption. In the study, subjects were first allocated to a joint liability lending scheme and were later transferred to an individual lending environment. The exact rules of the individual lending environment differed by treatment. Werner found that even though joint liability lending outperformed individual liability, there were moral hazard problems under joint liability lending.

The results from field experiments are mixed. Kono (2006) conducted a field experiment in Vietnam where joint liability games were similar to the one we implemented in the lab. The joint liability scheme typically performed worse than individual lending due to free-riding. Only when monitoring, communication, and endogenous group formation was possible did joint liability lending improve efficiency. However, Kono's study has a few important weaknesses. For example, there is no theoretical model predicting the outcomes for the joint liability lending scheme and she had the same subjects played in more than one treatment.

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 helped screen for superior projects.

Our experimental design is most similar to those of Abbink et al. (2006) and Kono (2006) since we also focus on repayment decisions and not on effort or monitoring. While Abbink et al. compare joint liability lending with hypothetical individual liability results, we also run an individual liability treatment in our lab as a benchmark. 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). Our experimental design however allowed subjects to explicitly decide if they would like to make an additional repayment for their defaulting partner. Another main difference is that we do not have an ex ante finite number of rounds, while Abbink et al. clearly states that subjects will only be playing for a maximum of eight rounds. This could have a significant impact on the results. With a finite number of rounds, backward induction predicts that subjects will never cooperate with each other while it is possible for subjects to cooperate in our infinitely repeated game in equilibrium. Our design also provides more control than Kono's experimental design. This is because we only allow each subject to participate in only one treatment.

2.5.1 Experimental design

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

Under individual liability lending, we set the repayment cost c to $\$E40$ while the repayment cost is $\$E45$ for the joint liability lending treatment. The slight difference in cost is made to stack the deck against the joint liability lending scheme. The cost of $\$E45$ is just large enough to render the efficient cover strategy equilibrium inconsistent. Therefore, with incomplete information used here, we would predict immediate default for the joint liability treatment while the low cost of $\$E40$ in the individual lending treatment should lead to repayment whenever possible.

In the joint liability lending scheme treatment the timing 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 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.

Since we want to test if a joint liability lending scheme can perform better than individual lending, we pick the most unfavourable scenario for joint liability lending. This is a situation with incomplete information with limited communication and a slightly higher repayment requirement.

We also run the individual liability treatment as a benchmark where each individual subject is informed about her project's outcome and makes an independent repayment decision. Table 2.1 shows the average number of rounds without default and repayment rates predicted by the theory for both treatments.

Table 2.1: Theoretical predictions for individual and joint liability lending

Treatments	**Repayment rates**
IL	0.6
PIMsg	0

* IL is an individual liability treatment and PIMsg is the joint liability treatment with incomplete information and messages

According to the theory, we formulate the following hypothesis.

Hypothesis 1. The individual liability treatment has statistically higher loan repayment rates than the joint liability lending treatment.

2.5.2 Experimental procedures

We conducted our experiment in the AdLab at the University of Adelaide, Australia using the computer program 'z-Tree' (Fischbacher (2007)). Subjects were recruited using ORSEE (Greiner (2004)). There were four sessions with 74 participants. Each session only contained one treatment. Most of the subjects were university students from various disciplines. The sample population comprised approximately equal numbers of male and female subjects. Subjects were given context-free instructions outlining the game at the beginning of each session.

Under the individual liability treatment, each individual was informed of the outcome of her project and informed that to continue the game, they needed to repay at least $\$E40$. Once the repayment decision was made, we showed the profit from the round. The game continued to the next round if repayments were sufficient. Over all, subjects played 10 games.

In the joint liability treatment, two subjects were randomly paired to form a group. Each subject's identity remained anonymous throughout the session. Subjects were informed that a game consisted of an undetermined number of rounds and that they would play 5 games in a session. After each game, we randomly changed the group composition such that subjects were never matched with the same partner twice. Each subject could chose to send one message out of the three described above or choose not to send any message. After subjects had realised their project outcome, 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.

Overall, the experiment was designed such that a new game did not start until all groups (or individuals under the individual-liability treatment) in the session had completed the current game, causing a considerable waiting period for some subjects. To reduce any continuation incentive due to boredom, we allowed subjects to do other quiet activities while waiting. Subjects were informed about this when we invited them such that they could bring study materials, a magazine, or a book to the session.

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 22.

2.5.3 Results

Our main objective of the experiment is to test whether joint liability can reduce the default rate under the least favourable setting. Recall that from our definition, the greater the probability of reaching a new period, the higher the welfare. We use a logistic regression model to test how each state of the world under different lending regimes affects the probability of reaching a new period. The subsequent Section shows that although there is an adverse effect when only one member has a successful project compared to individual lending, a joint liability lending scheme still reaches a significantly higher estimated average repayment rate compared to that of individual lending.

2.5.3.1 An overview of loan repayment

The characteristics of the data point our analysis to a logistic regression model. The dependent variable is zero if the repayment is insufficient and one if the repayment is sufficient for the game to continue; the covariate is treatment dummies.

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

where Ind, Joint1, Joint2 are the treatment dummies. Ind is the individual liability treatment and is the base category; Joint1 is the joint liability treatment when only one borrower has a successful project; and Joint2 is the joint liability treatment when both borrowers have a successful project.[7]

The left hand side of Table 2.2 shows the estimated log odds that the game continues. According to the logistic regression, the log odds that the game continues is negatively related to the joint liability treatment where only one member's project is successful as well as when both members' projects are successful. The probability of reaching a new period decreases with joint liability treatment. This shows that subjects faced coordination problems when playing as a group.

[7] We omitted the states of the world where there is no success under both individual and joint liability lending since the subjects will automatically default and there is no decision made.

Table 2.2: Logistic estimation of continuation probabilities: Individual and Joint liability lending

Variable	**Coefficient**	**Predicted continuation probability**
Constant	3.231***	
	(.320)	
Ind		.962
		(.010)
Joint1	-1.633***	.832
	(.320)	(.021)
Joint2	-.136	.957
	(.418)	(.013)
Log likelihood=-243.279; LR chi2(2) = 41.24; Prob>chi2 = 0.0000		
standard errors are shown in parentheses		*** significant at 0.001

The right hand side of Table 2.2 shows the predicted probability that the game continues under different states of the world. Notice that the predicted probability that the game continues is very close to one in all treatments and states of the world. The predicted probability of one means that under a certain state of the world, subjects always repay and the new period is reached with the probability of one while the predicted probability of zero implies that subjects never repay the loan. These results reveal that when one or both subjects are able to repay the loan, they will most likely do so. For example, under a joint liability lending scheme, when both group members have a successful project they are predicted to repay 96 percent of the time.

2.5.3.2 Comparing individual and joint liability lending

First, we test if there is any statistically significant difference in the probability that the game continues under the three different states of the world. We find that there is a significance difference between the individual liability treatment and the joint liability treatment when there is only a single success ($p < 0.05$). However, there is no statistically significant difference in the continuation probability between the individual liability and joint liability with double successes ($p \approx 0.747$).

We then calculate the predicted repayment rates of each treatment using the underlying probability for a certain state of the world to occur. For an individual liability lending treatment, the probability that there is one successful project is $p = 0.6$. For a joint liability lending treatment, the probability that there is one successful project is $2p(1-p) = 0.48$ and the probability that both projects are successful is $p^2 = 0.36$. The estimated repayment rate under an individual liability lending is 57.7 percent while the estimated repayment rate under a traditional joint liability lending scheme is 74.4 percent. Even though the individual liability treatment yields significantly higher continuation probability than the joint liability treatment with a single success, the joint liability lending still performs better than the individual liability lending. Our overall results emphasise the advantage of the insurance effect. We then tested if this difference of predicted repayment rates across treatments is statistically different. Formally we test:

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

where ind is the predicted probability of continuation (at the mean) under individual liability treatment; $joint1$ is the predicted probability of continuation (at the mean) under joint liability treatment when there is only one success; and $joint2$ is the predicted probability of continuation (at the mean) under joint liability treatment when there are two successes.

The test strongly rejected the null hypothesis ($p < 0.05$). There is a statistically significant difference in the estimated repayment rates under joint and individual liability lending treatments.

Result 1. A joint liability treatment has statistically higher loan repayment rates than an individual liability lending treatment.

The results contradicts our theoretical prediction that, with our parameter settings and information structures, individual liability lending should outperform joint liability lending.

Our results show a very strong support for the joint liability lending scheme where even under the most difficult setting for subjects to overcome coordination problems and free-riding incentives, joint liability is still more efficient than an individual liability lending scheme. The insurance effect boosts the benefit of using joint liability lending.

These results also contradict a field experiment in Vietnam by Kono (2006) where they found that individual liability outperforms the joint liability lending scheme. The difference may be due to the different subject pool and the conditions in which the experiment was conducted.

2.6 Conclusion

In this Chapter, we examined the potential welfare gain from using joint liability lending. By not making any assumption on social capital, we were able to focus on the benefits of an insurance effect and explain the repayment behaviour of group member in a broader context.

Our theoretical results showed that under complete information, the joint liability lending scheme is afflicted with incentives to free-ride. However, if the cost of repayment per unit of income is low enough and the group members are able to coordinate and repay, it can still benefit from an insurance effect.

Theoretically, a joint liability lending scheme under incomplete information will not be able to improve social welfare compared to an individual liability lending scheme if the cost of loan repayment per unit of income is high and the probability that the project will be successful is low. In that case, group members have no incentive to cover for one another and we end up in a default equilibrium which generates lower social surplus than an individual liability lending scheme. However, if the probability that the project is successful is high then there are two countervailing effects that can lead to joint liability to improve or worsen social surplus. Either the high chance of success leads to more defaulting borrowers due to the free-riding incentive or it leads to a higher incentive to cooperate for long-term gain.

We used an experiment to test our theoretical prediction and analysed whether our subjects were able to overcome the free-riding incentives such that joint liability could lead to a higher social welfare than individual liability lending. Our results contradicted our theoretical prediction that for the chosen parameters free-riding dominated and showed strong support for the joint liability lending scheme. Subjects in our experiment appeared to be able to overcome the free-riding incentive and were able to take advantage of the insurance effect.

In the next Chapter, we propose an alternate joint liability lending scheme that performs no worse than the one that is used by most microlending institutions but potentially could save considerably on transaction cost.

Chapter 3

An Alternate Joint Liability Lending Scheme

3.1 Introduction

In the previous Chapter, we outlined the moral hazard problems inherent in lending and explained that the problem is more severe when borrowers do not have collateral. We also outlined that joint liability can potentially improve social welfare via the insurance effect where borrowers in a group cover for their partner whenever possible. Although a traditional joint liability lending scheme creates an incentive to free-ride, borrowers can still benefit from the insurance effect. Whether a joint liability scheme can improve social welfare compared to individual lending depends on the equilibrium selected. Joint liability can only improve welfare when borrowers are able to coordinate with each other. Our experiment in the previous Chapter demonstrated that, moving from an individual liability lending scheme, partners in a joint liability scheme can improve their social surpluses even with minimum ability to communicate and no information about each other's income.

In practice however, even though micro lending 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)). The main culprit is often attributed to high transaction costs per borrower (Armendáriz de Aghion and Morduch (2000)). This is because the cost of monitoring and collecting repayments does not change significantly with the size of the loan and most loans are very small.

