Microcredit Games with Noisy Signals: Collusion or Free-Riding? *

Hisaki Kono †

Institute of Developing Economies

February 28, 2013

Preliminary and incomplete. Please do not cite without permission.

Abstract

Compared with individual liability, joint liability can increase strategic default through collusion and free-riding. By using experimental repayment games which mimic microcredit programs, we found that joint liability increased strategic default when the signals were not precise or not available. Our investigation on collusion and free-riding suggests that subjects did free-ride under joint liability, but we could not find any evidence for free-riding under individual liability. A part of the results are also supporting collusion under joint liability, but they are also consistent with free-riding. We also found that subjects did not seem to respond to free-riding when they made decision on shouldering their partners and future repayment decision, which might explain why subjects chose free-riding.

Keywords To be added...

JEL Classification To be added...

*This research was supported by the Institute of Developing Economies (IDE-JETRO) and the Japan Society for the Promotion of Science (KAKENHI 20730198). I thank our research assistants Nguyen Thi Huyen Tram, Tran Thi Song Phung, Dang Van Trinh, Pham Thi Tam, Nguyen Mau Trung, Chau Thi Tu, and Nguyen Van Ba for outstanding fieldwork.

†Institute of Developing Economies, 3-2-2 Wakaba, Mihama-ku, Chiba 261-8545, Japan. Phone: +81 (43) 299-9606. E-mail: Hisaki_Kono@ide.go.jp

1 Introduction

The access to the credit for the poor people in developing countries has been remarkably improved by the advent of microcredit, unsecured small loans for the last two decades. Microcredit Summit Campaign (2013) reported that as of 2011, 3,703 microfinance institutions (MFIs) reached 195 million clients, 124 million of whom were among the poorest when they took their first loan. Microcredit has become a popular poverty alleviation policy partly because it is financially sustainable, supported by quite high repayment rates, typically around 90% to 98%. Joint liability - requiring group members to be jointly liable for the repayment of other members' loans - was believed to be an important factor for achieving high repayment rates. Economists have shown theoretically how joint liability can solve the asymmetric information problem in lending to the poor without collaterals (See (Ghatak, 1999) for adverse selection, (Stiglitz, 1990) for moral hazard, and (Besley and Coate, 1995) for strategic default).

During the last decade, however, some MFIs have departed from joint liability. Giné and Karlan (2011)'s randomized experiment provides a support for this trend - they found no difference in repayment rates between joint liability centers and individual liability centers which were randomly chosen from the pre-existing joint liability centers. Kono (2013) also supported this view by providing lab experimental data on strategic behavior in Vietnam to show that joint liability did not outperform individual liability, and it might increase strategic default if strong social sanctions are not available. Some recent papers provide evidence for collusion under joint liability in Mexico (Allen, 2012), India (Breza, 2012), and Pakistan (Kurosaki and Khan, 2012). When negative income shocks happen to some members, then the remaining members are more likely to choose strategic default because joint liability requires the remaining members to shoulder for their partners as well as to repay their own loans.[1]

Collusion is not only the problem of joint liability. Free-riding can also work. Because joint liability requires other members to help defaulting members, some members might be enticed to choose strategic default expecting that other members will shoulder for them. Collusion and free-riding can generate different predictions. If collusion works, then a borrower is less likely to choose strategic default when they observe high partner's income because

[1]Strategic default is not a solely factor driving the results of Giné and Karlan (2011). Moral hazard will be also an issue, and Giné et al. (2010) showed that joint liability induced subjects to choose risky investment - moral hazard - in a experimental game conducted in Peru.

they do not worry about shouldering for their partners. on the other hand, if free-riding works, then a borrower may be more likely to choose strategic default when they observe high partner's income because they know their partners have sufficient income to shoulder for them. Previous literature did not distinguish the importance of collusion and free-riding, and the purpose of this paper is to investigate which effects are actually working.

We use experimental repayment games conducted in Vietnam to examine how the repayment decision differs between individual liability and joint liability. To make individual liability comparable with joint liability where borrowers can share income shocks, we incorporate repeated game framework where borrowers under individual liability can also share the income shocks. To give an incentive for repayment, we incorporate dynamic incentives, or contingent renewal: a borrower or group can access further loans only if she or the group as a whole repay the loans. Dynamic incentives are considered as an important mechanism to ensure repayment in microcredit programs (Alexander-Tedeschi, 2006; Giné, Goldberg, and Yang, 2012). To resemble the real microcredit settings, we let subjects play the games face-to-face, which would allow subjects to utilize social sanction outside the games. Reflecting the situation that borrowers have some information on their partners' income, we introduce noisy signals on partner's income. This imperfect information would make a room for free-riding even under individual liability. With this setting, free-riding and collusion can be identified by the response to partner's signal. While collusion predicts that partner's good signal will reduce strategic default, free-riding implies the opposite. Without experimental games, it will be difficult to capture the free-riding effect because if shouldering debts is made through informal money transfer before the repayment date, we will not be able to observe free-riding in the data.

In the experimental games, we found some evidence supporting the free-riding with the presence of quite precise signal. Under imprecise signal, then observing good signal will not induce strategic default as it is not so reliable and partners will not have sufficient income to cover his/her deficit. We also examine the effect of joint liability and signal availability on strategic default decision. We found that introducing precise signals will reduce strategic default under joint liability but it does not affect strategic default under individual liability. Then we investigate how subjects reacted to likely strategic default of their partners. We found that under the precise signal treatment, subjects did not respond to likely strategic default, which may allow their partners to default strategically to free-ride.

The rest of the paper is organized as follows. Section 2 presents a conceptual model which describes the incentives for collusion and free-riding under joint liability. Section 3 describes our experimental design. Section 4 explains our empirical methodology and Section 5 reports the results. Section 6 concludes.

2 Model

This section introduces a simple model of the repeated repayment game which would help readers understand the incentive problems that microcredit borrowers face. To keep the argument simple, we assume perfect monitoring, that is, borrowers can observe their partner's income. We also assume that the borrowers are risk neutral and a group consists of two borrowers, each of whom takes a loan with repayment amount of B.

The incentive for repayment is given by dynamic incentives, or more precisely, contingent renewal: borrowers can access future loans only if they repay current loans. Under individual liability, borrower $i = 1, 2$ can receive further loans only if borrower i repays B.[2] Under joint liability, borrower i can receive further loans only if the group repays $2B$ irrespective of i's own repayment record.[3] The discount factor is denoted by δ. We normalize the utility of not receiving the loans (and thus no investment) to be zero. There are no strategic interactions between borrowers outside of the repayment game.[4] We also assume that borrowers cannot save and hence cannot use the income earned in the previous periods to repay the current loan.

The investment funded by the loan given to borrower i, $i = 1, 2$, generates a stochastic income $g_i \in [0, \bar{g}]$ which is i.i.d. over borrowers and periods, and whose cumulative distribution function is denoted by $F(g_i)$. Any borrower's decision does not affect the realization of g_i to exclude the moral hazard problem. Borrowers only decide whether and how much to repay, and whether and how much to contribute for helping their partners.[5]

[2]Dynamic incentives play a key role in keeping repayment rate high in microcredit programs. See Alexander-Tedeschi (2006) and Giné, Goldberg, and Yang (2012).

[3]We restrict our attention to the simple joint liability and ignore the possibility of designing the optimal joint liability contracts. Recent studies show the possibility of improving joint liability contracts by introducing *partial* joint liability. See Bhole and Ogden (2010) and Allen (2012), which may explain why in reality the strict joint liability is not required.

[4]This is a simplified and unrealistic assumption because borrowers in microcredit programs often live in the same villages or areas. In the experiment, subjects made their decision face-to-face and hence they could resort to some social sanctions outside the repayment game.

[5]Though our experimental procedure only requires borrowers to choose whether to shoulder their partner's loans, we deal with the case where borrowers can also choose the amount of contribution for helping their partners for generality.

The timing of the stage game is as follows. After observing (g_1, g_2), the borrowers simultaneously decide their repayment amounts r_i, $i = 1, 2$. Then the borrowers observe (r_1, r_2). If $r_i = r_j = B$, then the stage game is over and both borrowers continue playing in the next period. If $r_i = B$ but $r_j < B$, $j \neq i$, then borrower i is asked whether to shoulder j's deficit, $B - r_j$. Under joint liability, borrower i cannot continue playing in the following periods unless she shoulders j's deficit. Under individual liability, borrower i can continue playing in the following periods no matter whether she shoulders j's deficit or not. But if borrower i shoulders j's deficit, then borrower j can also continue playing in the following periods. Otherwise, borrower j cannot continue the game. On the other hand, if $r_i, rj < B$, then nobody can shoulder the deficit and hence the game will be over. We assume that borrowers cannot write binding contracts on risk-sharing, and hence risk-sharing arrangement should be self-sustained by the repeated interaction.

Let the amount that borrower i shoulders for borrower j be d_i. Then borrower i's contribution can be written as $a_i = r_i + d_i$. We assume that when borrower i contributes a_i but finally the group defaults, then borrower i will lose γa_i where $\gamma \in [0, 1]$. In reality, once a borrower repays a_i to a MFI, the MFI would not return a_i to her when the group defaults. This corresponds to $\gamma = 1$. On the other hand, Besley and Coate (1995) assume that $\gamma = 0$. This will be correspond to the situation where borrowers communicate each other beforehand to reach agreement on the repayment decision. Note that once borrower i repaid B, then γB is sunk when she decides whether to shoulder for her partner.

Because we are assuming perfect monitoring, i.e., borrowers can observe both (g_1, g_2) and (r_1, r_2), they can detect any partner's strategic default. If borrowers cannot observe partner's income, then they can only observe the repayment decision and cannot tell if partner's default is strategic or not.

