

# Joint-Liability in Microcredit: Evidence from Bangladesh

Hameem Raees Chowdhury<sup>1</sup>

Published online: 30 March 2016

© The Author(s) 2016. This article is published with open access at Springerlink.com

**Abstract** The joint-liability lending model in microcredit predicts social ties between groups of borrowers to incentivise repayment. However, it also promotes free riding behaviour. Repeated experimental games conducted in Bangladesh are used to empirically analyse key theoretical hypotheses predicted under joint-liability (repeated experimental games are conducted by the author on the field in Manikganj, Dhaka, Bangladesh in December 2014); treated groups of microcredit borrowers are compared to control groups of non-microcredit borrowers alongside questionnaire findings. Treated individuals forego short-run gains from non-repayment and benefit from higher long-run gains from progressing on to further rounds. The paper also finds that treated individuals are significantly less likely to free ride and more likely to shoulder for their partner compared to control individuals. Optimal individual and group characteristics to maximise repayment under joint-liability are then identified.

**Keywords** Microcredit · Joint-liability · Social ties · Free riding · Repeated games

**JEL** O10 · C90 · D70

“Give a man a fish and he will eat for a day. Give a woman microcredit, and she, her husband, her children, and her extended family will eat for a lifetime” (Bono 2010, page 1).

*But who feeds (repays) the lender?*

---

✉ Hameem Raees Chowdhury  
H.R.Chowdhury@warwick.ac.uk; hameemc@hotmail.co.uk

<sup>1</sup> University of Warwick, Coventry, UK

## Introduction

Microcredit has grown exponentially since 1983 and is viewed as a revolutionary tool for global poverty alleviation (Yunus 1999).<sup>1</sup> The rise in prominence is attributed to the joint-liability lending model pioneered by Grameen Bank whereby traditional lender requirements for physical collateral are bypassed through mutual responsibility for individual loans. Theoretical hypotheses predict microcredit groups outperform others in the joint-liability setting, however the extent to which this contributes to repayment rates in excess of 95 % in microcredit remains unexplained. The shift in world industry structure toward for-profit lenders<sup>2</sup> means sustainability of this annual US\$ 38 billion<sup>3</sup> global market is contingent on the application of these theories in practice.

Theoretical hypotheses predict sustainable long-run repayment as microcredit groups foster positive non-economic social ties from interactions. From a borrower perspective, joint-liability suggests individuals in microcredit groups show moral discipline by foregoing short-run benefits from non-repayment in preference for long-run dynamic gains from repayment. Joint-liability success utilises social ties between microcredit borrowers (Besley and Coate 1995; Ghatak and Guinnane 1999); however it incentivizes free riding (Kono 2013). There remains dispute among lenders on the optimal observable individual and group characteristics to maximise repayment.

Empirical results from repeated experimental games used to model joint-liability settings are applied alongside questionnaire findings to test the theoretical hypotheses, with particular focus on differences between treated microcredit borrower groups compared to the control non-microcredit borrower groups.<sup>4</sup> The author conducts the games in the district of Manikganj, Dhaka, Bangladesh.

Results from the joint-liability games show evidence of treated groups more likely choosing repayment and subsequently partaking in more rounds compared to control groups. This holds even controlling for unobservable development of relationships over time among treated groups. Treated individuals also comparatively forego short-run gains from non-repayment to benefit from higher long-run dynamic gains. Furthermore they are less likely to free ride and more likely to shoulder (support) partners compared to controls, suggesting relative fostering of social ties. From a lender perspective, this paper identifies characteristics including female-gender and neighbours that optimise

<sup>1</sup> Muhammad Yunus, the founder of microcredit, was awarded the Nobel Peace Prize in 2006.

<sup>2</sup> MIX Market database 2009: 490 of 1169 Monetary Conditions Index MCIs (42 %) were for profit-MCIs, controlling two-thirds of the assets deployed. A notable for-profit MCI is Banco Compartamos (Swibel 2007; Chu and Cuellar 2008).

<sup>3</sup> MIX "MicroBanking Bulletin Issue #19. December, 2009, pp.49": 74 million people held microloans totalling US\$38 billion in 2009.