Collecting loan repayments can be even more costly when group members are geographically separated. If one of the members fails to repay, then it creates even higher transaction costs since the bank will have to ask the non-default members to cover for their partner. It is possible to improve a joint liability lending scheme if we can find a mechanism where borrowers can benefit from an insurance effect but with fewer transactions between the bank and the borrowers.

We propose an alternate joint liability lending scheme that can potentially reduce transaction costs. In our scheme, 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. Our theoretical results show that under certain parameters, our proposed scheme has the potential to perform better than current practices.

We test this alternate joint liability lending scheme against the current practice in further experiments. Our results confirm that there is no statistical difference in the performance of the alternate scheme and the current practice. This means that the repayment rates in our scheme are not different from those in the usually employed scheme. Therefore, if our scheme is implemented, it could save considerable transaction cost since only one round of repayments is involved without leading to higher default rates.

The organisation of this Chapter is as follows. We first set up a simple game theoretical model for our alternate joint liability lending scheme. Subsequently, we compare the predicted equilibrium welfare under this alternate scheme with that under a traditional joint liability scheme. Then we explain our experimental design which we use to test for performance differences of the schemes. Finally, we report our experimental results and discuss their implications.

3.2 Setting

We retain our assumptions regarding the lender's role as well as our assumptions on borrowers from the first Chapter. The only change we make here refers to the timing and the rules for default. There is only one lender whose objective is to recover the opportunity cost of the funds. The borrowers' role under the alternate scheme is as follows.

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 an unsuccessful project pays $\theta_i = 0$.

The difference between the alternate scheme and the traditional joint liability lending from the previous Chapter is the interaction between the bank and the borrower.

Bank and borrowers interaction

We again use a repeated game framework with the following timing and rules.

1. The bank lends the money to the borrowers.
2. Borrowers invest in projects with a success probability of p.
3. Nature independently draws the project outcomes. Borrowers observe the project outcome.
4. Borrowers decide on their repayment amount.
5. If the repayment is sufficient to cover the bank's cost of funds, then the bank continues to lend and the process returns to (1). Otherwise, lending ceases for all members in the group and the game ends. If a group overpays, then the amount overpaid is redistributed equally among group members.

3.3 An alternate joint liability lending scheme

There are criticisms that the punishment under the current approach to the joint liability lending is too harsh(Tedeschi et al. (2006); Rai and Sjöström (2004)) and that we can further improve social welfare by modifying the current approach.

Tedeschi et al. (2006) considered an infinitely repeated game where defaulted borrowers are denied credit for only a certain period of time. She suggested that the current practices, where defaulted borrowers will not have access to another loan in the future, is inefficient since some potentially profitable projects may not be funded. She then showed that dynamic incentives are still effective in deterring strategic default borrowers even though the punishment period is limited. Lenders do not need to punish defaulted borrowers indefinitely to encourage loan repayment.

Rai and Sjöström (2004) took a different approach to the loan repayment problems. Instead of focusing on social sanctions or peer monitoring, they focused on designing a mechanism which generated the most efficient outcome. They argued that while joint liability may induce higher loan repayment, it is not always efficient. In particular, the system where the bank imposes punishment on an involuntary defaulted group is inefficient. They suggested that the best outcome can be achieved by using cross-reporting where group members report their partner's income to the bank. This system enables the bank to only punish borrowers who falsely under-report their income. This would induce mutual insurance among borrowers where a more successful borrower has an incentive to help out their partner. Rai and Sjöström's underlying assumption on the efficiency of this mechanism is that group members have lower cost of monitoring each other than the bank.

While cross-reporting may achieve the best possible outcome, Bhole and Ogden (2010) argued that it leads to “tension amongst borrowers”. They proposed a “flexible group lending contract” where the bank’s punishment on the defaulted group is based on the amount repaid by each borrower. That is, the bank’s punishment to each borrower is endogenously determined based on each group member’s repayment decision. They demonstrated that even though this mechanism is less efficient than the cross-reporting mechanism, the performance is still better than using conventional individual lending contracts.

Although the alternate mechanism described above may improve social welfare, the mechanism required a more sophisticated tool and heavily relied on the loan officer’s judgement. Our alternate scheme is a simple “rule of thumb” that is easy to implement. This may not always yield the most efficient outcome however we assert that it can still generate higher welfare than an individual liability lending scheme. Thus, there is still potential welfare to be gained from adopting the alternate scheme.

As in the previous Chapter, we will start with the case where we assume that group members can costlessly verify their partner’s project outcome. We will later relax this assumption in the next Section when we assume incomplete information among borrowers.

3.3.1 An alternate scheme with complete information

Under complete information, we assume that group members can costlessly monitor project outcomes of their partners. This assumption implies that group members have certain social capital lacked by the bank.

We have shown in the previous Chapter that the repayment structures of a traditional joint liability lending scheme encourage free-riding when both group members have a successful project. We proposed some changes in repayment structures that may improve a joint liability lending scheme by implicitly asking group members to "cover" for their partner and then redistribute any overpayment back to the group.

Under this scheme, the timing is:

1. Borrowers observe all θ_i where $\theta_i \in \{0, \pi\} \forall i \in \{i, j\}$
2. Borrowers take their repayment decision, d_i where $i \in \{i, j\}$ and $d_i \in (0, \pi)$.
3. If $d_i + d_j \geqslant 2c$, loans are renewed and the process returns to (1). If $d_i + d_j > 2c$, the bank redistribute $\frac{1}{2}(d_i + d_j - 2c)$ back to each member. However, if $d_i + d_j < 2c$, the game ends.

When borrower i reaches a period t and observed her project's outcome θ_i but has not decided on the amount to be repaid d_i, then her 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 1) her income from her investment, 2) her repayment decision d_i ,and 3) 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 $s_i = \{d_i(\theta_{it}, \theta_{jt}, H_t, t)\} \quad \forall t, H_t, \theta_{it}, \theta_{jt}$ and $Eu_i(s_i, s_j) = \theta_i - d_i + \phi V + \frac{1}{2}\lambda(d_i + d_j - 2c)$.

Of the many equilibria we illustrate three - cover, default, and cover with default as trigger strategy. We show that there is a space of parameters where all three equilibria coexist.

A cover equilibrium is the equilibrium where both borrowers always repay c when they have successful projects and if one of them has an unsuccessful project, a successful partner repays $2c$.

A default equilibrium is the equilibrium where group members never repay.

A cover with default as trigger strategy equilibrium is the equilibrium where initially both borrowers always repay c when they have successful projects and if one of them has an unsuccessful project, a successful partner repays $2c$. However, once any player deviates from repaying the loan even though they could, borrowers will never repay again.

A cover and a cover with default as trigger strategy equilibrium represent the best possible equilibrium where group members benefit from an insurance effect. The default equilibrium results in the worst possible welfare for group members.

Since a group necessarily defaults if both their projects are unsuccessful, we only need to focus on the critical states of the world. These states of the world are when either both or at least one of the projects are successful.

One problem with a traditional joint liability lending scheme shown in the previous Chapter is that group members always have an incentive to free-ride. Unlike the traditional scheme, our alternate scheme encourages cooperation within a group.

We later use an experiment to determine if the alternate scheme can improve social welfare compared to a traditional joint liability scheme.

We first look at strategies that depend only on the current period's type drawn but are independent from history. We can simplify our notation and drop time indexes and history. So denote the repayment decision of player i in round r for given types θ_i, θ_j as $d_i(\theta_i, \theta_j) \in \{0, c\}$ with $\theta_i, \theta_j \in \{0, \pi\}$.

Proposition 11. There exists an equilibrium with the strategy profile $s_i^* = (d_i(\pi, \pi) = c, d_i(\pi, 0) = 2c, \cdot) \quad \forall i$ iff $\frac{c}{\pi} \leqslant \frac{p}{2(1-p)+p^2}$.[1]

[1]The $\cdot$ represents the remaining part of the strategy which is trivial.

Proof. First note that the condition required for $d_i(\pi, 0) = 2c$ to be optimal is always stricter than the condition required for $d_i(\pi, \pi) = c$. Observe that when both players play s_i, $d_i(\pi, \pi) = c$ only requires,

$$\pi - c + V_i \geqslant \pi$$
$$V_i \geqslant c$$

while the condition for $d_i(\pi, 0) = 2c$ requires

$$\pi - 2c + V_i \geqslant \pi$$
$$V_i \geqslant 2c$$

where V_i is the continuation value when both players play s_i and

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

Since the condition required for $d_i(\pi, 0) = 2c$ is stricter, the critical condition for this equilibrium is $\frac{c}{\pi} \leqslant \frac{p}{2(1-p)+p^2}$.

□

First note that this equilibrium is more efficient than the equilibrium under individual liability lending. The probability of reaching a new period in the cover equilibrium is $1-(1-p)^2$ while it is only p under individual liability lending. The efficiency gain comes from an insurance effect. Lending only ceases when both of the borrower's projects are unsuccessful. The cover equilibrium also achieves the highest expected surplus for a group of two borrowers as lending will cease only if the joint profit from the project is not sufficient for the loan repayment. Secondly, note that unlike in the traditional joint liability lending, this cover equilibrium can be achieved without a trigger strategy. It is also superior to the free-ride equilibrium resulting from traditional joint liability lending in that borrowers are sharing their surplus equally.

Unfortunately, there is also the least efficient equilibrium where joint liability lending results in lower social surplus than individual lending. We call this equilibrium the default equilibrium, where borrowers never repay the loans and the game immediately ends in the first stage.

Proposition 12. There exists an equilibrium with the strategy profile $s_i^* = (d_i(\theta_i, \theta_j) = 0) \quad \forall i$, a default equilibrium, iff $\frac{c}{\pi} \geqslant \frac{p}{2}$

Proof. As the other player will never repay the loan, we only have to check that there is no incentive for player i to deviate to repay $2c$. The condition required for

$d_i(\theta_i, \theta_j) = 0$ to be optimal is

$$\pi \geqslant \pi - 2c + \frac{p(\pi - 2c)}{1 - p}$$

Therefore the condition is $\frac{c}{\pi} \geqslant \frac{p}{2}$.

$\square$

Note that this equilibrium achieves the lowest expected surplus for a group of two borrowers as the probability of reaching a new period is zero.

From our results, there are coordination problems if $\frac{p}{2} \leqslant \frac{c}{\pi} \leqslant \frac{p}{2(1-p)+p^2}$. Note that the parameter space where the alternate scheme can potentially improve welfare is larger than under a traditional lending scheme. This is because the repayment structure implicitly requires group members to cover for their partner. It is possible for group members to cooperate and play "cover" equilibrium even though the cost of repayment per unit of income ($\frac{c}{\pi}$) is quite high. However, the final outcome depends on the equilibrium selected by borrowers. If they can coordinate on the cover equilibrium in parameter areas where the best equilibrium in the traditional scheme does not exist, then they will gain higher surplus from using the alternate joint liability scheme.

We have seen that trigger strategy has a potential to improve total surplus in a cover equilibrium under a traditional joint liability lending scheme. In our alternate joint liability scheme, a trigger strategy is not helpful. Specifically, the parameter space in which a cover equilibrium without a trigger strategy can be sustained is greater than that where a trigger equilibrium exists. We demonstrate this in the following Proposition.