2.1 Joint liability

First consider the repayment decision under joint liability. The group can access future loans only if it repays $2B$. First notice that $r_i = r_j = 0$ is a stage game Nash equilibrium and hence constitute a Subgame Perfect equilibrium (SPE).

Now consider the following "no strategic default" action profile. When the group has sufficient income, i.e., $g_i + g_j \geq 2B$, then the group repays $2B$ in the following way: (i) if both players have sufficient income, they both repay B; (ii) if one of them, say j, have insufficient income, then j repays what she has, and i shoulders for her. Formally, (i) if

$g_i, g_j \geq B$, then $r_i = B$; (ii) if $g_j < B < g_i$ and $g_i + g_j \geq 2B$, then $r_i = B$, $r_j = g_j$, and $d_i = B - g_j$. When the group does not have sufficient income, $g_i + g_j < 2B$, then the group has no prospect of repaying $2B$ and hence both i and j default irrespective of their income. Calling this action C, the action profile (C, C) corresponds to the case of no strategic default with risk sharing.[6]

This action profile requires us to consider the following four cases separately: (i) $g_i, g_j \geq B$; (ii) $g_j < B < g_i$ and $g_i + g_j \geq 2B$; (iii) $g_i < B < g_j$ and $g_i + g_j \geq 2B$; and (iv) $g_i + g_j < 2B$. In case (i), $r_i = r_j = B$ while $d_i = d_j = 0$. In case (ii), $r_i = B$ and $r_j = g_j$ with $d_i = B - g_j$, resulting in $a_i = 2B - g_j$. Case (iii) is the other way around and $r_i = g_i$, leaving i zero payoff. In these three cases, the borrowers continue playing in the future period. In case (iv), $r_i = r_j = 0$ and no future periods. Let p_1, p_2, p_3, p_4 be the probabilities of cases (i) to (iv), respectively.

Borrower i's expected payoff from playing (C, C) every period under joint liability can be expressed as

$$\begin{aligned}
EV_i^{J,CC} \quad = \quad & p_1 E(g_i - B + \delta EV_i^{J,CC} | g_i \geq B, g_j \geq B) \\
& + p_2 E(g_i + g_j - 2B + \delta EV_i^{J,CC} | g_i \geq B, g_j < B, g_i + g_j \geq 2B) \\
& + p_3 E(\delta EV_i^{J,CC} | g_i < B, g_j > B, g_i + g_j \geq 2B) \\
& + p_4 E(g_i | g_i + g_j < 2B),
\end{aligned}$$

Since g_i and g_j are i.i.d. and $p_2 = p_3$, we can obtain $EV_i^{J,CC} = EV_j^{J,CC} = EV^{J,CC}$ where

$$EV^{J,CC} \quad = \quad \frac{1}{1 - \delta(p_1 + 2p_2)} [E(g) - (p_1 + 2p_2)B]. \tag{1}$$

Let D denote the action of not repaying in any cases. We assume $\delta E(g) < 2B$ to exclude the case where a borrower always prefer to repay even if her partner always defaults.[7] This assumption ensures that the strategy profile of always playing (D, D) is a Nash equilibrium

[6] One can think other 'risk sharing' strategy which makes consumption levels of both borrowers equal whenever $g_i + g_j \geq 2B$. But with risk neutrality, the payoff from this strategy is the same as the payoff from the action profile (C, C).

[7] If j always defaults, then i's expected payoff from always repaying given sufficient income (i.e. $g_i \geq 2B$) is $g_i - 2B + \delta EV_i^{J,CD}$, where $.EV_i^{J,CD}$ is the expected payoff from this strategy profile. Then

$$\begin{aligned}
EV_i^{J,CD} \quad & = \quad \Pr(g_i \geq 2B) E[g_i - 2B + \delta EV_i^{J,CD} | g_i \geq 2B] + \Pr(g_i < 2B) E[g_i | g_i < 2B] \\
& = \quad E(g) - 2\Pr(g_i \geq 2B)B + \delta \Pr(g_i \geq 2B) EV_i^{J,CD},
\end{aligned}$$

or $EV_i^{J,CD} = \frac{E(g) - 2\Pr(g_i \geq 2B)B}{1 - \delta \Pr(g_i \geq 2B)}$. The payoff from not repaying is g_i. The condition that $g_i - 2B + \delta EV_i^{J,CD} < g_i$ reduces to $\delta E[g] < 2B$.

of the stage game and thus a subgame perfect equilibrium (SPE). Hence in order to derive the condition that the action profile (C, C) is supported in the SPE, we only need to consider a trigger strategy profile σ^J in which borrowers play (C, C) as long as no deviation has occurred but switch to (D, D) in all the periods after any deviation, and examine the conditions that σ^J has no profitable one-shot deviation (Mailath and Samuelson, 2006). Since they will default in case (iv) regardless of C or D, we only need to consider the incentive problems in cases (i), (ii), and (iii).

Here we state the incentive problems borrowers face. First consider case (i), $g_i, g_j \geq B$. The payoff from repaying is $g_i - B + \delta EV_i^{J,CC}$. Consider one-shot deviation in which she repays ϕB, $\phi < 1$. The most profitable one-shot deviation could be $\phi > 0$ because paying ϕB reduces the amount borrower j should shoulder to continue the game and hence induce borrower j to shoulder for borrower i. Given that γB is sunk when borrower j decides whether to shoulder, borrower j's incentive to shoulder is larger when γ is large, and borrower j will shoulder even if $\phi = 0$ if γ is sufficiently large. Expecting borrower j will shoulder, borrower i would have an incentive to default if g_j is sufficiently large: free-riding borrower j's willingness to shoulder.

On the other hand, in case (ii), $g_j < B < g_i, g_i + g_j \geq 2B$, borrower i needs to shoulder borrower j's deficit, $B - g_i$. Hence if she decides to repay B, then she finally needs to contribute $2B - g_j$ in order to obtain further loans. This will discourage borrower i to repay g_j is small. It implies that if one member receive negative income shocks, the whole group will default - collusion.

Appendix shows that the condition that the action profile (C,C) is sustained in the subgame perfect equilibrium (SPE) in case (i) is

$$\delta E(g) \geq B + \frac{1 - \delta(p_1 + 2p_2)}{2\delta(p_1 + 2p_2) - 1}\gamma B. \tag{2}$$

if $(2 - \gamma)B - \delta E(g) \geq 0$, and

$$\delta E(g) \geq \frac{1}{\delta(p_1 + 2p_2)} B. \tag{3}$$

otherwise. The analogous condition in case (ii) is

$$\delta E[g] \geq B + [1 - \delta(p_1 + 2p_2)]B. \tag{4}$$

While it is indeterminate which of condition (4) and (2) is stricter, condition (4) is less strict than condition (3). Hence free-riding can be a biding incentive constraint. Notice that when γ is large so that $(2 - \gamma)B - \delta E(g) < 0$, then the condition in case (i) is (3). Hence when γ is large, then the binding incentive constraint is likely to be free-riding.

Note that if social sanctions can be imposed on a deviating members, these conditions are relaxed. Especially, we can show that if social sanctions are greater than B, then the condition for no strategic default to be sustained in a SPE is less stricter than under individual liability.

2.2 Individual Lending

Next consider the repayment decision under individual liability. Borrower i can access future loans only if she repays her own repayment amount B. But if she does not shoulder for her defaulting partner, then only she plays the game in the following rounds and has no partners to share risk with.

So first we consider the repayment decision when only one borrower play the game, and denote by $V_i^I(g_i)$ the expected payoff for borrower i given income g_i in this situation. Then $V^I(g)$ will satisfy

$$V^I(g) = \max\{g - B + \delta \int_0^{\bar{g}} V^I(\mathtt{g})dF(\mathtt{g}),\ g\}. \tag{5}$$

The expression in the maximum operator implies that the borrower will choose repay when

$$\delta \int_0^{\bar{g}} V^I(g)dF(g) \geq B. \tag{6}$$

Let $p = \Pr(g \geq B) = 1 - F(B)$. Then from equation (5), we can obtain

$$\int_0^{\bar{g}} V^I(g)dF(g) = \frac{1}{1-\delta p}\left[\int_0^B gdF(g) - pB\right].$$

By substituting this, the condition (6) can be simplified as $\delta \int_0^{\bar{g}} gdF(g) \geq B$, or

$$\delta E(g) \geq B \tag{7}$$

Now we allow consider the repayment decision under individual liability with voluntary risk sharing. Consider the following "risk-sharing" action profile: (i) when a borrower has sufficient income, i.e., $g_i \geq B$, then she repays B; (ii) if one of them, say j, have insufficient income, but the group has sufficient income, then j repays what she has, and i shoulders $d_i = B - g_j$ for her; and (iii) if the group has no sufficient income, then defaulting member will not be shouldered. Formally, (i) if $g_i, g_j \geq B$, then $r_i = B$; (ii) if $g_i > B$, $g_j < B$, and $g_i + g_j \geq 2B$, then $r_i = B$, $r_j = g_j$, and $d_i = B - g_j$; and (iii) if $g_i > B$ but $g_i + g_j < 2B$, then $r_i = B$, $r_j = 0$, and $d_i = 0$. We denote this action by C'.