<sup>4</sup> Henceforth, treated (microcredit) groups refer to those that are actively jointly-liaible for a microcredit loan at present. Control (non-microcredit) groups are otherwise, which includes microcredit borrowers from different groups, as this paper focuses on isolating social ties as the determinant of differences in experimental games.

repayment. However it finds factors such as income and age are insignificant contrary to popular thought.

## Related Literature

Microcredit gained traction subsequent to implementation of joint-liability lending.<sup>5</sup> Between 1997 and 2005 the number of clients increased by 740 % and institutions by 406 %.<sup>6</sup> Higher market concentration and transition toward for-profit lenders demand repayment rates in excess of 95 % for sustainability (Hossain 1988; Morduch 1999).<sup>7</sup> Theoretically, joint-liability success revolves around social ties within groups which counteract three key problems:<sup>8</sup> moral hazard<sup>9</sup> (Banerjee et al. 1994; Laffont and Rey 2003), adverse selection<sup>10</sup> (Ghatak 1999; Gangopadhyay et al. 2005), and free riding<sup>11</sup> (Besley and Coate 1995; Wydick 2001; Bhole and Ogdén 2010). This paper isolates free riding, extending games by Kono (2013) by setting income exogenously and randomly selecting participants to control for moral hazard and adverse selection respectively.

Focusing therefore on social ties<sup>12</sup> as a solution to free riding, Besley and Coate (1995) and Ghatak and Guinnane (1999) theoretically prove high social ties deter group member shirking on repayments.<sup>13</sup> The former model defines benefits from repaying through dynamic incentives<sup>14</sup> of future loans and avoiding social punishment. The latter uses historic and contemporary examples as proof, although there is ambiguity on the extent social ties explain the increased repayment.

Cason et al. (2012) and Zeller (1998) empirically show stronger social ties lead to improved repayment rates and lender profitability if it exceeds monitoring costs. Abbink et al. (2006) finds group-lending to outperform individual-lending, although curiously self-selected groups show a higher yet less stable willingness to repay. This variance can be explained by contagion, a subset of group free riding where dominant strategy for individuals is to default should they observe high likelihood of default by

<sup>5</sup> Joint-liability lending is interchangeable with group lending. It applies to 68 % of all borrowers (Lapenu and Zeller 2002).

<sup>6</sup> See Daley-Harris 2012; for statistics on growth of MCIs.

<sup>7</sup> Government credit programs have less than 25 % repayment rates (Adams and Vogel 1986; Braverman and Guasch 1986).

<sup>8</sup> See Freixas and Rochet 1997 for the key problems for lenders of capital.

<sup>9</sup> See Stiglitz 1990; Varian (1990) for further theory on moral hazard.

<sup>10</sup> See Akerlof 1970 for further theory on adverse selection.

<sup>11</sup> See Olson 1965 for further theory on free-riding.

<sup>12</sup> Social ties is interchangeable with the term social capital, defined as “features of social organisation such as trust, norms, and networks that can improve efficiency of society by facilitating co-ordinated actions” (Putnam et al. 1994, p. 67).

<sup>13</sup> Future inability to access loans should the group collectively be unable to repay their liabilities is an effective dynamic incentive device (Stiglitz and Weiss 1983). The threat of future retaliation induces cooperative behaviour (Bó 2005).

<sup>14</sup> In reality many MCIs (e.g. Grameen Bank) do not impose future participation punishments (Todd 1996; Rahman 1999)

the group. Contagion in joint-liability is evident in Mexico (Allen 2012), Pakistan (Kurosaki and Khan 2012) and India (Breza 2012). Abbink et al. (2006) provides evidence that the larger the loans, the bigger the incentive to free ride although the less lender and group tolerance toward defaulters. Inability to control behavioural endogeneity which positively influences social ties and repayment is persistent across empirics.

The counter-hypothesis is social ties reduce repayment through forgiveness toward defaults (Guinnane 1994). Empirical study by Wydick (1999) and Cassar et al. (2007) applying games by Abbink et al. (2006) in Guatemala, South Africa, and Armenia respectively emphasise no significant gains from social ties, particularly for the latter comparing acquaintance groups against strangers.<sup>15</sup> The unobservable social ties are however measured by weakly correlated proxy dependant variables in the game structure which invalidate findings.