First we define a stage game strategy, which represents covering for the other player if possible. Player k plays covering in the stage game if $s_k = (d_k(\pi,\pi) = c, d_k(\pi,0) = 2c, \cdot)$.

Proposition 13. There exists an equilibrium with

$$s^*_{it} = \begin{cases} s^c_{it} \quad \text{if } s_{j(t-n)} = s_k \quad \forall n > 0 \\ d^r_{it}(\theta_i, \theta_j) = 0 \quad \forall \theta_i, \theta_j \quad \text{otherwise} \end{cases}$$

iff $\frac{p}{2} \leqslant \frac{c}{\pi} \leqslant p^2(2-p)$.

Proof. Note that from Proposition 12 we show that the second action is optimal iff $\frac{c}{\pi} \geqslant \frac{p}{2}$. It remains to be shown that action s_k is optimal when s^*_i is played by all players. In what follows we will show the conditions where playing $d_i(\pi,\pi) = c$ and $d_i(\pi,0) = 2c$ is optimal for all players $i \in \{i,j\}$ when both players play s^*_i.

We first show that for $d_i(\pi,\pi) = c$ to be optimal requires

$$\pi - c + V^c_{it} \geqslant \pi + p\pi$$

$$V^c_{it} \geqslant p\pi + c$$

while for $d_i(\pi,0) = 2c$ to be optimal requires

$$\pi - 2c + V_{it}^{c} \geqslant \pi$$
$$V_{it}^{c} \geqslant 2c$$

.

where $V_{it}^{c} = \sum_{t=0}^{\infty}(1-(1-p)^2)^t(p^2(\pi - c) + p(1-p)(\pi - 2c))$.

Our assumption implies $c \geqslant p\pi$. Therefore, the condition for $d_i(\pi, \pi) = c$ is stricter. It follows that s_k is optimal if and only if $\frac{c}{\pi} \leqslant p^2(2-p)$.

□

Note that this equilibrium is more efficient than that under individual liability lending. The probability of reaching a new period under this trigger strategy is $1-(1-p)^2$ which is higher than p in individual liability lending. Note also that a parameter space where a cover equilibrium with trigger strategy exists under this alternate scheme is the same as the space under the traditional joint liability lending scheme. Observe that there are some parameter values where the cover equilibrium without a trigger strategy can reach a better welfare than the equilibrium with a trigger strategy.

Figure 3.1 summarises the equilibria we have derived so far. We show the cost of repayment per unit of income ($\frac{c}{\pi}$) on the vertical axis and the probability that the project is successful (p), on the horizontal axis. Rational borrowers will not be willing to repay the loan in the space above the 45° line. We only select three possible equilibria as an example. There can be many more equilibria such as a non-cover equilibrium where group members only repay the loan when both of them have a successful project. The non-cover equilibrium yields lower social welfare than individual liability lending as the loan for both players will end with certainty even if one of them has a successful project.

The green and brown areas are where cover equilibrium exists. Notice that a scenario where borrowers may play cover equilibrium almost touches the 45° line. This means that under the alternate scheme, joint liability can be very efficient even without using a trigger strategy. The orange area, brown, and dark brown areas are the space where only default equilibrium exists. It is mainly above the 45° line where it is not profitable to repay the loan and to continue their investment. The dark brown area is where a cover with default as trigger strategy equilibrium exists. Notice that this area is smaller than the area where cover equilibrium exists. This is because the punishment from the trigger strategy is so harsh that for some parameter values borrowers are not willing to inflict it on each other. The overlapping area is where all of the equilibria described above can occur. In this overlapping area, the resulting social welfare depends on borrowers' equilibrium selection.

3.3.2 An alternate scheme with incomplete information

We now relax the assumption that group members can costlessly observe the project outcome of their partner. In this Section, θ_i is known to only borrower i but not

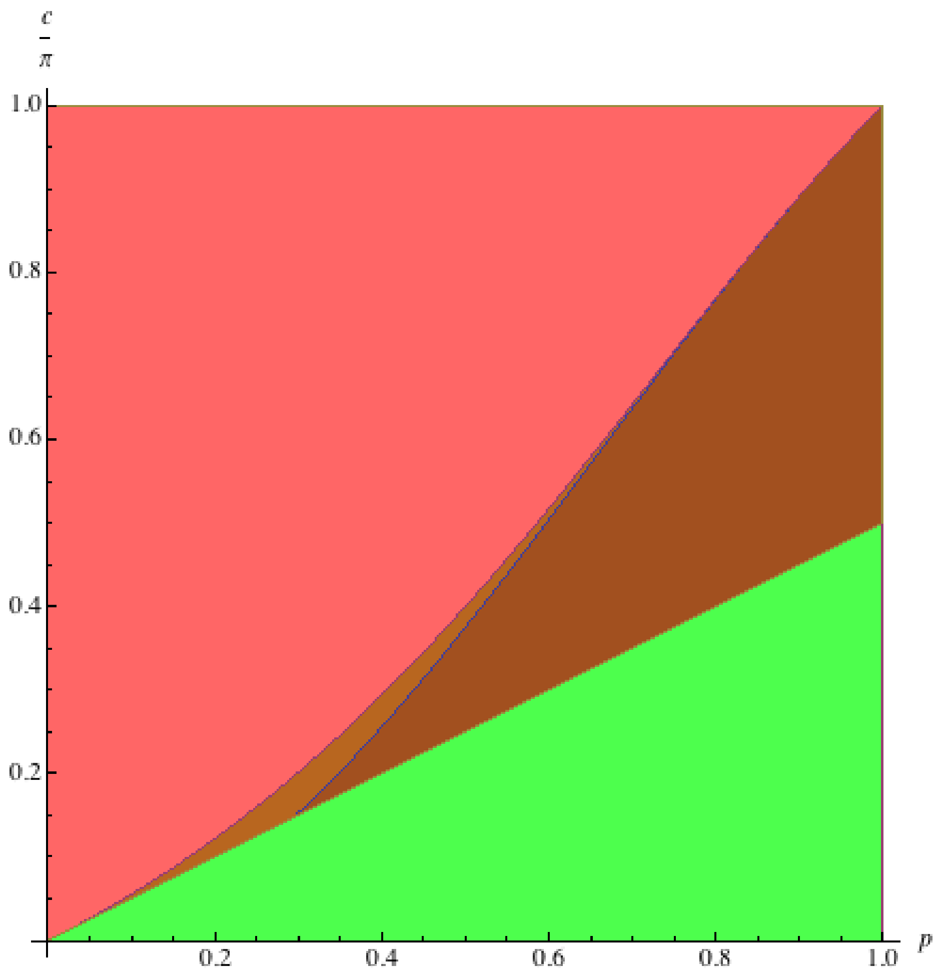

FIGURE 3.1: An alternate joint liability under complete information

to others. After observing their own returns, borrowers then simultaneously send a message about their project's outcome, $m_i(\theta_i)$, to their partner. We assume that messages are restricted to either "my project is successful"' or "my project is unsuccessful", denoted by π and 0 respectively. They then form a belief about their partner's income from the project and simultaneously decide on the amount to be repaid. Borrowers may reveal their true type or may lie when they send out the messages.

The lending scheme is the same as described in the previous Section. However, the timing of the game has changed. For this game, the timing is:

1. Borrowers observe only 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 $d_i + d_j > 2c$.

The borrower's payoff is identical to the case of complete information.

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 $Eu_i(s_i, s_j) = \theta_i - d_i + \phi V + \frac{1}{2}\lambda(d_i + d_j - 2c)$.

We show that with incomplete information, the alternate regime loses its advantage over the traditional joint liability lending scheme. This is because under incomplete information, players in the traditional scheme lose much of their free-riding incentive, since they no longer have a guarantee that the partner can cover for them in the second round.

We demonstrate the coordination problem by focusing on the two socially best and worst equilibria, a cover and a default equilibrium. We show that both equilibria can coexist under a certain parameter space. The default equilibrium is less efficient than the unique equilibrium under individual liability, while the cover equilibrium is more efficient since partners take advantage of an insurance effect.

When borrowers cannot monitor their partner's project outcome, they will always have an incentive to lie when they have a successful project. In what follows, we will formalise this intuition and will show that this can create difficulties for borrowers to benefit from an insurance effect of joint liability lending.[2]

3.3.2.1 Separating equilibrium

We first show that borrowers have an incentive to lie to their partner when their project is successful except when they both intend to default and let the game end.

Proposition 14. There is no stationary equilibrium where $m_i(\pi) \neq m_i(0) \quad \forall i$ where the probability of reaching the new period is greater than p.

Proof. First, note that Proposition 12 takes into account that the default equilibrium exists whenever $\frac{c}{\pi} \leqslant \frac{p}{2}$ regardless of the realised type profile. There is a stationary equilibrium where $m_i(\pi) \neq m_i(0) \quad \forall i$. However, under the default equilibrium, the probability of reaching a new period is $0 < p$.

The remaining potential non-stationary separating equilibria are the equilibrium containing the action $s^d = (d_i(\pi, \pi) = c, d_i(\pi, 0) = 0, \cdot) \quad \forall i$ and the equilibrium containing the action from Proposition 11 which is $s^c = (d_i(\pi, \pi) = c, d_i(\pi, 0) = 2c, \cdot) \quad \forall i$.

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

First we investigate the conditions for which s^d is compatible with $m_i(\pi) \neq m_i(0) \quad \forall i$.

Observe that $d_i(\pi, \pi) = c$ requires

$$\pi - c + V_i \geqslant \pi$$
$$V_i \geqslant c$$

and $d_i(\pi, 0) = 0$ requires

$$\pi \geqslant \pi - 2c + V_i$$
$$2c \geqslant V_i$$

where

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

Combining the two conditions, we find that the action s^d requires $\frac{p}{2-p^2} \leqslant \frac{c}{\pi} \leqslant p$.

Sending $m_i(\pi) \neq m_i(0) \quad \forall i$ requires,

$$\pi - p^2c + V_i \geqslant \pi$$
$$V_i \geqslant p^2c$$
$$p \geqslant \frac{c}{\pi}$$

which is already the condition for the s^d equilibrium. Sending a truthful message is compatible with this action. However, the game will only continue when both players are successful and the probability of reaching a new period is $p^2 < p$.

We next show that the action s^c is incompatible with sending a truthful message when the project is profitable. For player i to send $m_i(\pi) = \pi$ requires

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

Since $(1-p)2c$ is always smaller than $2c$, player i always has an incentive to lie. The proof for player j is analogous to that of player i.

□

Proposition 14 has shown that if borrowers cannot monitor each other's project outcome, then they cannot take advantage of an insurance effect by playing a separating equilibrium.

3.3.2.2 Pooling equilibrium

In any pooling equilibrium, the belief after observing a message has to be the prior belief $\mu(\pi|m_j) = p \quad \forall m_j$, since updating is not possible. We show that 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.

Proposition 15. 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 scheme. This equilibrium is more efficient than the equilibrium under individual liability lending and achieves the highest expected surplus. This is because the bank will always get the repayment unless both group members have unsuccessful projects. The probability of reaching a new period under this equilibrium is $1-(1-p)^2$. As the range where this is possible is narrower, there is less chance of reaching this equilibrium than when subjects have complete information.