This action profile requires us to consider the following five cases separately: (i) $g_i, g_j \geq B$, (ii) $g_j < B \leq g_i, g_i + g_j \geq 2B$, (iii) $g_i < B < g_j, g_i + g_j \geq 2B$, (iv) $g_i + g_j < 2B$, $g_i \geq B$, and (v) $g_i + g_j < 2B$, $g_i < B$. The cases (i) to (iii) are equivalent to the cases (i) to (iii) in joint liability. Case (iv) in joint liability is separated into two subcases. Under joint liability, once $g_i + g_j < 2B$, the game is over. But under individual liability, even if $g_i + g_j < 2B$, borrower i can continue the game if $g_i \geq B$ though her partner will not. Let probability of cases (iv) and (v) be p_{41} and p_{42}, respectively, where $p_{41} + p_{42} = p_4$. Note also that $p \equiv \Pr(g \geq B) = p_1 + p_2 + p_{41}$.

Borrower's expected payoff from always playing (C', C'), $EV^{I,CC}$, can be expressed as

$$\begin{aligned} EV^{I,CC} &= p_1 E(g_i - B + \delta EV_i^{I,CC} | g_i \geq B, g_j \geq B) \\ &\quad + p_2 E(g_i + g_j - 2B + \delta EV_i^{I,CC} | g_i \geq B, g_j < B, g_i + g_j \geq 2B) \\ &\quad + p_3 E(\delta EV_i^{I,CC} | g_i < B, g_j > B, g_i + g_j \geq 2B) \\ &\quad + p_{41} E(g_i - B + \delta EV_i^{I} | g_i + g_j < 2B, g_i \geq B) + p_{42} E(g_i | g_i + g_j < 2B, g_i < B), \end{aligned}$$

or

$$EV^{I,CC} = \frac{1}{1 - \delta(p_1 + 2p_2)} \frac{1}{1 - \delta p} \left\{ [1 - \delta(p_1 + 2p_2)] E(g) - (1 - \delta p)(p_1 + 2p_2)B - p_{41}B \right\}. \quad (8)$$

In case of perfect monitoring, individual liability is free from free-riding and collusion. First consider case (i), $g_i, g_j \geq B$. Think one shot-deviation in which i repays ϕB, $\phi < 1$. Under individual liability, j can obtain the future loans even if j does not shoulder for i, as long as j repays her own loan. Hence j will have no incentive to shouldering for the deviating partners. The condition for no profitable one-shot deviation turns out to be $\delta E(g) \geq B$.

Next consider case (ii), $g_j < B < g_i, g_i + g_j \geq 2B$. Borrower i can access future loans even if she does not shoulder for j. The condition for repaying the loans without shouldering for j is again $\delta E(g) \geq B$. So collusion will not occur.

But under joint liability, risk-sharing among borrowers is less likely to occur than under joint liability. Appendix shows that in order for the risk-sharing arrangement to be self-sustained, the following condition should be satisfied,

$$\delta E[g] \geq B + \frac{1 - \delta p}{\delta p_2} [1 - \delta(p_1 + 2p_2)] B. \quad (9)$$

which is stricter than the condition that no strategic default is sustained in a SPE under joint liability.

2.3 Imperfect Public Monitoring

We do not provide a formal model of the repayment decision under imperfect monitoring, and we just point out the following observations.

First, when borrowers only observe partner's signal, then they cannot distinguish strategic default and non-strategic default perfectly. Both under joint liability and individual liability, borrowers might choose strategic default expecting that their partners consider they did not default strategically but due to insufficient income, especially when the signal indicates low income status. Hence introducing imperfect monitoring would increase the incentives for free-riding both under joint liability and individual liability.

We believe that imperfect information is common even in the rural villages. Even though group members have good information on their partner's income, they usually cannot perfectly observe their income and they only have some signals on their income. This fact will create a room for free-riding even under individual liability as we have argued.[8]

3 Experimental Design

3.1 Experimental Games

To investigate repayment decision, we conducted a framed field experiments[9] in four rural villages in Quang Ngai Province, one of the poorest province in Vietnam, in August and September 2008.

A game takes the repeated game structure. A group consists of two or six players, which were formed randomly. In each round, subjects received loans to earn stochastic incomes g_i, and decides whether to repay B or not after observing own income and signal on partner's income. With contingent renewal, defaulting individuals (under individual liability) or groups (under joint liability) could not play further rounds in that game. The points earned in previous rounds could not be used to repay the current round's loan. To mimic the infinite horizon games with discount factor δ, we introduced random stopping

[8]Introducing noisy signals was also required for ethical concerns. Because the subjects made decision face-to-face, if we let them perfectly observe their partner's income, then cheating behavior observed in the experiment might harm their social relationship. Though the very fear of social punishment plays a key role in preventing strategic default under joint liability, we still believe that borrowers rarely know others' income exactly and imperfect monitoring would be a better approximation for the reality.

[9]Harrison and List (2004)

rule: irrespective of their choices, the game will finish with the probability of 1/6, implying $\delta = 5/6$.[10] After the game finishes, the groups were reshuffled for the next game.

We conducted the experiments using cards. At the beginning of the game, each subject receives an envelope including three cards as an "income". The card is either 10 points or 0 point. These three cards are either two 10 point cards and one 0 point card (20 points in total), one 10 point card and two 0 point cards (10 points in total), or no 10 point card and three 0 point cards (0 point in total). Hence income g takes three possible values: $g \in \{0, 10, 20\}$. For the distribution of g_i, we conducted three treatments: letting $\mathbf{q} = (q_{20}, q_{10}, q_0)$ where $q_g = \Pr(g_i = g)$, $g = 0, 10, 20$, (i) $\mathbf{q} = (30, 65, 5)$, (ii) $\mathbf{q} = (50, 25, 25)$, and (iii) $\mathbf{q} = (60, 20, 20)$. If we apply these parameter values to our theoretical model assuming perfect monitoring, the model predicts no strategic default under individual liability, and occurrence of strategic default irrespective of the choice of the value of γ. We set $\gamma = 1$ to approximate the situation that a MFI would not return the amount (partially) repaid in case of default. In some games, communication between the group members were allowed.

We did not find any significant difference in the subject's behavior across the distribution treatments nor communication treatments. Hence we pool observations across communication and distribution treatments and focus on the following two dimension of the treatments.

Individual Lending vs. Joint Liability Our first treatment is individual lending vs. joint liability. In the individual lending treatment, a subject will be able to continue to play only if he/she repays his/her own loan (and the cast of the die is not one). In the joint liability treatment, a subject will be able to continue to play only if the group as a whole repays the total amount of the group loan. If some members in the group did not repay their own loans, the other members would be asked to shoulder for them, but they can continue the game whether they shoulder or not.

Noisy signal The second treatment is the availability and precision of the signal associated with income. We have three treatments: no signal, signal with precision of 75%, and signal with precision of 90%. More precise signal will give more precise information whether other members default strategically or nonstrategically, which in turn affects the strategic default decision making.

[10] Abbink, Irlenbusch, and Renner (2006) conducted finite horizon games, in which case choosing strategic default is only the equilibrium. In each round, our research assistants roll a die and if the cast of the die is one, the game will be terminated even if the players repay the loans.

We focus on how repayment decision was affected by the signals on the partner's income. Collusion predicts that if the signal indicates that their partner's realized income is high, then a borrower will not default strategically because she does not need to shoulder for her partner. On the other hand, free-riding predicts the opposite. Signals indicating high partner's income will give a borrower free-riding incentives. We will investigate how the response to partner's signal differs between joint liability and individual liability, and between precise signal and less precise signal.

3.2 Recruitment of the Subjects

We set up our lab in the local commune office and asked the village officials to recruit as our subjects a member from poor households who are likely to be a target of governmental loans for the poor family.[11] We collected 360 subjects.

Twelve subjects joined per session. When subjects came to our lab, we conducted a series of experimental games, followed by a questionnaire survey.[12] All rules regarding the experimental rules were explained by using large poster boards before each game started. Games to be played was randomly assigned. The games were played with cards. The survey and experiment took two and a half hours, with the average payout of 100,000VND (about 6.2US$), which was much higher than the urban experiment to cover the travel costs to our lab from their villages. Every 10 points were converted to 1,000VND. The payment was made at the end of the session.

After collecting the data, we found that some subjects do not satisfy the criterion of microcredit clients, e.g. they are too young or too old, or they are too educated. We exclude the subjects with age less than 18 or more than 65, and the subjects with tertiary level education. It leaves us 347 subjects.

Table 1 summarizes the characteristics of our subjects used in our analysis. The first column represents the average characteristics of all the subjects in the rural experiment, while the rest of the column reports the weighted average of the characteristics of the subjects who

[11]Government of Vietnam provides loan for the poor households through the Agribank and the Vietnam Bank for Social Policies. Their clients are similar to the typical microcredit programs with the exception that the Agribank mainly provides agricultural loans which are repaid at harvest at once.

[12]Though we concerned the possibility that the outcomes in the games might affect the answers to the questionnaire, we chose this order so that we could calculate the reward for each subject during the questionnaire survey. Conducting experiments followed by questionnaire survey is standard in the lab experiment, because they concern the possibility that some questions in the questionnaire survey might affect the decision in the experimental game.

played that treatment. Because a subject played multiple individual or joint liability games, the observations reported below exceed the total number of the subjects. The characteristics are well balanced across the treatments.