Theoretical research into changes from joint-liability to individual-liability hypothesise decreases in repayment *ceteris paribus* for groups with sufficient social ties (Banerjee et al. 1994), empirical examples being Peru where there is positive correlation between intra-group trustworthiness and strong social ties with higher repayment rates (Karlan 2005; Karlan 2007). In contrast, other experiments show no difference after change from joint to individual liability (Giné and Yang 2009; Giné and Karlan 2009). Against popular literature, the latter deems excessive pressure of joint-liability to discourage good borrowers. The consensus however supports social ties, alongside features such as dynamic incentives and frequent installment as important drivers of repayment rather than joint-liability itself (Armendáriz de Aghion and Morduch 2010). Townsend (2003) describes under theories of selection the ambiguity of Pareto optimal regimes subject to exogenous environmental characteristics. Joint-liability as a cure to free riding cannot be exemplified through one theory.

Comparing alternative game structures, findings in Malawi suggest no difference in repayment between joint and individual-liability (Schaefer-Kehnert 1980). Kono (2006) counter-intuitively finds Vietnamese borrowers have lower repayment rates under joint-liability, even with peer monitoring and punishments through social ties. Thai microcredit programs show similar patterns of negative effects on repayment from social ties. Positive gains to repayment are found to be possible only through high local sanctions and correlated returns (Ahlin and Townsend 2007). Critically, however, the empirics did not control for other lending characteristics and endogenous selection of borrowers, and questions are raised at the excess regional variability. Kono (2013) bypasses endogeneity problems in conducting framed joint-liability experiments in Vietnam. His empirical findings conclude free-riding exceeds players helping group members, resulting in relative underperformance of joint-liability.

To the author's knowledge, this paper is the first to investigate differences in repayment decisions between treated groups of microcredit borrowers and control groups of non-microcredit borrowers in identical joint-liability settings through game theoretical application. Attanasio et al. (2001) and Duflo et al. (2013) pioneered comparisons with treated groups. However, the studies focus on poverty alleviation for women and development effects respectively.

<sup>15</sup> This contradicts Giné et al. 2010, who suggests the opposite.

## Model

This paper models joint-liability settings through repeated experimental games to compare actions of treated microcredit groups against control non-microcredit groups, and in particular identifies the role of social ties versus free riding. The methodology used extends the model of repayment decisions utilised by Kono (2013).

The game is designed where at the beginning of each round each player  $i$  is allocated a stochastic income  $g_i \in [0, \bar{g}_i]$  which is independent and identically distributed over individuals and rounds, representing exogenous investment returns funded by the loans.<sup>16</sup> Players in an  $n$ -person group are required to pay a repayment sum of  $nB$  collectively. Player  $i$  first chooses the action  $r_i$  of whether to repay personal liability,  $B$ . If yes ( $r_i = B$ ), then player  $i$  is given the choice to shoulder (repay)  $d_i$  toward any remaining group liabilities. Repayment is dynamically incentivised as participation in the next round contingent on full group repayment such that  $\sum_{i=1}^n r_i + \sum_{i=1}^n d_i = nB$ . Otherwise, all members in the group are eliminated. This represents borrowers only being able to access further loans subject to full group repayment under joint-liability irrespective of individual repayment decisions.<sup>17</sup> The discount factor,  $\lambda$ , is applied between periods to replicate a finite time horizon to the games where irrespective of outcome the game may end with probability  $1/6$  after each round ( $\lambda = 5/6$ ).<sup>18</sup> Utility for player  $i$  of not receiving loans (thus inability to invest) is 0.

The model assumes for two-player groups ( $n=2$ ) that all players are unable to engage in any strategic interaction within groups outside of the experiment,<sup>19</sup> and that each stage is independent from the previous (players cannot save income from past periods). In contrast to prior experiments, imperfect monitoring is assumed whereby players cannot observe their group members' income levels and decisions, and can only observe personal income,  $g_i$ , and personal decisions  $r_i$  and  $d_i$ ; hence players are unable to determine with certainty if group members are free riding. Note that if the group defaults where  $\sum_{i=1}^n r_i + \sum_{i=1}^n d_i < nB$ , player  $i$  loses  $r_i + d_i$  as the lender does not return an individual's repayment.<sup>20</sup> Lender terms are not considered and are assumed to be homogenous as it does not contribute to the paper's focus on individual choice in a joint-liability setting.