Unfortunately, there also exists a minimum-welfare equilibrium where lending ceases immediately after round one.

Proposition 16. 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 12. □

Figure 3.2 shows that when there is incomplete information, the alternate lending scheme is not inferior to the traditional joint liability lending scheme. In the blue and the purple areas, it is possible for group members to play the cover equilibrium. The coordination problem still 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. Remarkably, under this alternate scheme the area where maximum insurance is an equilibrium is

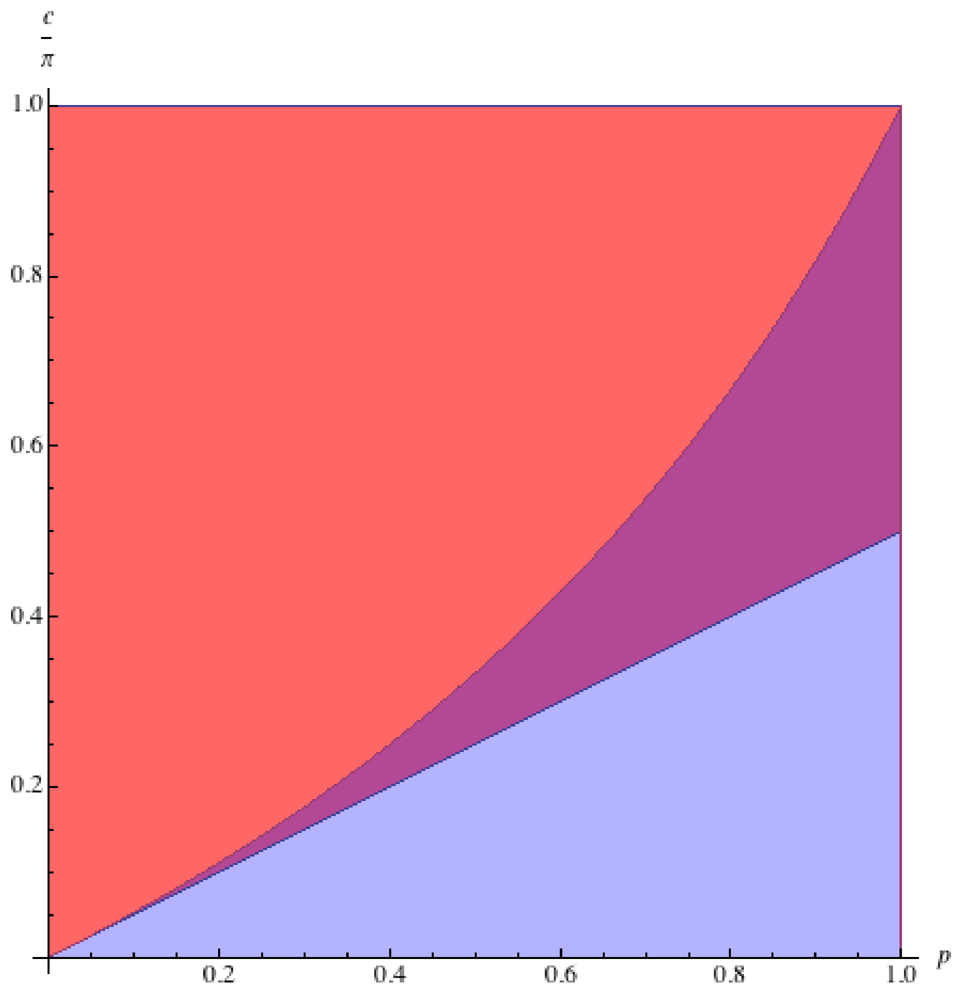

FIGURE 3.2: An alternate joint liability under incomplete information

hardly smaller under private information compared to the case where states of the world are observable.

3.4 Welfare comparison

In this Section, we compare the potential welfare benefit from our alternate joint liability lending scheme with the traditional one under both information structures.

Proposition 17. Under complete information, the alternate scheme can potentially improve the maximum expected total surplus if $\frac{p}{2(1-p)+p^2} \leqslant \frac{c}{\pi} \leqslant \frac{p}{2(1-p+p^2)}$.

Proof. From the previous Chapter, the conditions where a traditional joint liability lending scheme reaches the maximum total surplus are $\frac{c}{\pi} \leqslant \frac{p}{2(1-p+p^2)}$ and $\frac{p}{2} \leqslant \frac{c}{\pi} \leqslant p^2(2-p)$. The alternate scheme performs best when $\frac{c}{\pi} \leqslant \frac{p}{2(1-p)+p^2}$.

Since $p^2(2-p)$ and $\frac{p}{2(1-p)+p^2}$ are always less than $\frac{p}{2(1-p)+p^2}$ when $p < 1$, the alternate scheme allows for an efficient equilibrium in the range in question, while the traditional scheme does not.

□

Proposition 18. Under Incomplete information, the alternate scheme can potentially achieve the same social welfare as the traditional scheme.

Proof. From the previous Chapter, the condition where a traditional joint liability lending scheme 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.

□

3.5 An experimental comparison of an alternate and a traditional joint liability lending scheme

We use an experiment to compare the efficiency between the alternate joint liability lending scheme and a traditional joint liability lending scheme. If subjects are able to cooperate well and take advantage of an insurance effect in our alternate scheme as they were in the traditional scheme, then it might be advantageous for the bank to use the alternate joint liability lending scheme to enable them to reduce the transaction costs. Recall that the alternate scheme does not require a second round of repayment decisions.

3.5.1 Experimental design

The experimental design follows the theoretical framework described in this Chapter. In the previous Chapter we set the probability of a successful project to $p = 0.6$ and the successful project revenue to $\$E100$. We retained these parameters so that we can compare the results with those of the previous Chapter.

The timing of the game is similar to the traditional joint liability lending scheme described previously. The only change is that instead of having a two-step repayment, we only allow subjects to make a single repayment decision. The game timing 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 repayment.

2. The partners can communicate with each other before reaching their repayment decision by choosing one of the following three messages: "I do not want to talk"; "My project is successful"; "My project is unsuccessful". They can enter any amount to repay from $\$E0$ to $\$E100$.

3. 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.

Because our main interest is to compare the alternate scheme with the traditional joint liability lending scheme, we retain the information structure used in the previous experiment. This is a situation with incomplete information with limited communication and a cost of repayment of $\$E45$.

In theory, we should expect all groups to immediately default under both joint liability lending treatments. However, we have seen from the previous Chapter that subjects were able to overcome the free-riding incentive. Therefore, we formulate the following hypothesis:

Hypothesis 2. There is no statistical difference between the estimated repayment rates of the alternate and the traditional joint liability lending scheme.

3.5.2 Experimental procedures

We conducted our experiment in the AdLab at the University of Adelaide, Australia using the computer program 'z-Tree' (Fischbacher (2007)). Subjects were recruited using ORSEE (Greiner (2004)). There were two sessions with 42 participants. Each session only contained one treatment. Most of the subjects were university students from various disciplines. Subjects were given context-free instructions outlining the game at the beginning of each session.

The experimental procedures are the same as described in the previous Chapter. That is, two subjects were randomly paired to form a group. The identity of each subject remained anonymous throughout the session. We changed the group composition after each game such that they would not be matched with the same partner twice. Subjects were informed at the beginning of the session that they would play 5 games in a session and that each game consisted of an undetermined number of rounds. Group members are able to send the same messages as in the traditional lending treatment. As subjects realised their project outcome, instead of choosing the amount they would repay, subjects were asked to enter the amount they would be willing to contribute. 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 16.

3.5.3 Results

In this Chapter we compare an alternate scheme with the traditional joint liability scheme under an incomplete information condition and with limited communication. We use a logistic regression model to test how each state of the world under different lending scheme affects the probability of reaching a new period. The subsequent Section shows that there is no significant difference in the estimated average repayment rate between the two lending schemes.

3.5.3.1 An overview of loan repayment

We use a logistic regression model. The dependent variable is 0 if the repayment is insufficient and 1 if the repayment is sufficient for the game to continue; the covariate is treatment dummies.

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

where Joint1, Joint2, Alt1, Alt2 are the treatment dummies. Joint1 is the traditional joint liability treatment where only one borrower has a successful project ; Joint2 is the traditional joint liability treatment where both borrowers have a successful project; Alt1 is the alternate joint liability treatment when only one borrower has a successful project and is the base category; and Alt2 is the alternate joint liability treatment when both borrowers have a successful project.[3]

Table 3.1: Logistic estimation of continuation probabilities: traditional and alternate joint liability lending

Variable	**Coefficient**	**Predicted continuation probability**
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 left hand side of Table 3.1 shows the estimated log odds that the game continues. The log odds of reaching a new period is positively related to the traditional joint liability lending scheme. The probability of reaching a new period decreases slightly when we switch from a traditional to the alternate joint liability scheme.

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

The right hand side of Table 3.1 shows the predicted probability that the game continues under different states of the world. Recall from the previous Chapter that the predicted probability of reaching a new period of one means that under certain states of the world, subjects will always repay the loans. Table 3.1 shows that coordination is easier and the predicted probability of continuation is higher when both group members have successful projects. The predicted probability of reaching a new period for both traditional and the alternate joint liability scheme under this state of the world is very close to one. However, when only one group member has a successful project, it is harder to coordinate the loan repayment. Observe that the probability of reaching a new period under a single success is approximately 10 percent lower than that under double successes in both treatments.

3.5.3.2 Traditional versus alternate joint liability lending

We test whether there is any statistically significance difference between the traditional and the alternate joint liability treatment under difference states of the world. Our results show no statistically 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 3.1 to calculate the estimated repayment rates. Recall that the estimated repayment rate under the traditional joint liability lending scheme is 74.4 percent. We used the same method and underlying probability for a certain state of the world to occur to compute the estimated repayment rate under the alternate scheme. The estimated repayment rate is 73.1 percent which is a little lower than the estimated repayment rate under the traditional scheme. We then test if there is any significant difference between repayment rates of the two treatments. Formally we test:

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

where $joint1$ is the predicted continuation probability (at the mean) under the traditional joint liability treatment when there is only one success; $joint2$ is the predicted continuation probability (at the mean) under the joint liability treatment when there are two successes; $alt1$ is the predicted continuation probability (at the mean) under the alternate joint liability treatment when there is only one success; and $alt2$ is the predicted continuation probability(at the mean) under the alternate joint liability treatment when there are two successes.

We cannot reject the null hypothesis that there is no difference between the two treatments ($p \approx 0.473$). There is no statistically significant difference in the estimated repayment rates under an alternate and a traditional joint liability lending scheme.

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

The results conform with our prediction that when there is incomplete information among group members, both joint liability lending schemes 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 may be because group members reciprocated their partner generosity when their project failed and thus lead to a higher level of cooperation than anticipated by the theory.

3.6 Conclusion

In this Chapter, we examined an alternate joint liability lending scheme that may reduce transaction costs. It was not our aim to find an optimal joint liability scheme but rather to find an alternate scheme that can reduce transaction costs without compromising the high repayment rates. Since our alternate scheme reduces a step in the transaction, it lowers transaction costs.