Table 1: Summary statistics of the subjects across treatments

Rural experiment	Total	IL	JL	no signal	75% signal	90% signal
Female	0.40	0.40	0.40	0.37**	0.41	0.43
	(0.49)	(0.49)	(0.49)	(0.48)	(0.49)	(0.49)
Age	41.86	41.73	41.78	42.06	41.30	41.76
	(10.80)	(10.70)	(10.86)	(10.70)	(10.69)	(10.88)
Education	7.50	7.53	7.48	7.47	7.52	7.52
	(3.07)	(3.08)	(3.06)	(3.09)	(3.10)	(3.04)
Married	0.92	0.92	0.92	0.92	0.91	0.92
	(0.27)	(0.27)	(0.27)	(0.27)	(0.29)	(0.27)
Risky Choice	2.68	2.68	2.69	2.72	2.69	2.66
	(1.42)	(1.44)	(1.41)	(1.44)	(1.40)	(1.42)
GSS	0.40	0.40	0.40	0.40	0.40	0.40
	(0.34)	(0.33)	(0.33)	(0.34)	(0.32)	(0.33)
Cooperate	1.80	1.80	1.80	1.80	1.81	1.80
	(0.33)	(0.33)	(0.33)	(0.33)	(0.34)	(0.33)
Observations	347	1183	1111	828	560	994

4 Empirical Strategy

Let EU^R_{ikt} denote player i's expected payoff from repaying the loan at round t in session k, and EU^S_{ikt} the expected payoff from strategic default. Under joint liability and individual liability with transfers, EU^R depends on the belief on their partners' strategy, which in turn will depend on the history and the partners' incomes. EU^S will also depend on the belief on their partners' strategy, especially whether they will shoulder i's loan. The subject will choose strategic default ($y_{ikt} = 1$) if and only if $EU^S_{ikt} > EU^R_{ikt}$. We parametrize this difference as

$$EU^S_{ikt} - EU^R_{ikt} \quad = \quad \mathcal{T}_{ik}\theta + \mathcal{I}_{ikt}\gamma + c_i + \eta_k + \zeta_t + \epsilon_{ikt} \equiv \mathbf{x}_{ikt}\beta + c_i + \epsilon_{ikt}, \tag{10}$$

where c_i represents the time-invariant individual effects which reflect the psychological unwillingness against strategic default and risk attitude, η_k is the session order effect, ζ_t is the round effect, and ϵ_{ikt} is the remaining unobserved factors. $\mathcal{T}_{ik}$ is the set of the treatment variables such as joint liability. The reference category is individual liability. $\mathcal{I}_{ikt}$ is the vector of the variables included in the player's information set such as own income and the sum of other member's income. The information set could include the history of the game, but since including the history of the game does not allow us to analyze the behavior in the first round, we do not include the history in the baseline analysis.

One econometric problem caused by our experimental design with the dynamic incentive is the attrition. Since defaulted individuals or groups could not continue the game, we only observe selected samples. Our strategy is to use the fixed effect linear probability model with restricting the sample to the observation of the first four rounds in order to minimize attrition effects.[13] While the fixed effect model would not generate consistent estimates, we argue below that this model would provide lower bounds of the parameters of interest. The standard errors are clustered by the sessions to allow for correlation between subjects in the same session. The results are robust to the change in this restriction on the rounds in which the observations are used for the analysis.

To see the possible direction of the bias in the fixed effect linear probability model, let s_{ikt} denote the selection indicators which takes one if $(y_{ikt}, \mathbf{x}_{ikt})$ is observed and zero otherwise.[14] Also let $\ddot{\mathbf{x}}_{ikt} = \mathbf{x}_{ikt} - (\sum_l \sum_r s_{ilr})^{-1} \sum_l \sum_r s_{ilr}\mathbf{x}_{ilr}$. Then the fixed effect estimator $\hat{\beta}$ can be written as

$$\hat{\beta} = \beta + \left(N^{-1} \sum_{i=1}^{N} \sum_{k} \sum_{t} s_{ikt} \ddot{\mathbf{x}}'_{ikt} \ddot{\mathbf{x}}_{ikt} \right)^{-1} \left(N^{-1} \sum_{i=1}^{N} \sum_{k} \sum_{t} s_{ikt} \ddot{\mathbf{x}}'_{ikt} \epsilon_{ikt} \right), \qquad (11)$$

and the consistency of the fixed effect estimators require $\sum_k \sum_t E(s_{ikt}\ddot{\mathbf{x}}'_{ikt}\epsilon_{ikt}) = 0$, which is satisfied when ϵ_{ikt} is mean independent of s_{ikt} given $(\ddot{\mathbf{x}}_{ikt}, c_i)$. Wooldridge (2010) suggests to add $s_{ik,t+1}$ to the estimated equation as a simple test for the sample selection bias, and we find it is significant with p-value < 0.001.[15]

Note that ϵ_{ikt} captures unobserved time-variant factors such as belief on the partner's

[13] Though probit or logit models are popular choice of the binary choice model, the fixed effect probit is inconsistent. The fixed effect logit can produce consistent estimates, but with many categorical variables, the iteration did not converge.

[14] More precisely, the set of variables we cannot observe are $(y_{ikt}, \mathcal{I}_{ikt})$ because we know $\mathcal{T}_{ik}$, the order of the session and the round for the missing observations.

[15] The coefficient of $s_{ik,t+1}$ is negative, reflecting the fact that we could not observe those who defaulted strategically unless their members shouldered for them.

decision and psychological willingness to default strategically. Attrition occurs after one of the three events: (a) the random stopping rule with probability of 1/6, (b) insufficient income, and (c) strategic default committed by the player herself or other members. It will be safe to assume that events (a) and (b) do not systematically affect future ϵ_{ikt}. On the other hand, the trigger strategies described in our theoretical model implies that own or partner's strategic default induce all the members to choose strategic default in the following rounds as punishment. This indicates that ϵ_{ikt} gets larger after event (c), implying negative correlation between ϵ_{ikt} and s_{ikt}. Then $E(s_{ikt}\ddot{\mathbf{x}}'_{ikt}\epsilon_{ikt}) = E[\ddot{\mathbf{x}}'_{ikt}E(s_{ikt}\epsilon_{ikt}|\ddot{\mathbf{x}}'_{ikt})]$ is likely to be negative for treatment variables[16] and hence the fixed effect estimator tends to provide the lower bound in the sense that $\hat{\beta} < \beta$. Hence as long as we find positive significant coefficients, we suppose that these terms really affect repayment decision. Intuitively, if a treatment, say joint liability, increases strategic default (positive coefficient), then the observed data overrepresent those who still chose to repay in spite of joint liability. The bias will be larger for the treatment with more strategic default.

To confirm that the fixed effect estimator provides lower bounds, we also report the results obtained by the inverse probability weighting (IPW) (Robins, Rotnitzky, and Zhao, 1995; Wooldridge, 2010). It allows for any correlation between the variable predicting the sample selection, say $\mathbf{z}_{ikt}$, and the error term ϵ_{ikt}, but requires the following conditions:

$$\Pr(s_{ikt} = 1|\mathbf{z}_{ik1}, \dots, \mathbf{z}_{ikt}, \epsilon_{ik1}, \dots, \epsilon_{ikt}, s_{i,t-1} = 1) = \Pr(s_{ikt} = 1|\mathbf{z}_{ikt}, s_{i,t-1} = 1), \quad (12)$$

$$\Pr(s_{ikt} = 1|\mathbf{z}_{ikt}, s_{i,t-1} = 1) > 0 \text{ for every value of } \mathbf{z}_{ikt}. \quad (13)$$

The IPW weights each observation by the inverse of $\Pr(s_{ikt} = 1|\mathbf{z}_{ikt}, s_{i,t-1} = 1)$. However, because the individuals or groups who default cannot play the following rounds, $\Pr(s_{ikt} = 1|\mathbf{z}_{ikt}, s_{i,t-1} = 1)$ would be zero for certain values of $(y_{ik,t-1}, \mathbf{x}_{ik,t-1})$, violating condition (13). To avoid $\Pr(s_{ikt} = 1|\mathbf{z}_{ikt}, s_{i,t-1} = 1)$ being zero, we restrict $\mathbf{z}_{ikt}$ to own repayment decision, own income, and the sum of the partner's income. Excluding the partner's repayment decision will invalidate assumption (12), but we expect that IPW corrects for sample selection to some extent, and tend to produce greater coefficients than the fixed effect estimator.[17]

[16] Because for the binary variables, the demeaned value is positive when that treatment is assigned.

[17] There are at least two other econometric procedures to correct for sample selection: Heckman-type procedure and bound analysis. The Heckman-type procedure exploits the excluded variables which determine sample selection but do not have direct impacts on y. But because in the repeated game, strategy is in general a function of past state variables and actions, any variables affecting the attrition (e.g. own and partner's incomes) could directly affect strategic default decision. Further, even if we are willing to assume that past incomes do not directly affect current y, they only capture the sources of attrition (b) in the main text and the

5 Results

5.1 Strategic Default

For the analysis, we only use the observations up to round 4 in each game to avoid overrepresenting the individual who played longer.[18] For analyzing the strategic default, we only focus on the observations which have enough income to repay the loans. In addition, because in the following analysis we examine the effect of the partner's signal and income, we only uses the observations in which their partners also continue playing the game. This also enables us to compare the joint liability with individual lending in which the players have their partners to share the income risks.

Table 2 summarizes the number of the observations which satisfy this criteria and the frequency of strategic default across the treatments. The average ratio of strategic default is 6.3%. The low frequency of strategic default rate will result in large standard errors in the estimation, and hence while we have around 4,800 observations, estimation using some subsamples will suffer from relatively large standard errors and may not be able to find statistically significant results. The overall default rate is 24.4, which is quite high compared to the most of microcredit programs. This might be due to the fact that in our experimental games, borrowers only can share the risk with other group members, while in the reality people would have much larger risk-sharing networks.[19]

Columns (1) and (2) in Table 3 reports the regression results estimating the effect of the treatments on strategic default, where Column (1) uses the fixed effect model and Column (2) uses fixed effect model with IPW. The treatment variables, $\mathcal{T}_{ik}$ include indicator variables

estimator will not correct for sample selection bias caused by (c). The bound analysis proposed by Lee (2009) employs the trimming procedure which provides the upper and lower bound on the average treatment effects without requiring the exclusion restrictions nor the conditions required for the IPW. However, this procedure does require the monotonicity assumption: the treatment assignment can only affect sample selection in "one direction" for all the individuals. In our setting, this requires that joint liability, for example, affects sample selection in the same direction for all the individuals. This condition does not allow the situation that joint liability makes some subjects more likely to default due to strategic default, but makes others less likely to default because of risk-sharing withing a group.