Unlike other scholars who tried to perfect the joint liability lending scheme (Rai and Sjöström (2004) and Bhole and Ogden (2010)) with assumptions on social capital, we described the possibility that our alternate scheme can achieve the same outcome without any assumption on social capital. Our theoretical results showed that when group members have information on each other's income, the alternate joint liability lending scheme has a potential to perform better than the traditional scheme. The redistribution of an overpayment and a reduction in repayment round can theoretically reduce the free-riding incentive. However, the potential welfare gain from using an alternate scheme in theory disappears when member's income is private. When there is incomplete information, both schemes should theoretically perform equally well. This may explain why many of the microlenders still use the traditional joint liability lending scheme even though the alternate scheme can potentially reduce their transaction costs.

We then used experiments to determine if the subjects were able to take advantage of joint liability under the alternate scheme. To compare it with the traditional joint liability treatment from the previous Chapter, subjects were in an environment where there is no information about their partner's income and the communication possibilities were limited in the sense that we restricted the message space to three messages. The results revealed that there was no statistical difference between the two schemes with respect to repayments and therefore welfare.

In the next Chapter, we test robustness of the alternate scheme by varying cost, information structures among partners, and the group's ability to communicate.

Chapter 4

The effect of cost, monitoring and communication on joint liability lending performance

4.1 Introduction

In this Chapter, we investigate how a subject's loan repayment decision is affected by changes in the cost of loan repayments, monitoring within a group, and the level of communication within a group. A priori we expect that repayment rates decrease with the cost of loan repayments. On the other hand it is an intuitive hypothesis that repayment rates increase if monitoring is possible and if borrowers can communicate with each other.

The level of repayment a borrower has to make (i.e. principal, interest and fees) is expected to influence the repayment rate. The higher the repayment, the more attractive is the moral hazard strategy of taking the money and run. In this Chapter, we test if the expected relationship between the repayment amount and the repayment rates holds empirically. Previously, we set the cost of loan repayment to $\$E45$ such that the theory predicts that borrowers default immediately. We have previously shown, however, that the high cost of repayment does not overpower the insurance effect of a joint liability scheme. Group members continued to act cooperatively towards each other. In this Chapter, we will lower the cost of loan repayment to $\$E40$ such that there are multiple equilibria and subsequently determine if there is an impact on the repayment rates from further reducing repayment requirements.

Our results show that reducing the cost of loan repayment to $\$E40$ significantly increases the repayment rates. This implies that it is easier for group members to coordinate and cooperate with each other when the cost of loan repayment is reduced.

Next, we test if monitoring affects the repayment decision. The bulk of literature supporting joint liability lending attributes the advantage of it over individual liability lending to social capital within the borrowing community (see Stiglitz (1990); Besley and Coate (1995) for example). It is often assumed that group members can costlessly monitor each other's activities while lenders do not have such advantage. This implies that joint liability may have limited or no success in improving repayment rates if it is applied within a community where there is low social capital. In other words, if group members cannot monitor each other's activities, then there may not be an advantage in using a joint liability lending over an individual lending scheme. In this Chapter, we vary the monitoring ability of borrowers, both when the cost of loan repayment is relatively low ($c = \$E40$) and when it is high ($c = \$E45$). The results from our experiment reveal that when the cost of loan repayment is low ($c = \$E40$) monitoring does not significantly affect the social welfare. However, monitoring can significantly improve social welfare when the cost of loan repayment is high ($c = \$E45$).

Lastly, we test if communication can improve loan repayment rates. Although theory predicts that communication does not affect the outcome of the game, there are many supportive experiments showing that communication can often improve efficiency in social dilemmas (for example, Cooper et al. (1992); Charness and Grosskopf (2004); Ben-Ner and Putterman (2009)). If communication further improves social welfare, then it may be seen as a substitute for costly monitoring tasks.

In this Chapter, we vary the communication protocol under both complete and incomplete information. The communication protocols used include free-form communication, selecting a message from a set of pre-written messages, and no communication. We find that there is a significant decline in repayment rates when we limit the communication and group members do not have the ability to monitor their partners. This supports our argument that communication may be used as a substitute for monitoring. The cost of communication is often lower than the cost of monitoring and communication can improve social welfare of the lending community with low social capital.

The organisation of this Chapter is as follows. We first justify our decision to vary the following three factors: cost of loan repayment, information structure, and ability to communicate. Next we describe the experimental design and procedure. Lastly, we report the results and consider the implications.

4.2 Cost, Monitoring, and Communication

In this Section, we form hypotheses on how changes in costs of loan repayment, group members' monitoring ability, and group members' ability to communicate affect the repayment decision.

4.2.1 Cost of loan repayment

The most obvious factor that may affect the loan repayment rate is the cost of loan repayment. The higher the repayment cost, the more likely that borrowers strategically default on their loan. This can be shown from the no-default condition in the individual lending scheme with the condition $\frac{c}{\pi} \leqslant p$ being necessary for repayment in equilibrium. Also, consider the joint liability lending scheme under complete information with the condition $\frac{c}{\pi} \leqslant \frac{p}{2(1-p)+p^2}$ being necessary for a "cover equilibrium".[1] From the above conditions, other things being equal, as c increases, the incentives to default increase. The high cost of repayment will eventually outweigh the benefit of repaying the loan (i.e. future earnings).

[1] p is the probability that the project will be successful, π is the income from the project when it is successful, and c is the cost of loan repayment.

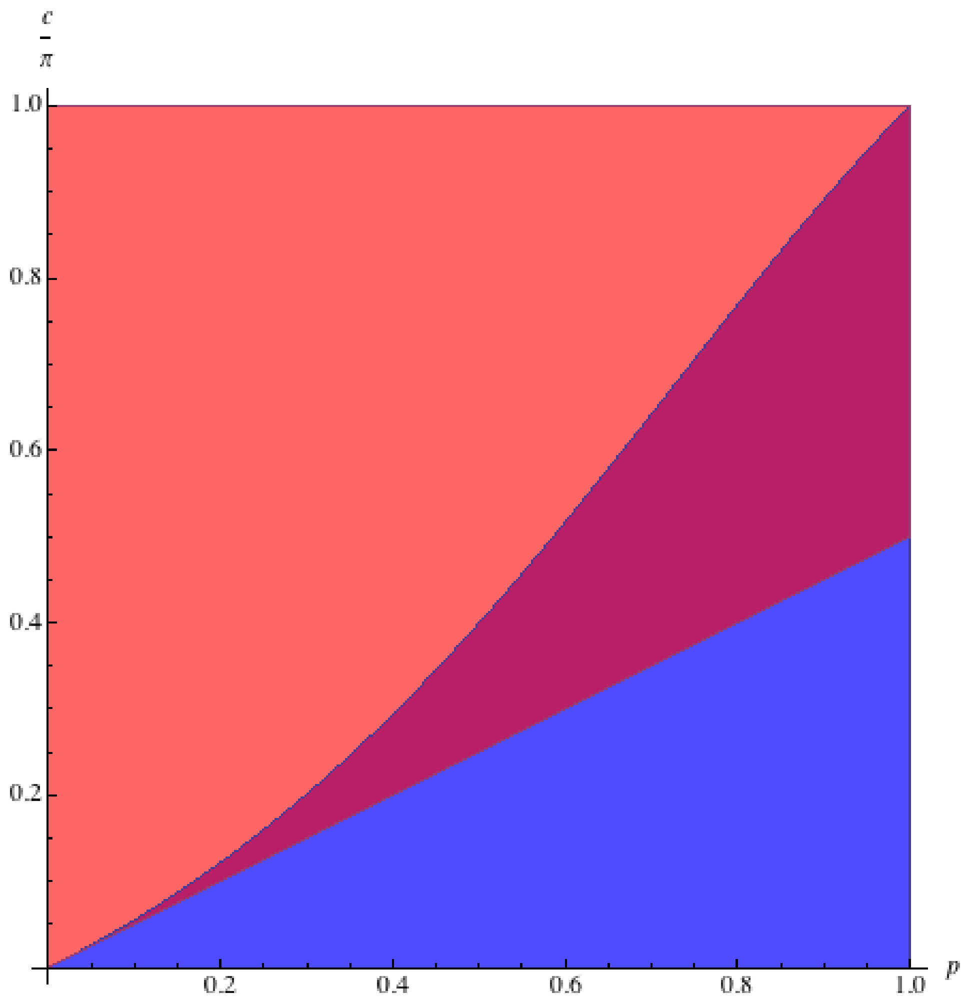

FIGURE 4.1: Impact of repayment costs on strategic default decisions

In what follows, we demonstrate how the repayment cost impact on loan repayment incentives. Figure 4.1 shows the effect of the loan repayment cost on strategic default decisions when borrowers can observe their partners' project outcome. We show the cost of loan repayment per unit of income ($\frac{c}{\pi}$) on the vertical axis and the probability that the project is successful (p) on the horizontal axis. The area above the blue triangle is where the default equilibrium occurs. The blue area is where only cover equilibrium occurs. The default equilibrium yields the worst possible outcome with respect to social welfare, while the cover equilibrium yields the best outcome.

In the pink area, both equilibria are sustainable. As the cost of loan repayment per unit of income rises, we move towards the space where there is only a default equilibrium. Thus the expected repayment rates are expected to decrease.

To determine if repayment decisions are indeed cost sensitive, we vary the cost of the loan repayment in our experiment between $c = \$E40$ and $c = \$E45$. We choose the incomplete information environment where monitoring is impossible. At $c = \$E40$ there are multiple equilibria including the constrained efficient equilibrium. So, if subjects can overcome the coordination problems, a joint liability lending scheme can deliver the best possible outcome and the insurance effect would prevail. At $c = \$E45$, there is only a default equilibrium. Theory predicts that subjects will immediately default in the first playing round and promptly end the game. However, there are legions of experiments where subjects cooperate to an extent even when theory predicts no cooperation. Hence, we do not expect subjects to immediately default when $c = \$E45$. In terms of Figure 4.1, our treatment with $c = \$E40$ is located in the pink parameter space, where both equilibria exist, while $c = \$E45$ lies in the red area where only a default equilibrium exists.

The inconsistency between the theoretical prediction and the experimental results could be attributed to (i) subject's social preferences; (ii) subject's preference for reciprocity or ;(iii) a combination of both. Subjects in our experiment may be inequality-averse such that they not only care about their own payoff but also the distribution of overall payoff (Fehr and Schmidt (1999)). They may be difference-averse as they compared their own payoff to their peers (Charness and Rabin (2002)). So they are willing to help out the less fortunate partner. Another explanation may be that our subjects have preferences for fairness and reciprocity (Rabin (1993); Falk and Fischbacher (2006); Dufwenberg and Kirchsteiger (2004)). These subjects would cooperate and help their partner who help them and punish those who are mean to them. Lastly, it may be that our subjects have preferences for reciprocity as well as considering their status among their peers (Cox et al. (2007)).

We expect that as we lower the cost of loan repayment, the bank will yield significantly higher repayment rates. Thus, our first hypothesis is as follows.

Hypothesis 3. The repayment rates significantly increase as the cost of repayment decreases from $c = \$E45$ to $c = \$E40$.

4.2.2 Monitoring

Another factor that may affect the loan repayment rates is the information each borrower has about their partner. Supporters of joint liability lending schemes often attribute the high repayment rates to monitoring ability among jointly liable borrowers (for example, Stiglitz (1990); Besley and Coate (1995)).

For Stiglitz (1990), the advantage of a joint liability lending scheme over individual lending is that it increases the incentive for partners to monitor each other's investment. This is because under joint liability group members are responsible for their partner's repayment. If their partner fails to repay, then they have to repay for them or risk losing future credit from the bank. Monitoring leads to less investment on risky projects and lower rates of default. The main assumption leading to this results is that, unlike the bank, group members do not incur costs of monitoring.

However, when there is a monitoring cost, joint liability lending alone is not enough to ensure repayment. Aniket (2005) showed that there is an equilibrium where group member will collude by exerting low effort. The lender needs to not only lend to a group but also needs to lend to group members sequentially in order to prevent collusion. Chowdhury (2005) also reached a similar conclusion that sequential lending is essential to ensure sufficient monitoring and loan repayments.

Besley and Coate (1995) showed how joint liability can lead to higher loan repayment rates than individual liability lending through social punishment. If the social punishment is costly enough, the group will always repay the loan whenever they can. They assumed that partners can costlessly monitor each other's income. However, Armendariz de Aghion (1999) showed that once the assumption on monitoring cost is relaxed, the effectiveness of joint liability lending in improving the loan repayment rates not only depends on the severity of social sanctions but also on the peer monitoring cost. Specifically, the lower the cost of peer monitoring, the higher the loan repayment rates. Thus, reduced monitoring decreases repayment rates.

In their experiment, Cason et al. (2008) concluded that the advantage of joint liability lending comes from the lower cost of monitoring between group members. When there is no difference in cost of monitoring, whether it is peer or lender monitoring, the advantage of using a joint liability lending scheme vanished. Wydick (1999) similarly concluded that monitoring and social sanction could significantly improve the repayment rates under a joint liability lending scheme.

Theoretical and empirical evidence suggest that if we remove the ability for partners to monitor each other then joint liability repayment rates will significantly decrease. This is one of the main arguments that were used to explain why the success of the Grameen Bank could not be replicated in other environments (Kenya's Jehudi scheme and the Good Faith Fund are among several examples).

The condition for a cover equilibrium with monitoring is $\frac{c}{\pi} \leqslant \frac{p}{2(1-p)+p^2}$ and that for the default equilibrium is $\frac{c}{\pi} \geqslant \frac{p}{2}$. When there is no information on their partner's income, the cover equilibrium condition becomes $\frac{c}{\pi} \leqslant \frac{p}{(2-p)}$. At $c = \$E45$, there is only a default equilibrium when there is no monitoring. However, when there is monitoring, we have multiple equilibria. Theoretically, monitoring has an advantage over no monitoring and we therefore expect significant differences in the repayment rates. Our theoretical results also show that at $c = \$40$, both cover and default equilibrium exist. The welfare outcome depends on the equilibrium selection by the players. If monitoring is crucial to the success of joint liability lending, then there should be a significant difference in the repayment rates between treatments where there is complete and incomplete information.

Figure 4.2 shows different equilibria under different information structures. The orange area is where a default equilibrium exists under both information structures. The pink, light pink, and blue areas are where a cover equilibrium exists under full monitoring. The light pink and blue area are where a cover equilibrium in the absence of monitoring exists. Notice that the area is smaller than that under full monitoring. This shows that monitoring can be advantageous. When $c = \$E45$, we are in the pink area. This shows multiple equilibria under complete information but only a default equilibrium under incomplete information. The case of $c = \$E40$ is

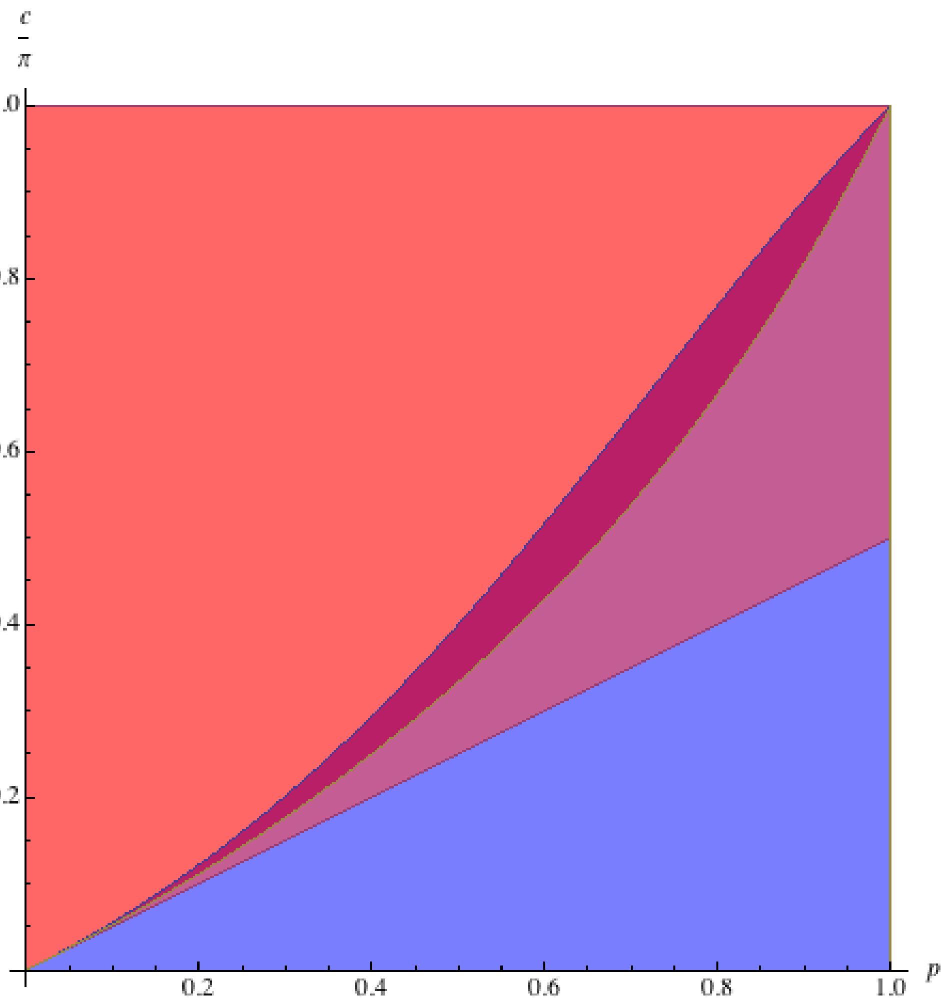

FIGURE 4.2: Equilibria under both complete and incomplete information

located in the light pink area. There are multiple equilibria under both information structures.

To determine if the repayment decisions are sensitive to the information among group members, we vary the information that group members receive about their partner's ability to repay. Additionally, we vary the cost of loan repayment. We first set the cost of loan repayment to $c = \$E45$ where monitoring has a clear theoretical advantage. Then we reduce the cost of loan repayment to $c = \$E40$ to see if that advantage still existed for parameters where theory does not predict an advantage.

Due to both theoretical and existing empirical evidence, we expect a significant difference between the repayment rates across treatments with and without monitoring. Accordingly, we formulate the following hypothesis.

Hypothesis 4. The repayment rates under full monitoring are significantly higher than when there is no monitoring regardless of the cost of repayment.

4.2.3 Communication

We considered if communication between group members could improve the loan repayment rates. There is ample evidence showing that pre-play communication generally improves coordination and thus leads to increases in social welfare (Cooper et al. (1992); Charness and Grosskopf (2004); Ben-Ner and Putterman (2009)).

Cooper et al. (1992) examined the effect of pre-play communication on a one-shot "Battle of The Sexes" game. They found that a one-way pre-play communication between subjects improved coordination while two-way communication was not as effective. Similarly, Charness and Grosskopf (2004) used a "Stag-hunt" game to study the effect of pre-play communication on coordination among subjects. They found that allowing subjects to send a one-way message to their partner significantly increased coordination and improved group welfare. Ben-Ner and Putterman (2009) used a "Trust" game where they found that communication helped building trust and increased the transfered amount. They suggested that communication may be a substitute for a contract to reduce high transaction cost. They also found that verbal messages worked better than when they only allowed subjects to select the numerical amount they would like to transfer. This empirical evidence tends to support the argument that pre-play communication can lead to better coordination and hence better welfare.

We test the effect of communication on repayment performance for a joint liability lending scheme when there was no monitoring within a group. When there is private information, subjects can choose to communicate to show their repayment intention or to signal their income to their partner. To test this, we vary communication as follows: 1) free-form communication where we let subjects chat freely with each other; 2) communication via messages where we only allow subjects to select the pre-written message signalling their project's outcome to their partner and; 3) no communication.

As previously indicated, repayment rates were well above zero when we only allowed subjects to select a pre-written message. We therefore expect that letting subjects communicate freely before making their repayment decision will significantly improve the repayment rates while no communication will hinder coordination and cooperation among subjects and yield significantly lower repayment rates. According to this, our hypothesis is:

Hypothesis 5. Free-form communication significantly increases repayment rates compared to the treatment with messages as a form of communication.

Hypothesis 6. No communication significantly decreases repayment rates compared to the treatment with messages as a form of communication.

4.3 Experimental design

The experimental design here is an extension to the experiment we described in the previous Chapter. We retain our basic parameter settings for the probability that a project will be successful at $p = 0.6$ and the successful project revenue at $\$E100$. There are three main variations for the treatments: 1) cost: from $c = \$E45$ to $c = \$E40$; 2) monitoring: from no monitoring (incomplete information) to full monitoring (complete information) and; 3) communication among group members: from sending selected messages to free-form communication and no communication.

The game timing also follows from the timing of the game in the previous Chapter. That is,

1. Subjects learn their project outcome. If their project is successful, they earn $\$E100$. If their project is unsuccessful, they do not earn any income and cannot make any repayment.

2. Where we allow free-form communication and communication via messages, the partners can communicate with each other before they enter their repayment decision from $\$E0$ to $\$E100$. Otherwise, subjects skip to immediately making a repayment decision.

3. If the total repayment of the group is greater than $2c$, the game continues to the next round. Otherwise, the game ends. If there is an overpayment in a group, we redistribute the excess amount equally among group members.

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

Table 4.1 outlines the two main dimensions we varied in our experiment.

Table 4.1: Treatment manipulations

	Monitoring	
Cost	$c = 40$, Yes	$c = 40$, No
	$c = 45$, Yes	$c = 45$,No

4.4 Experimental procedures

The experiment was conducted at the AdLab, University of Adelaide, Australia using the computer program 'z-Tree' (Fischbacher (2007)). There were 13 sessions with 264 participants. Each session contained one treatment. Main participants in these treatments were not exposed to previous treatments in our series of experiments. Most of the subjects were university students from a variety of disciplines. Context-free instructions outlining the game were given at the beginning of each session.

How subjects were matched, how group compositions were changed, number of games played within a session, and the information given to subjects remained the same as in the treatments reported in the previous Chapter. As in the other treatments in the earlier Chapter, subjects were also informed that they were permitted to bring study material or books to read during the waiting period between the games.