[18] Appendix reports the results using observations up to round 4 and round 3. The results are robust to these changes.

[19] One might suspect that this is partly because the income distribution in the real world would be more safe. But in the income distribution treatment of $\mathbf{q} = (30, 65, 5)$, where the probability of investment failure is only 5%, the default rate was 26.5%, slightly larger than the overall average. Hence the income distribution would not explain this high default rate.

Table 2: Type of games

	number of sessions	observation	% of strategic default	standard deviation
Individual Lending	103	2405	0.057	0.232
Joint Liability	97	2382	0.070	0.255
no signal	70	1652	0.064	0.245
75% signal	47	1060	0.052	0.224
90% signal	83	2075	0.068	0.252
Total	200	4787	0.063	0.244

for joint liability (reference category is individual lending); and for 75% precision signal and 90% precision signal (reference category is no signal treatment). We also include indicator variables for the income distribution treatments, for the communication treatment, and for the six group member treatment, though the coefficients of these variables are insignificant. Session and round fixed effects are included and the standard errors are clustered by subjects, which are reported in the parenthesis. For the other covariates, $\mathcal{I}_{ikt}$, we only include an indicator variable for high income (income of 20 points).

The result shows that joint liability increased strategic default. Though this is consistent with our model prediction which states that the condition for no strategic default to be sustained in a SPE is stricter under joint liability than under individual liability, the prediction of the model with perfect monitoring can not be directly applied to our experimental game with imperfect monitoring. Introducing either of 75% precision signals or 90% precision signal did not affect strategic default on average. The realization of higher income reduced strategic default. Correcting the sample selection by using the IPW little affects the estimated coefficients.

In Columns (3) and (4), we interact the joint liability indicator with the information treatment variables and income. The coefficient on joint liability becomes significant, implying that in the no signal treatment, joint liability increased strategic default by 4.1 percentage points. The interaction terms suggest that joint liability also increased strategic default in the 75% precision signal treatment by 6.9 percentage points (p value is 0.004), while in the 95% precision signal treatment, joint liability did not differ from individual liability ($p = 0.506$). While unobservable income can cause free-riding both under joint liability and individual liability, our results suggest that it significantly increase strategic default only under joint liability.

Table 3: Strategic default

	(1) FE	(2) IPW	(3) FE	(4) IPW
JL	0.019*	0.021	0.041*	0.038
	(0.010)	(0.014)	(0.021)	(0.031)
75% signal	-0.005	-0.001	-0.021	-0.021
	(0.012)	(0.020)	(0.015)	(0.020)
90% signal	-0.003	-0.002	0.013	0.010
	(0.008)	(0.010)	(0.012)	(0.016)
income=20	-0.083***	-0.086***	-0.070***	-0.073***
	(0.011)	(0.015)	(0.012)	(0.014)
JL× 75% signal			0.028	0.034
			(0.022)	(0.030)
JL× 90% signal			-0.030	-0.022
			(0.019)	(0.028)
JL× income=20			-0.026	-0.027
			(0.018)	(0.022)
Observations	4787	4389	4787	4389

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Income does not have a different effect between joint liability and individual liability. Correction for the sample selection again little affects the results and hence we only reports the results using the fixed effect model hereafter.

5.2 Collusion vs Free-Riding

Now we investigate our main research question: joint liability causes collusion or free-riding. Collusion implies that under joint liability, strategic default more likely occurs when the signal indicates that partner's income is low (bad signal), and less likely occurs when the signal on partner's income is good.[20] On the other hand, free-riding implies that a borrower more likely to choose strategic default when the signal indicates that partner's income is high. Hence by examining how borrowers responded to the signals on partner's income, we can distinguish which of collusion and free-riding occurred. Note that given the imperfect monitoring, free-riding can also occur under individual liability - choosing default expecting that their partner would assume that default is not strategic and hence shoulder for her.

Table 6 report the regression results. We include indicator variables for (i) partner's signal being bad, and (ii) partner's signal being good. In the two-member group treatment, partner's signal is treated to be bad (good) if the partner's signal is 0 (20). In the six-member group treatment, we regard partner's signal as bad (good) if the average of partners' signals is no greater than 4 (no less than 16). The results are robust to the change in these cutoff value. In Appendix, we report the results when we define partner's signal to be bad (good) if the average of partner's signal is no greater than 8 (no less than 12) or 6 (no less than 14) in the six-member group treatment.

We also include an indicator variable for own signal being 0, and its interaction term with joint liability. When borrower i's own signal indicates 0, the partner would assume that i does not have sufficient income. Both collusion and free-riding would predict a positive coefficient on this variable under joint liability. If it is collusion, then borrower i's bad signal will induce her partner to choose strategic default to avoid high repayment burden. Expecting her partner's default, i will also choose to default, implying that own bad signal induces strategic default. On the other hand, in case of free-riding, borrower i would expect that her default would not trigger her partner's punishment because the partner would assume that borrower i's default is non-strategic. Hence it is safe to default, again implying that own

[20]When we assume risk-neutral borrowers, then own income will not affect the repayment decision given partner's income fixed. But if borrowers are risk-averse, higher own income will increase the incentive to repay, which is consistent with the significantly positive coefficient on high income in Table 3.

bad signal induces strategic default. Because collusion only works under joint liability, it is expected that the interaction term will be positive, though the degree of free-riding can also differ between joint liability and individual liability.

Columns (1) and (2) report our baseline results for the 75% precision signal treatment and the 90% precision signal treatment, respectively. In the 75% precision signal treatment, we do not find any significant coefficients on these key variables. This is consistent with the fact that the signal was not precise enough for the subjects to rely on. On the other hand, we find the evidence for free-riding in the 90% precision signal treatment: subjects were more likely to choose strategic default when the signal indicated that the partner's income was good.

One could argue that this result can be consistent with collusion if partners tended to default strategically when their signals were good under joint liability. To check this, we include an indicator variable for own signal to be equal to 20, and its interaction term with joint liability in Columns (3) and (4). The above argument implies that this new interaction term should be positive. We found the results opposite: having good own signal decreased strategic default, instead of increasing it. Hence the result that partner's good signal increased strategic default indicates free-riding under joint liability.

In Column (2), we also find significant coefficients on own bad signal and on its interaction term with joint liability in the 90% precision signal treatment. The positive coefficient on the interaction term suggests that own bad signal increased strategic default under joint liability, consistent with our prediction, though the linear combination is not significant ($p = 0.146$). Surprisingly, the coefficient on own bad signal itself is negative, indicating that subjects were more likely to choose to repay under individual liability when the signal indicated their own income was zero.

One possible explanation for the negative coefficient on own bad signal is that repaying when signal indicates no income would help to build reputation that she is honest, and her partners would assume that she would not make strategic default. Then in the later rounds, her strategic default would not cause her partner's punishment and might give her higher payoffs by free-riding. If this is the case, then she would not repay when she found that her partner were likely to have zero income, since it would be no use of building reputation when her partner did not play the game any more and hence could not shoulder for her. In Columns (5) and (6), we examine this hypothesis by using an indicator variable for both own and partner's signal being bad. Contrary to the above argument, this term turns out to be negative: borrowers were more likely to repay when own and partner's signal were bad.

Table 4: Strategic default: collusion vs free-riding

	(1)	(2)	(3)	(4)	(5)	(6)
	75% sig	90% sig	75% sig	90% sig	75% sig	90% sig
JL	-0.022	-0.034	0.054	-0.028	0.009	-0.013
	(0.055)	(0.025)	(0.067)	(0.029)	(0.053)	(0.021)
P's signal bad	-0.035	-0.028	-0.040*	-0.029		
	(0.022)	(0.031)	(0.021)	(0.031)		
JL× P's signal bad	0.050	0.027	0.050	0.030		
	(0.051)	(0.044)	(0.050)	(0.045)		
P's signal good	-0.016	-0.020	-0.017	-0.021		
	(0.017)	(0.016)	(0.017)	(0.016)		
JL× p's signal good	0.024	0.041*	0.022	0.043*		
	(0.026)	(0.023)	(0.025)	(0.023)		
own signal=0	-0.004	-0.100**	0.014	-0.093**		
	(0.031)	(0.041)	(0.029)	(0.042)		
JL× own signal=0	0.123	0.191**	0.050	0.183**		
	(0.077)	(0.076)	(0.081)	(0.075)		
own signal=20			0.028	0.014		
			(0.027)	(0.025)		
JL× own signal=20			-0.102**	-0.016		
			(0.044)	(0.030)		
own signal=0 & P signal bad					-0.042	-0.294***
					(0.049)	(0.110)
JL× (own signal=0 & P signal bad)					0.330*	0.252**
					(0.191)	(0.115)
own signal=0 & P signal good					0.026	-0.054*
					(0.045)	(0.032)
JL× (own signal=0 & P signal good)					0.063	0.187
					(0.105)	(0.120)
Observations	1060	2075	1060	2075	1060	2075

The reputation hypothesis could not explain why our subjects tended to repay when own income was bad and hence they could potentially free-ride.

The interaction term of this indicator variable and joint liability is significantly positive, and the linear combination of the indicator variable and its interaction term is close to zero. If collusion worked, then this case (both own and partner's signal being bad) would be the worst situation to choose to repay because the partner was likely to choose no repayment: your partner was likely to have low income and hence you were likely to be required to shoulder for her if you chose repay; and even if your partner actually had sufficient income, your partner would expect that you did not have enough income, and hence would choose strategic default. Hence it seems that the result does not support collusion under joint liability.