The subjects were paid in cash at the end of each session. The subjects were paid AUD 5 show-up fee in addition to their earnings during the session. The exchange rate was one Australian Dollar for 50 Experimental Dollars. On average, each session took approximately one hour and subjects earned approximately AUD 19.

4.5 Results

The main purpose of this Chapter is to explore how changes in the cost of loan repayment, monitoring ability, and communication among group members affects the repayment rates. We stated our hypotheses about the consequences of these changes on the repayment rates earlier in this Chapter. In this Section, we will test those hypotheses using logistic regression models to determine how the probability of reaching the new period changes with different treatments.

4.5.1 Cost of loan repayments

We varied the cost of loan repayment from $c = \$E45$ to $c = \$E40$ when group members cannot monitor each other's income but were able to chat to their partner via a "chat box" in the program. We denote the two treatments as PI45 and PI40, respectively.

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

where Low1, Low2, High1, High2 are the treatment dummies. Low1 is the PI40 treatment where only one borrower has a successful project and is the base category; Low2 is the PI40 treatment where both borrowers have a successful project; High1 is the PI45 treatment when only one borrower has a successful project; and High2 is the PI45 treatment when both borrowers have a successful project.[2]

TABLE 4.2: Logistic estimation of continuation probabilities: $c = \$E40$ and $c = \$E45$

Variable	Coefficient	Predicted continuation probability
Constant	2.708***	
	(.180)	
Low1		.938
		(.011)
Low2	2.182**	.993
	(.732)	(.005)
High1	-.693**	.882
	(.320)	(.018)
High2	1.069	.978
	(.450)	(.009)
Log likelihood=-280.952 ; LR chi2(3) = 44.25; Prob>chi2 = 0.0000		
standard errors are shown in parentheses		*** significant at 0.001

The left hand side of Table 4.2 shows the estimated log odds that the game continues. The log odds of reaching a new period is positively related to both treatments where both group members have a successful project, while it is negatively related to the

[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.

treatment where only one member's project is successful. The probability of reaching a new period increases with double successes while it decreases with a single success.

The right hand side of Table 4.2 shows the predicted probability that the game continues under different states of the world. Notice that the probability of reaching a new period is slightly higher under the PI40 treatment compared to PI45 in a pairwise comparison for both states of the world. Thus subjects generally repay more often under PI40 than under PI45.

We use the values from Table 4.2 to calculate the estimated repayment rates. The estimated average repayment rate from PI40 treatment is 81.72 percent while the estimated average repayment rate from PI45 treatment is 77.54 percent. We then test if there is any significant difference between repayment rates of the two treatments. Formally we test:

$$2p(1-p)(low1) + p^2(low2) \gtreqless 2p(1-p)(high1) + p^2(high2)$$

where $low1$ is the predicted continuation probability (at the mean) under the PI40 treatment when there is only one success; $low2$ is the predicted continuation probability (at the mean) under the PI40 treatment when there are two successes; $high1$ is the predicted continuation probability (at the mean) under PI45 treatment when there is only one success; and $high2$ is the predicted continuation probability(at the mean) under the PI45 treatment when there are two successes.

The test strongly rejected the null hypothesis that there is no difference between the repayment rates under the two treatments ($p < 0.05$). This confirms our hypothesis that as the cost of repayment decreases, repayment rates increase.

Result 3. There is a statistical difference between the repayment rates when we vary cost from $\$E40$ to $\$E45$ (at $p < 0.05$).

Lowering the amount that has to be repaid (e.g. through lower interest rates) improves repayment rates.

4.5.2 Monitoring

We now turn to the impact of the information structure. We first examine the case where monitoring has an obvious advantage in theory. That is, we are comparing monitoring and no monitoring with repayment cost of $\$E45$ and group members were not permitted to communicate. We denote the treatment with monitoring as CI45-N (i.e. Complete Information with the cost 45 and no communication) and the treatment without monitoring as PI45-N (PI stands for private information). We further examine if monitoring could behaviourally improve coordination when there were multiple equilibria for both information conditions. We compare the treatment when cost of repayment is $\$E40$ and we allow free-form communication within a group. We denote the treatment with monitoring as CI40 and the treatment without monitoring as PI40.

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

where Monitor1, Monitor2, Nomonitor1, Nomonitor2 are the treatment dummies. Monitor1 is the CI45-N treatment where only one borrower has a successful project and is the base category; Monitor2 is the CI45-N treatment where both borrowers have a successful project; Nomonitor1 is the PI45-N treatment when only one borrower has a successful project; and Nomonitor2 is the PI45-N treatment when both borrowers have a successful project.

TABLE 4.3: Logistic estimation of continuation probabilities: monitoring versus no monitoring with $c = \$E45$

Variable	**Coefficient**	**Predicted continuation probability**
Constant	2.828***	
	(.225)	
Monitor1		.944
		(.012)
Monitor2	1.657**	.989
	(.623)	(.006)
Nomonitor1	-1.441***	.8
	(.278)	(.026)
Nomonitor2	1.138	.981
	(.552)	(.009)
Log likelihood= -234.955 ; LR chi2(3) = 76.99; Prob>chi2 = 0.0000		
standard errors are shown in parentheses		*** significant at 0.001

The left hand side of Table 4.3 shows the estimated log odds that the game continues. The relationship of the probability of reaching a new period and the states of the world are similar to our previous results. That is, a state of the world where we have double successes tends to increase the log odds of probability of reaching the new period while a single success tends to decrease that probability.

The right hand side of Table 4.3 shows the predicted probability that the game continues under different states of the world. Note that when there is full monitoring, the estimated probability of reaching a new period is always close to one even when there is only a single success. That is, subjects in this treatment almost always repay the loan whenever they can. In particular, monitoring is instrumental in ensuring that a successful borrower covers for an unsuccessful one. The estimated probability of reaching a new period is much lower for the treatment without monitoring when there is a single success.

We calculate the estimated repayment rates using the values from Table 4.3. The estimated average repayment rate from the CI45-N treatment was 80.22 percent while the estimated average repayment rates from the PI45-N treatment was 73.72 percent. We then test if there was any significant difference between repayment rates of these two treatments. Formally we test:

$$2p(1-p)(monitor1) + p^2(monitor2) \gtreqless 2p(1-p)(nomonitor1) + p^2(nomonitor2)$$

where $monitor1$, $monitor2$, $nomonitor1$, and $nomonitor2$ denote the corresponding treatment dummies' predicted continuation probability(at the mean).

The test strongly rejected the null hypothesis that there is no difference between the repayment rates under the two treatments ($p < 0.05$). This confirms our hypothesis and our theoretical results that monitoring does have some advantage over no monitoring.

Result 4. Monitoring significantly improves the repayment rates when the cost of repayment is $c = \$E45$ (at $p < 0.05$).

We then test if this result holds when monitoring has no clear advantage.

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

where Monitorl1, Monitorl2, Nomonitorl1, Nomonitorl2 are the treatment dummies. Monitorl1 is the CI40 treatment where only one borrower has a successful project and is the base category; Monitorl2 is the CI40 treatment where both borrowers have a successful project; Nomonitorl1 is the PI40 treatment when only one borrower has a successful project; and Nomonitorl2 is the PI40 treatment when both borrowers have a successful project.

The left hand side of Table 4.4 shows the estimated log odds that the game continues. Again, double successes have a positive relationship with the log odds of the probability of reaching the new period while a single success is negatively related to the log odds of the probability of reaching the new period.

The right hand side of Table 4.4 shows the predicted probability that the game continues under different states of the world. Observe that here where theory predicts multiple equilibria, the estimated probability of reaching a new period of both treatments are close to one. Subjects almost always repay the loan when their project is successful and they also readily cover for an unsuccessful partner. Interestingly, the

TABLE 4.4: Logistic estimation of continuation probabilities: monitoring versus no monitoring$c = \$E40$

Variable	Coefficient	Predicted continuation probability
Constant	3.152***	
	(.283)	
Monitorl1		.959
		(.011)
Monitorl2	1.69	.992
	(.764)	(.006)
Nomonitorl1	-.444	.938
	(.335)	(.011)
Nomonitorl2	1.738*	.993
	(.764)	(.005)
Log likelihood= -201.1697 ; LR chi2(3) = 26.72; Prob>chi2 = 0.0000		
standard errors are shown in parentheses		*** significant at 0.001

ability to monitor does not seem to be required for the high probability of continuation when the cost of repayment is low.

We calculated the estimated repayment rates using the values from Table 4.4. The estimated average repayment rate from CI40 treatment was 81.74 percent while the estimated average repayment rate from PI40 treatment was 80.77 percent. We then test if there was any significant difference between repayment rates of the two treatments. Formally we test:

$$2p(1-p)(monitorl1) + p^2(monitorl2) \gtreqless 2p(1-p)(nomonitorl1) + p^2(nomonitorl2)$$

where *monitorl*1, *monitorl*2, *nomonitorl*1, and *nomonitorl*2 denote the corresponding treatment dummies' predicted continuation probability(at the mean).

The test cannot reject the null hypothesis that there is no difference between the repayment rates under the two treatments ($p \simeq 0.195$).

Result 5. There is no significant difference in the estimated repayment rates between monitoring and non-monitoring treatments when the cost of repayment is $c = \$E40$.

In the case of low repayment cost, monitoring is not required to ensure high repayment rates. Subjects are able to coordinate on socially efficient equilibria.

4.5.3 Communication

Finally, we investigate if communication can improve the repayment rates by comparing a no monitoring treatment where group members could communicate freely with others to a treatment where they could only send a pre-written message to their partners, and to a treatment where no communication is allowed. The repayment cost were set to $c = \$E45$ in all three communication conditions. The three treatments are denoted as PI45, PI45-Msg, and PI45-N, respectively.

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

where Chat1, Chat2, Msg1, Msg2, Nocom1, and Nocom2 are the treatment dummies. Chat1 is the PI45 treatment where only one borrower has a successful project and is the base category; Chat2 is the PI45 treatment with double successes; Msg1 is the PI45-Msg treatment with a single success; Msg2 is the PI45-Msg treatment with double successes; Nocom1 is the PI45-N treatment with a single success; and Nocom2 is the PI45-N treatment with double successes.

TABLE 4.5: Logistic estimation of continuation probabilities: variations in communication protocol

Variable	**Coefficient**	**Predicted continuation probability**
Constant	2.015***	
	(.173)	
Chat1		.882
		(.018)
Chat2	1.76***	.978
	(.448)	(.009)
Msg1	-.473*	.824
	(.237)	(.024)
Msg2	.610	.932
	(.370)	(.021)
Nocom1	-.629**	.8
	(.238)	(.026)
Nocom2	1.951***	.981
	(.533)	(.009)
Log likelihood= -441.352 ; LR chi2(5) = 86.13; Prob>chi2 = 0.0000		
standard errors are shown in parentheses		*** significant at 0.001

The left hand side of Table 4.5 shows the estimated log odds that the game continues. We observe that double successes increase the log odds of the probability of reaching a new period while a single success decreases the log odds of the probability of reaching a new period regardless of the treatment.

The right hand side of Table 4.5 shows the predicted probability that the game continues under different states of the world. Notice that it is much harder for subjects to cooperate in a state of the world where there is only one successful group member. The estimated probability of reaching a new period when there is a single success is approximately ten percentage points less than when there are double successes.

We calculate the estimated repayment rates using the values from Table 4.5. The estimated average repayment rate from the PI45 treatment is 77.54 percent while the estimated average repayment rate from PI45-Msg treatment was 73.10 percent and the estimated average repayment rate from PI45-N treatment is 73.72 percent. We now test if there are any significant differences between repayment rates in these treatments. Formally we test:

$$2p(1-p)(chat1) + p^2(chat2) \gtreqless 2p(1-p)(msg1) + p^2(msg2)$$

$$2p(1-p)(chat1) + p^2(chat2) \gtreqless 2p(1-p)(nocom1) + p^2(nocom2)$$

$$2p(1-p)(msg1) + p^2(msg2) \gtreqless 2p(1-p)(nocom1) + p^2(nocom2)$$

where $chat1$, $chat2$, $msg1$, $msg2$, $nocom1$, and $nocom2$ denote the corresponding treatment dummies' predicted continuation probability(at the mean).

The first two tests strongly rejected the null hypothesis that there is no difference between the repayment rates from treatments PI45 and PI45-Msg ($p < 0.05$) as well as the treatments with PI45 and PI45-N ($p < 0.05$). This confirms our hypothesis that communication can help group members cooperate better. However, we cannot reject the null hypothesis that there is no difference between the repayment rates between treatments PI45-Msg and PI45-N. This may be because the pre-written messages only allow subjects to signal their project outcome but not their repayment intention. Thus, it does not have a strong impact on cooperation.

Result 6. Free-form communication significantly improves the repayment rates when $c = \$E45$.

Result 7. There is no significant difference in repayment rates between the treatment with pre-written messages communication and no communication treatment when $c = \$E45$.

Pre-play communication may be able to substitute for monitoring if partners are allowed to communicate freely.

4.6 Conclusion

In this Chapter, we examined the impact of changes in cost of loan repayment, ability to monitor the partner's income, and the ability to communicate within a group.

The implications are that cost of loan repayment and communication ability among group members are crucial to improving social welfare. Social capital such as the ability to monitor partner's income does not have a clear cut advantage and joint liability appears to be able to perform equally well without it as long as the cost of repayments are low. When the cost of repayment is high though, monitoring can help to improve the occurrence of successful borrowers covering for their unsuccessful partners, which over all slightly improves social welfare.

Chapter 5

Conclusion

In this thesis we examined the following questions: (i) Can a joint liability lending scheme outperform an individual liability lending scheme?; (ii) Will an alternative joint liability lending scheme further improve the social welfare compared to a traditional joint liability lending scheme?; (iii) How is a group repayment decision affected by changes in cost of loan repayment, monitoring, and the level of communication possible?

In Chapter two our theoretical analysis showed that joint liability has a potential to improve social welfare via an insurance effect. However, there was also a possibility that both borrowers strategically default on their loan. We designed experiments to study the choice made by real humans. The results showed that even though subjects under a joint liability lending scheme were put in an environment that does not support cooperation among members, a joint liability lending scheme still had higher repayment rates than an individual liability lending scheme.

We proposed a simpler form of joint liability lending in Chapter three. Our scheme has the potential to reduce transaction costs, since it only requires one round of repayment decisions (compared to two in the traditional scheme). Our theoretical results showed that an alternate joint liability lending scheme reduces the incentive to free-ride when borrowers have complete information on their partner's income. That is, the alternate scheme can potentially improve the group's welfare. However, there is no difference in welfare under a stationary equilibrium when borrowers cannot observe their partner's income. Since the results on social welfare rest upon equilibrium selection, we used experiments to empirically test how the alternate scheme performed against the traditional joint liability lending scheme. The results showed that the alternate scheme performed no worse than the traditional scheme. We concluded that our alternate scheme might, over all, improve social welfare as it can reduce transaction costs without jeopardising repayment rates.

Unlike in the two previous Chapters, in Chapter four we investigated how cost of loan repayment, monitoring within a group, and the level of communication within a group affected the group's repayment decision. We found that as the cost of loan repayment was reduced, the repayment rates increased as expected. When we varied whether group member could observe their partner's income, we found that more information could statistically increases the repayment rates under certain circumstances. Lastly, we found that communication among the group increased the repayment rates when there was a lack of monitoring. This implied that communication may be able to substitute for costly monitoring.

Bibliography

Abbink, K., B. Irlenbusch, and E. Renner (2006). Group size and social ties in microfinance institutions. *Economic Inquiry 44*(4), 614.

Ahlin, C. and R. Townsend (2007). Using Repayment Data to Test Across Models of Joint Liability Lending. *Economic Journal 117*, F11–F51.

Andreoni, J. (1995). Cooperation in public-goods experiments: kindness or confusion? *The American Economic Review*, 891–904.

Aniket, K. (2005). Sequential group lending with moral hazard. Technical report, Edinburgh School of Economics, University of Edinburgh.

Armendariz de Aghion, B. (1999). On the design of a credit agreement with peer monitoring. *Journal of Development Economics 60*(1), 79–104.

Armendáriz de Aghion, B. and J. Morduch (2000). Microfinance beyond group lending. *Economics of transition 8*(2), 401–420.

Armendariz de Aghion, B. and J. Morduch (2007). *The Economics of Microfinance.* The MIT Press.

Banerjee, A., A. Banerjee, and E. Duflo (2011). *Poor Economics: A Radical Rethinking of the Way to Fight Global Poverty*. PublicAffairs.

Ben-Ner, A. and L. Putterman (2009). Trust, communication and contracts: An experiment. *Journal of Economic Behavior & Organization 70*(1-2), 106–121.

Besley, T. and S. Coate (1995). Group lending, repayment incentives and social collateral. *Journal of development economics 46*(1), 1–18.

Bhole, B. and S. Ogden (2010). Group lending and individual lending with strategic default. *Journal of Development Economics 91*(2), 348 – 363.

Bolton, G. and A. Ockenfels (2000). Erc: A theory of equity, reciprocity, and competition. *American economic review*, 166–193.

Braverman, A. and J. Guasch (1986). Rural credit markets and institutions in developing countries: Lessons for policy analysis from practice and modern theory. *World Development 14*(10–11), 1253 – 1267.

Cason, T., L. Gangadharan, and P. Maitra (2008). Moral Hazard and Peer Monitoring in a Laboratory Microfinance Experiment. *Purdue University, Institute fir Research in the Behavioral Economics and Management Science, Paper No 1208.*

Cassar, A., L. Crowley, and B. Wydick (2007). The effect of social capital on group loan repayment: Evidence from field experiments. *Economic Journal 117*(517), F85–F106.

Charness, G. and B. Grosskopf (2004). What makes cheap talk effective? experimental evidence. *Economics Letters 83*(3), 383–389.

Charness, G. and M. Rabin (2002). Understanding social preferences with simple tests. *The Quarterly Journal of Economics 117*(3), 817–869.

Che, Y. (2002). Joint Liability and Peer Monitoring under Group Lending. *The BE Journal of Theoretical Economics 2*(1), 3.

Chowdhury, P. (2005). Group-lending: Sequential financing, lender monitoring and joint liability. *Journal of Development Economics 77*(2), 415–439.

Cooper, R., D. DeJong, R. Forsythe, and T. Ross (1992). Communication in coordination games. *The Quarterly Journal of Economics 107*(2), 739–771.

Cox, J., D. Friedman, and S. Gjerstad (2007). A tractable model of reciprocity and fairness. *Games and Economic Behavior 59*(1), 17–45.

Dufwenberg, M. and G. Kirchsteiger (2004). A theory of sequential reciprocity. *Games and Economic Behavior 47*(2), 268–298.

Falk, A. and U. Fischbacher (2006). A theory of reciprocity. *Games and Economic Behavior 54*(2), 293–315.

Fehr, E. and K. Schmidt (1999). A theory of fairness, competition, and cooperation. *The Quarterly Journal of Economics 114*(3), 817–868.

Fischbacher, U. (2007). z-tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics 10*(2), 171–178.

Gangopadhyay, S., M. Ghatak, and R. Lensink (2005). Joint liability lending and the peer selection effect. *Economic Journal 115*(506), 1005–1015.

Ghatak, M. (1999). Group lending, local information and peer selection. *Journal of Development Economics 60*(1), 27–50.

Ghatak, M. (2000). Screening by the company you keep: Joint liability lending and the peer selection effect. *Economic Journal*, 601–631.

Ghatak, M. and T. Guinnane (1999). The economics of lending with joint liability: theory and practice1. *Journal of development economics 60*(1), 195–228.

Gine, X., P. Jakiela, D. Karlan, and J. Morduch (2010). Microfinance games. *American Economic Journal: Applied Economics 2*(3), 60–95.

Gomez, R. and E. Santor (2003). Do Peer Group Members Outperform Individual Borrowers? A Test of Peer Group Lending Using Canadian Micro-Credit Data.

Greiner, B. (2004). An online recruitment system for economic experiments.

Karlan, D. (2007). Social connections and group banking. *Economic Journal 117*(517), F52–F84.

Kono, H. (2006). Is Group Lending A Good Enforcement Scheme for Achieving High Repayment Rates?: Evidence from Field Experiments in Vietnam.

Madajewicz, M. (2004). Joint liability versus individual liability in credit contracts. *Discussion Papers*.

Morduch, J. (1999). The microfinance promise. *Journal of economic Literature 37*(4), 1569–1614.

Morduch, J. (2000). The microfinance schism. *World Development 28*(4), 617–629.

Paxton, J., D. Graham, and C. Thraen (2000). Modeling group loan repayment behavior: New insights from Burkina Faso. *Economic Development and Cultural Change 48*(3), 639–655.

Rabin, M. (1993). Incorporating fairness into game theory and economics. *The American Economic Review*, 1281–1302.

Rai, A. S. and T. Sjöström (2004). Is grameen lending efficient? repayment incentives and insurance in village economies. *The Review of Economic Studies 71*(1), 217–234.

Sharma, M. and M. Zeller (1997). Repayment performance in group-based credit programs in Bangladesh: An empirical analysis. *World Development 25*(10), 1731–1742.

Stiglitz, J. (1990). Peer monitoring and credit markets. *The World Bank Economic Review 4*(3), 351.

Stiglitz, J. and A. Weiss (1983). Incentive effects of terminations: Applications to the credit and labor markets. *The American Economic Review 73*(5), 912–927.

Tedeschi, A. et al. (2006). Here today, gone tomorrow: Can dynamic incentives make microfinance more flexible? *Journal of development economics 80*(1), 84–105.

Van Tassel, E. (1999). Group lending under asymmetric information. *Journal of Development Economics 60*(1), 3–25.

Wenner, M. (1995). Group credit: A means to improve information transfer and loan repayment performance. *Journal of Development Studies 32*(2), 263–281.

Werner, P. (2010). The dynamics of cooperation in group lending-a microfinance experiment. *Working Paper Series in Economics*.

Wydick, B. (1999). Can social cohesion be harnessed to repair market failures? Evidence from group lending in Guatemala. *Economic Journal 109*(457), 463–475.

Wydick, B. (2001). Group lending under dynamic incentives as a borrower discipline device. *Review of Development Economics 5*(3), 406–420.