We also include an indicator variable for own bad signal and partner's good signal. The best situation for free-riding would be when own signal indicates zero income and partner's signal indicate that they have high income. Hence free-riding under individual liability would predict that the coefficient on this term should be positive. But the result suggests opposite. Subjects were less likely to default strategically in that situation. Hence it seems that under joint liability, subjects did not choose free-riding. On the other hand, its interaction term with joint liability is positive, though not significant. The linear combination is also insignificant, but the point estimate is somehow large (0.133). Subjects might utilize the opportunity of free-riding under joint liability.

In all, we did not find evidence for free-riding or collusion under individual liability. Under individual liability, we find some evidence for free-riding. The positive and significant coefficient on the interaction term of joint liability and own signal indicating zero income would imply the existence of collusion as well, though this coefficient is also consistent with free-riding.

5.3 Response to Free-riding

Now we examine how subjects responded to partner's default and likely free riding behavior. Notice that in the case of collusion, the group would default and hence there would be no stage for deciding shouldering for other members and no future rounds. Because the subjects could only observe the signals and could not precisely know if the partners defaulted strategically, we investigate the effect of the partner's seemingly strategic default, that is, default when their signal indicates they have sufficient income to repay.

First we investigate how likely other members would shoulder for seemingly strategically defaulting partners. Table 5 reports the estimation results where we include indicator variables for likely strategic default. Because subjects faced decision to shoulder only when they had sufficient income (i.e. 20 points) and some other members had defaulted, the observations to be used is the selected ones. But as long as players defaulted strategically with expecting that their partners would shoulder for them and this expectation is correct on average, then the estimated coefficients would underestimate the true effects and hence provide lower bounds.

In Columns (1) and (2), we only include the treatment variables. Despite the fact that we set $\gamma = 1$, joint liability reduces the likelihood of shouldering in the 75% precision signal treatment, instead of increasing it. In the 90% precision signal treatment, joint liability has positive effect but its effect is not significant. With less precise signals. joint liability does not necessarily induce risk-sharing among group members.

Table 5: Response to partner's default: Shoulder other member's loans

	(1)	(2)	(3)	(4)	(5)	(6)
	75% sig	90% sig	75% sig	90% sig	75% sig	90% sig
JL	-0.246*	0.157	-0.313**	0.174	-0.322**	0.162
	(0.132)	(0.122)	(0.141)	(0.155)	(0.144)	(0.157)
p:sig$\geq$ 10& default			-0.010	0.065	-0.087	0.051
			(0.100)	(0.083)	(0.129)	(0.111)
JL$\times$ (p:sig$\geq$ 10& default)			0.154	0.001	0.296	0.060
			(0.187)	(0.147)	(0.200)	(0.172)
p:sig= 20 & default					0.108	0.037
					(0.163)	(0.142)
JL$\times$ (p:sig= 20 & default)					-0.238	-0.103
					(0.237)	(0.187)
Observations	245	378	245	378	245	378

Columns (3) and (4) report the coefficients of variables indicating partner's likely strategic default and its interaction terms with joint liability. We include a binary variable indicating if any of their partners defaulted despite the signals suggesting sufficient income (i.e. 10 or 20 points) to repay, and its interaction term with joint liability. The coefficients of these variables turn out to be insignificant. In this specification, the coefficient of joint liability itself captures the effect of default when the partner's signal was bad. The point estimate implies that when the partners defaulted with bad signals in the 75% precision signal treatment, then subjects were less likely to shoulder for them. Hence again, we found that joint liability does not necessarily induce risk-sharing among group members if the signals were not so precise. It is also possible that it reflects the fact that under individual liability, subjects were willing to shoulder for the partners who defaulted with bad signals. In Columns (5) and (6), we add another indicator variable for the partner's default when theirs signal was good, but this term and its interaction term with joint liability are not significant and the results do not change.

In sum, whether to shoulder or not does not depend on whether their partners defaulted strategically or not. This is consistent with the trigger strategy where the punishment occurs from the next round because given the sunk cost, it would be optimal for the remaining borrowers to shoulder in order to obtain the next loans.[21]

Next, we examine how the likely strategic default affected future repayment decision. Columns (1) to (2) in Table 6 investigate how default affected partner's repayment decision in the next round. We include an indicator variable which takes one if any partner did not repay in the last period.[22] The results show that partner's default affected the future repayment decision under joint liability only in the 75% signal treatment. With the 90% precision signal, on the other hand, partner's default in the previous round did not affect the repayment decision.

In Columns (3) and (4), we include an indicator variable for any partner's seemingly strategic default. Its interaction term with joint liability is also included. The results show that when partners defaulted in spite of the signal indicating sufficient income to repay, strategic default was triggered under joint liability in the 75% precision signal treatment. Under individual lending, partner's past likely strategic default did not affect strategic default decision. On the other hand, likely strategic default did not significantly affect the partner's repayment decision in the future round in the 90% precision signal treatment. This might

[21] When we use the ratio of the partners who defaulted strategically, we find that subjects tend to shoulder for their partners when *more* partners defaulted strategically under joint liability. This result is driven by the fact that more members are are required to shoulder as more partners chose default.

[22] Appendix Table 10 reports the results when we use the ratio of the partners who defaulted in the last period in case of the six-player games. We also report the results using the ratio of the partners who defaulted with signal being no less than 10 in the last round. The results are almost similar to the results presented in the main text.

Table 6: Response to partner's default: Future repayment decision

	(1) 75% sig	(2) 90% sig	(3) 75% sig	(4) 90% sig	(5) 75% sig	(6) 90% sig
JL	0.006	-0.010	0.005	-0.011	0.009	-0.012
	(0.054)	(0.021)	(0.054)	(0.021)	(0.053)	(0.021)
p:default(t-1)	-0.027	0.018	-0.024	0.011	-0.024	0.010
	(0.025)	(0.027)	(0.031)	(0.035)	(0.032)	(0.035)
JL× (p:default(t-1))	0.131**	0.006	0.020	-0.032	0.016	-0.033
	(0.056)	(0.043)	(0.051)	(0.046)	(0.051)	(0.046)
p:sig≥ 10& default(t-1)			-0.006	0.012	0.018	0.018
			(0.029)	(0.046)	(0.055)	(0.055)
JL× (p:sig≥ 10& default(t-1))			0.174***	0.073	0.039	0.109
			(0.066)	(0.068)	(0.085)	(0.098)
p:sig= 20 & default(t-1)					-0.033	-0.010
					(0.046)	(0.065)
JL× (p:sig= 20 & default(t-1))					0.207*	-0.058
					(0.108)	(0.109)
Observations	1060	2075	1060	2075	1060	2075

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

justify choosing free-riding under joint liability in the 90% precision signal treatment because choosing strategic default would not trigger partner's strategic default in the future.

In Columns (5) and (6), we add an indicator variable which takes one if the partner's signal was 20 but he/she defaulted in the last round. The result indicates that increased strategic default responding to likely strategic default under joint liability is concentrated on the cases where partners defaulted despite of the signal saying 20 point income in the 75% precision signal treatment. On the other hand, borrowers do not seem to respond partner's likely strategic default when the signal is precise.

6 Conclusion

Compared with individual liability, joint liability can increase strategic default through collusion and free-riding. By using experimental repayment games which mimic microcredit programs, we found that joint liability increased strategic default when the signals were not precise or not available. Our investigation on collusion and free-riding suggests that subjects did free-ride under joint liability, but we could not find any evidence for free-riding under individual liability. A part of the results are also supporting collusion under joint liability, but they are also consistent with free-riding. We also found that subjects did not seem to respond to free-riding when they made decision on shouldering their partners and future repayment decision, which might explain why subjects chose free-riding.

Using observational data, it is difficult to identify who defaulted strategically because we do not know if they actually did not have enough fund to repay or not. Some recent studies still succeed in finding some results supporting the existence of strategic default under joint liability, but all of them just focus on collusion. But as we have shown, free-riding could play an important role as well under joint liability, and the contract design for microcredit programs should consider both free-riding and collusion.

References

Abbink, Klaus, Bernd Irlenbusch, and Elke Renner. 2006. "Group Size and Social Ties in Microfinance Institutions." *Economic Inquiry* 44 (4):614–628.

Alexander-Tedeschi, Gwendolyn. 2006. "Here Today, Gone Tomorrow: Can Dynamic Incentives Make Microfinance More Flexible?" *Journal of Development Economics* 80 (1):84–105.

Allen, Treb. 2012. "Optimal (Partial) Group Liability in Microfinance Lending." .

Besley, Timothy and Stephen Coate. 1995. "Group Lending, Repayment Incentives and Social Collateral." *Journal of Development Economics* 46 (1):1–18.

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

Breza, Emily. 2012. "Peer Effects and Loan Repayment: Evidence from the Krishna Default Crisis." .

Ghatak, Maitreesh. 1999. "Group Lending, Local Information, and Peer Selection." *Journal of Development Economics* 60 (1):27–50.

Giné, Xavier, Jessica Goldberg, and Dean Yang. 2012. "Credit Market Consequences of Improved Personal Identification: Field Experimental Evidence from Malawi." *American Economic Review* 102 (6):2923–54.

Giné, Xavier, Pamela Jakiela, Dean Karlan, and Jonathan Morduch. 2010. "Microfinance Games." *American Economic Journal: Applied Economics* 2 (3):60–95.

Giné, Xavier and Dean S Karlan. 2011. "Group versus Individual Liability: Short and Long Term Evidence from Philippine Microcredit Lending Groups ."

Harrison, Glenn W. and John A. List. 2004. "Field Experiments." *Journal of Economic Literature* 42 (4):1009–1055.

Kono, Hisaki. 2013. "Is Joint Liability A Good Enforcement Scheme for Achieving High Repayment Rates ? Evidence from A Framed Field Experiment in Vietnam." .

Kurosaki, Takashi and Hidayat Ullah Khan. 2012. "Vulnerability of Microfinance to Strategic Default and Covariate Shocks: Evidence from Pakistan." *Developing Economies* 50 (2):81–115.

Lee, David S. 2009. "Training, Wages, and Sample Selection: Estimating Sharp Bounds on Treatment Effects." *Review of Economic Studies* 76 (3):1071–1102.

Mailath, George J. and Larry Samuelson. 2006. *Repeated Games and Reputations: Long-Run Relationships*. Oxford University Press.

Microcredit Summit Campaign. 2013. *Vulnerability: The State of the Microcredit Summit Campaign Report, 2013*.

Robins, James M., Andrea Rotnitzky, and Lue Ping Zhao. 1995. "Analysis of semiparametric regression models for repeated outcomes in the presence of missing data." *Journal of the American Statistical Association* 90 (429):106–121.

Stiglitz, Joseph E. 1990. "Peer Monitoring and Credit Market." *World Bank Economic Review* 4 (3):351–366.

Wooldridge, Jeffrey M. 2010. *Econometric Analysis of Cross Section and Panel Data*, vol. 1. The MIT Press.

A Repayment Decision under Joint Liability

Consider the trigger strategy profile σ^J described in the main text, in which the borrowers always play the action profile (C, C) as long as no deviation has occurred but switch to (D, D) in all the rounds after any deviation. We rewrite borrower i's expected payoff from always playing (C, C), (8),

$$EV^{J,CC} = \frac{1}{1 - \delta(p_1 + 2p_2)}[E(g) - (p_1 + 2p_2)B].$$

To derive the conditions under which the action profile of always choosing (C, C) is sustained in the SPE, we only need to examine the conditions for no profitable one-shot deviations in each of cases (i), (ii), and (iii).

Case (i): $g_i \geq B, g_j \geq B$

The expected payoff from always playing (C, C) is $g_i - B + \delta EV^{J,CC}$. Consider a one-shot deviation for i in which i repays ϕB, $\phi \in [0, 1)$. If $g_j = B$, then borrower j has no surplus to shoulder for i and the group defaults, leaving i the payoff $g_i - \phi B$. So i will choose $\phi = 0$. i will not deviate if and only if $g_i - B + \delta EV^{J,CC} \geq g_i$. This condition reduces to $\delta E(g) \geq B$, which is identical to the case of individual lending, (7).

Now suppose $g_j > B$. Because the maximum amount that j can contribute is g_j, if $\phi B + g_j < 2B$, then the group will default. If $\phi B + g_j \geq 2B$, then i will face the decision whether to shoulder $B - \phi B$ for i. If she shoulders, they can play in the next period but because of the trigger strategy, she will not repay and just obtain g_j in the next period. Hence the expected payoff from shouldering is $g_j - B - (B - \phi B) + \delta E(g)$ while the payoff from not shouldering is $g_j - \gamma B$, where $\gamma \in [0, 1]$ is the ratio of B the borrower actually repays to the MFI when she chooses to repay but the group defaults. Thus j will shoulder for i if

$$\phi B \geq (2 - \gamma)B - \delta E(g) \qquad \text{and} \qquad \phi B + g_j \geq 2B. \tag{14}$$

Because i wants to minimize $\phi \in [0, 1)$, i will choose ϕ^* satisfying $\phi^* B = \max\{2B - g_j, (2 - \gamma)B - \delta E(g), 0\}$.

Subcase (i-1): $(2 - \gamma)B - \delta E(g) \geq 0$

When $2B - g_j \geq (2 - \gamma)B - \delta E(g)$, then $\phi^* B = 2B - g_j$. i's expected payoff from choosing ϕ^* is $g_i - (2B - g_j) + \delta E(g)$. If i chooses $\phi = 0$, then the group will default and she will obtain g_i. Because $g_j > B$, if individual lending is feasible, i.e., $\delta E(g) \geq B$, then choosing

$\phi = \phi^*$ gives higher expected payoff than choosing $\phi = 0$. Hence the condition that this one-shot deviation is not profitable becomes

$$g_i - B + \delta EV^{J,CC} \geq g_i - (2B - g_j) + \delta E(g), \tag{15}$$

which can be rewritten as

$$\delta E(g) \geq B + \frac{1 - \delta(p_1 + 2p_2)}{\delta(p_1 + 2p_2)}(g_j - B). \tag{16}$$

Notice that this condition depends on g_j, and in order for the strategy profile σ^J to be a SPE, this condition should be satisfied for any g_j. However, since we are considering the case of $2B - g_j \geq (2 - \gamma)B - \delta E(g)$, the value of g_j is constrained by $g_j \leq \delta E(g) + \gamma B$. Hence the condition for the strategy profile σ^J to be a SPE can be written as

$$\delta E(g) \geq B + \frac{1 - \delta(p_1 + 2p_2)}{\delta(p_1 + 2p_2)}(\delta E(g) - (1 - \gamma)B),$$

which reduces to

$$\delta E(g) \geq B + \frac{1 - \delta(p_1 + 2p_2)}{2\delta(p_1 + 2p_2) - 1}\gamma B. \tag{17}$$

On the other hand, if $2B - g_j < (2 - \gamma)B - \delta E(g)$, then $\phi^* B = (2 - \gamma)B - \delta E(g)$. The analogous argument above shows that if individual lending is feasible, then choosing $\phi = \phi^*$ gives higher expected payoff than choosing $\phi = 0$. Thus the condition for this one-shot deviation not to be profitable becomes

$$g_i - B + \delta EV^{J,CC} \geq g_i - [(2 - \gamma)B - \delta E(g)] + \delta E(g), \tag{18}$$

which reduces to (17). Note that if $\gamma = 0$, then condition (17) becomes identical to the condition for no strategic default under individual lending.

Subcase (i-2): $(2 - \gamma)B - \delta E(g) < 0$

If $2B - g_j > 0$, then $\phi^* B = 2B - g_j$. As shown in subcase (i-1), i will choose $\phi = \phi^*$ if individual lending is feasible, and the condition that the one-shot deviation is not profitable is given by (16). Because here we are considering the case of $2B - g_j > 0$, the condition for σ^J to be a SPE becomes

$$\delta E(g) \geq \frac{1}{\delta(p_1 + 2p_2)}B. \tag{19}$$

On the other hand, if $2B - g_j < 0$, then $\phi^* = 0$ and j will shoulder for i. Thus i will not deviate if and only if

$$g_i - B + \delta EV^{J,CC} \geq g_i + \delta E(g),$$

which is reduced to the condition (19).

Case (ii): $g_i > B, g_j < B, g_i + g_j \geq 2B$

The expected payoff from always playing (C, C) is $g_i + g_j - 2B + \delta EV^{J,CC}$. Because $g_j < B$, the best one-shot deviation for i is not to repay, resulting in the payoff of g_i. Substituting $EV^{J,CC}$, the condition for no profitable one-shot deviations can be written as

$$\delta E[g] \geq B + [1 - \delta(p_1 + 2p_2)](B - g_j). \tag{20}$$

Because the RHS is decreasing in g_j and the minimum value of g_j is 0, the condition for σ^J to be a SPE is

$$\delta E[g] \geq B + [1 - \delta(p_1 + 2p_2)]B. \tag{21}$$

Case (iii): $g_i < B, g_j > B, g_i + g_j \geq 2B$

The expected payoff from always playing (C, C) is $\delta EV^{J,CC}$. Consider a one-shot deviation for i where i repays $\psi < g_i$. If $g_i + g_j = 2B$, then choosing any $\psi < g_i$ will result in group default, leaving her the payoff $g_i - \psi$. So i will choose $\psi = 0$ and the condition for no profitable one-shot deviations is $\delta EV_1^J \geq g_i$, which can be written as

$$\delta E(g) \geq \delta(p_1 + 2p_2)B + [1 - \delta(p_1 + 2p_2)]g_i.$$

Because $g_i < B$, the RHS is smaller than B. This implies that as long as $\delta E(g) \geq B$, or individual lending is feasible, there are no incentives for strategic default in this case.

Next consider the case where $g_i + g_j > 2B$. Because the maximum amount that j can contribute is g_j, if $\psi + g_j < 2B$, then the group will default. If $\psi + g_j \geq 2B$, then j will face the decision whether to shoulder $B - \psi$ for i. With the trigger strategy, the expected payoff from shouldering is $g_j - B - (B - \psi) + \delta E(g)$ while the payoff from not shouldering is $g_j - \gamma B$. Thus j will shoulder the deficit if $\psi \geq (2 - \gamma)B - \delta E(g)$ when $\psi + g_j \geq 2B$. Because i wants to minimize ψ, i will choose ψ^* satisfying $\psi^* = \max\{2B - g_j, (2 - \gamma)B - \delta E(g), 0\}$. Analogous argument to Case (i) shows that the strategy profile σ^J is a SPE if (17) and (19) are satisfied.

Note that condition (21) is less strict than condition (19), while it is indeterminate which of condition (21) and (17) is stricter. Hence the conditions for the action profile (C, C) to be sustained in the SPE under joint liability are (19) when $(2 - \gamma)B - \delta E(g) < 0$, and

$$\delta E[g] \geq \max\{B + [1 - \delta(p_1 + 2p_2)]B, B + \frac{1 - \delta(p_1 + 2p_2)}{2\delta(p_1 + 2p_2) - 1}\gamma B\} \tag{22}$$

$$= B + [1 - \delta(p_1 + 2p_2)]B \max\left\{1, \frac{\gamma}{2\delta(p_1 + 2p_2) - 1}\right\} \tag{23}$$

otherwise.

B Repayment Decision under Individual Lending with Voluntary Transfers

The expected payoff from always playing (C', C') is

$$EV^{I,CC} = \frac{1}{1-\delta(p_1+2p_2)}\frac{1}{1-\delta p}\left\{[1-\delta(p_1+2p_2)]E(g)-(1-\delta p)(p_1+2p_2)B-p_{41}B\right\}.$$

Now consider the conditions which ensure that the action profile of always playing (C', C') is sustained in a SPE. Contrary to the case of joint liability, borrowers are not obliged to help a defaulting partner to continue borrowing. Transfer decision can be made before or after the repayment decision, but the difference in this timing does not affect the derived condition as shown below.

Case (i): $g_i \geq B, g_j \geq B$

Consider one-shot deviation in which borrower 1 chooses to repay $d' < B$. Since her partner will not help regardless of the timing of transfer decision, she will not deviate if and only if $g_i - B + \delta EV^{I,CC} \geq g_i$. With some calculations, this condition reduces to $\delta E(g) \geq B$.

Case (ii): $g_i > B, g_j < B, g_i + g_j \geq 2B$

This is the case where the incentive for helping other members matters. There are two possible deviations: (1) not repay, resulting in payoff g_i, or (2) repay but not give transfers to borrower 2, generating the expected payoff $g_i - B + \delta EV^I$. As long as individual lending is feasible, i.e., $\delta E(g) \geq B$, deviation (2) will give higher expected payoff. Then the condition for no deviation is $g_i - B - (B - g_j) + \delta EV^{I,CC} \geq g_i - B + \delta EV^I$, which reduces to

$$\delta E[g] \geq B + \frac{1-\delta p}{\delta p_2}[1-\delta(p_1+2p_2)](B-g_j). \tag{24}$$

Unlike (20), $[1-\delta(p_1+2p_2)](B-g_j)$ is multiplied by $\frac{1-\delta p}{\delta p_2}$. Note that $p_2 = 1-(p_1+p_3+p_{41}+p_{42}) = 1-(p+p_{42})$. Thus $\frac{1-\delta p}{\delta p_2} = \frac{1-\delta p}{\delta-\delta(p+p_{42})} > 1$ and so the RHS is larger than the RHS of (20). In order for no deviations to occur, (9) should be satisfied.

Case (iii): $g_i < B, g_j > B, g_i + g_j \geq 2B$

If the borrower deviates, then the game will terminate. But here the timing of transfer decision matters a bit. If the transfer decision is made before repayment decision, then borrower 2 already transfer $B - g_i$ to borrower 1 and choosing not repaying leaves her payoff of B. On the other hand, if the transfer decision is made after the repayment decision, then deviation leaves her payoff of g_i. In the former case, the condition for no deviation is $\delta EV^{I,CC} \geq B$, which is reduced to $\delta E(g) \geq B$. In the latter case, the condition for no deviation is $\delta EV^{I,CC} \geq g_i$, which is satisfied if $\delta E(g) \geq B$ because $g_i < B$.

Case (iv): $g_i + g_j < 2B, g_i \geq B$
The condition for no deviation in this case is $g_i - B + \delta EV^I \geq g_i$, which again results in $\delta E(g) \geq B$.

Thus as long as (9) is satisfied, the strategy of repaying and sharing risk constitute a SPE. If (9) is not satisfied but the condition of $\delta E(g) \geq B$ holds, borrowers will repay but will not make transfers.

C Robustness check

Table 7: Strategic default: using observations up to round 2

	(1)	(2)	(3)	(4)	(5)
	all	all	round>1	round>1	round>1
JL	0.015	0.027	0.051	-0.006	-0.006
	(0.010)	(0.024)	(0.036)	(0.026)	(0.026)
75% signal	-0.006	-0.025	-0.025	-0.016	-0.016
	(0.013)	(0.018)	(0.025)	(0.024)	(0.024)
90% signal	-0.006	0.001	-0.015	-0.017	-0.017
	(0.010)	(0.015)	(0.022)	(0.022)	(0.022)
income=20	-0.079***	-0.067***	-0.063***	-0.090***	-0.091***
	(0.012)	(0.014)	(0.020)	(0.018)	(0.018)
JL× 75% signal		0.034	0.086**	0.090**	0.090**
		(0.027)	(0.043)	(0.042)	(0.042)
JL× 90% signal		-0.015	0.012	0.023	0.023
		(0.023)	(0.036)	(0.036)	(0.036)
JL× income=20		-0.025	-0.058*		
		(0.021)	(0.031)		
partner(P) default(t-1)				-0.005	0.020
				(0.059)	(0.076)
JL× P default(t-1)				0.163**	0.183
				(0.082)	(0.122)
shoulder(t-1)					-0.024
					(0.036)
JL× shoulder(t-1)					-0.022
					(0.081)
Observations	3285	3285	1303	1303	1303

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Strategic default: using observations up to round 3

	(1)	(2)	(3)	(4)	(5)
	all	all	round>1	round>1	round>1
JL	0.010	0.025	0.029	0.000	0.000
	(0.009)	(0.021)	(0.028)	(0.019)	(0.019)
75% signal	-0.006	-0.024	-0.026	-0.021	-0.021
	(0.012)	(0.015)	(0.020)	(0.020)	(0.020)
90% signal	-0.004	0.009	0.001	-0.001	-0.001
	(0.009)	(0.013)	(0.018)	(0.018)	(0.018)
income=20	-0.080***	-0.070***	-0.072***	-0.083***	-0.083***
	(0.011)	(0.012)	(0.016)	(0.014)	(0.014)
JL× 75% signal		0.032	0.063*	0.065**	0.065*
		(0.023)	(0.034)	(0.033)	(0.033)
JL× 90% signal		-0.025	-0.011	-0.007	-0.007
		(0.020)	(0.028)	(0.027)	(0.027)
JL× income=20		-0.020	-0.024		
		(0.019)	(0.025)		
partner(P) default(t-1)				0.001	0.006
				(0.036)	(0.054)
JL× P default(t-1)				0.112**	0.126
				(0.052)	(0.078)
shoulder(t-1)					-0.006
					(0.032)
JL× shoulder(t-1)					-0.015
					(0.054)
Observations	4175	4175	2193	2193	2193

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Strategic default: using other threshold value for partner's good and bad signals

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	75% sig	90% sig	75% sig	90% sig	75% sig	90% sig	75% sig	90% sig
JL	-0.004	-0.040	-0.009	-0.033	0.070	-0.033	0.066	-0.026
	(0.059)	(0.027)	(0.058)	(0.026)	(0.071)	(0.030)	(0.069)	(0.030)
P's signal bad	-0.036	-0.026	-0.024	-0.017	-0.037*	-0.028	-0.030	-0.020
	(0.022)	(0.031)	(0.021)	(0.034)	(0.021)	(0.031)	(0.021)	(0.034)
JL× P's signal bad	0.024	0.023	0.033	0.010	0.023	0.027	0.034	0.013
	(0.051)	(0.043)	(0.052)	(0.046)	(0.050)	(0.044)	(0.051)	(0.047)
P's signal good	-0.004	-0.027	-0.003	-0.026	-0.005	-0.027	-0.004	-0.027
	(0.018)	(0.018)	(0.018)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
JL× p's signal good	-0.001	0.055**	0.008	0.042*	-0.000	0.057**	0.006	0.045*
	(0.030)	(0.025)	(0.026)	(0.026)	(0.029)	(0.025)	(0.026)	(0.026)
own signal=0	-0.004	-0.102**	-0.006	-0.099**	0.014	-0.095**	0.013	-0.092**
	(0.031)	(0.041)	(0.030)	(0.041)	(0.029)	(0.043)	(0.029)	(0.043)
JL× own signal=0	0.124	0.191**	0.125	0.190**	0.052	0.181**	0.051	0.181**
	(0.077)	(0.076)	(0.077)	(0.077)	(0.082)	(0.076)	(0.082)	(0.076)
own signal=20					0.026	0.014	0.028	0.015
					(0.027)	(0.025)	(0.028)	(0.025)
JL× own signal=20					-0.101**	-0.018	-0.102**	-0.017
					(0.045)	(0.030)	(0.045)	(0.030)
Observations	1060	2075	1060	2075	1060	2075	1060	2075

Table 10: Strategic default: collusion vs free-riding

	(1) 75% sig	(2) 90% sig	(3) 75% sig	(4) 90% sig	(5) 75% sig	(6) 90% sig
JL	-0.022	-0.007	-0.024	-0.009	-0.003	-0.007
	(0.157)	(0.030)	(0.157)	(0.030)	(0.159)	(0.030)
partner(P) default(t-1)	0.003	0.088	0.028	0.117	0.026	0.108
	(0.044)	(0.059)	(0.064)	(0.100)	(0.062)	(0.102)
JL× P default(t-1)	0.143*	-0.004	0.053	-0.139	0.045	-0.130
	(0.074)	(0.084)	(0.109)	(0.105)	(0.108)	(0.107)
p:sig≥ 10& default(t-1)			-0.094	-0.046	-0.097	0.013
			(0.085)	(0.113)	(0.121)	(0.139)
JL× (p:sig≥ 10& default(t-1))			0.183	0.247	0.020	0.287
			(0.142)	(0.158)	(0.173)	(0.204)
p:sig= 20 & default(t-1)					0.009	-0.137
					(0.092)	(0.106)
JL× (p:sig= 20 & default(t-1))					0.240	-0.058
					(0.153)	(0.221)
Observations	613	1223	613	1223	613	1223

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$