The order of the decisions in round  $t$  can be summarised as follows:

1. Players  $i=1, 2$  are allocated stochastic income  $g_i$  and simultaneously choose their repayment amount,  $r_i$ , where  $i=1, 2$ . The decisions  $(r_i, r_j)$  are observed by both players.
- 2a. If  $r_i = r_j = B$  then both players have met group repayment conditions for the round.

<sup>16</sup> Moral hazard is excluded as player incomes (returns on investment),  $g$ , are independent of their actions.

<sup>17</sup> Inability for individuals to access future loans should the group default is an effective dynamic incentive device (Stiglitz and Weiss 1983). The threat of future retaliation induces cooperative behaviour (Bó 2005).

<sup>18</sup> Assume  $\lambda E(g) < 2B$  to exclude players having a dominant strategy of always repaying regardless.

<sup>19</sup> Unrealistic as borrowers of microcredit live in the same community; to control for this experiment decisions are made face-to-face (Kono 2014). Borrowers cannot enter binding contracts and outcomes are from repeated interactions.

<sup>20</sup> Applies in reality assuming no strategic interaction between players such that players are unable to interact and agree on their decisions prior to repayment (contrary to model by Besley and Coate 1995).

- 2b. If  $r_i = B$  but  $r_j < B, j \neq i$ , then player  $i$  has the option of shouldering (paying)  $d_i = B - r_j$  for the deficit of player  $j$ . By joint-liability, both players meet group repayment conditions for the round only in the scenario where player  $i$  pays the full deficit of player  $j$ . Vice versa if  $r_j = B$  but  $r_i < B, j \neq i$ .
- 2c. If  $r_i, r_j < B$ , both players have not met group repayment conditions for the round (group default) and are eliminated.
3. Given that both players have met group repayment conditions for the round where  $\sum_{i=1}^n r_i + \sum_{i=1}^n d_i = nB$ , progression onto the next round is conditional on the discount factor  $\lambda = 5/6$ .
4. Both players in groups that progress participate in a further repetition in round  $t + 1$ .

## Experimental Procedures

The repeated experimental game is conducted in five rural villages in Manikganj, Bangladesh in December 2014. The experiments are conducted in village centres on random groups of  $n=2$  players, sampling 10 % of the population from each village. Participating players first complete a verbal questionnaire before an explanation on taking part in the game.<sup>21</sup> This includes information on variables including if the group is a treated microcredit or control non-microcredit group.<sup>22</sup>

The repeated game is then administered. Stochastic income for each player at the start of each period is privately allocated through the sum of the points of three randomly allocated cards, each representing either 10 points or 0 points forming three possible income values:  $g \in \{0, 10, 20\}$ .<sup>23</sup> The probability distribution of  $g_i$  is determined by  $q = (q_0, q_{10}, q_{20})$  where given  $q_g = \Pr(g_i = g)$ , let  $q = (25\%, 25\%, 50\%)$ . Each player then simultaneously submits a card face down to represent repayment (10) or default (0). Should player  $i$  default, player  $j$  is then given the option of shouldering and must submit a further card face down to shoulder on their behalf (10) or otherwise (0). Players have satisfied group liabilities upon total group repayment of value 20. If satisfied, progress onto the next repeated round is contingent on not rolling *six* on a standard six-sided dice.<sup>24</sup> Figure 1 illustrates the game tree for player  $i$  in the repeated experimental game.

Players are given economic incentives in the field experiments to better reflect reality. Each player earns a fixed fee of 50 taka for the opportunity cost of participation, and a variable bonus of 10 taka for each 10 card that is unused for repayment and accumulated at game end. This replicates incentives of short-run gains from free riding and long-run gains from cooperation to participate in future rounds.

To prevent implications on external social ties, players cannot observe group member's income levels (cards allocated). Proshikar<sup>25</sup> also runs a regional monopoly in microcredit

<sup>21</sup> Questionnaire is done prior to the game as otherwise the game outcomes may affect questionnaire answers (Kono 2014).

<sup>22</sup> *microcredit* is the key independent dummy variable of note.

<sup>23</sup> Minimum income is 0 (three cards of 0 points) and maximum income is 20 (two cards of 10 points, one card of 0 points).

<sup>24</sup> This represents the discount factor and satisfies Abbink et al. (2006)'s finite horizon games.

<sup>25</sup> Proshikar (NGO) is the sole lender of microcredit in Manikganj and is the third largest lender in Bangladesh.

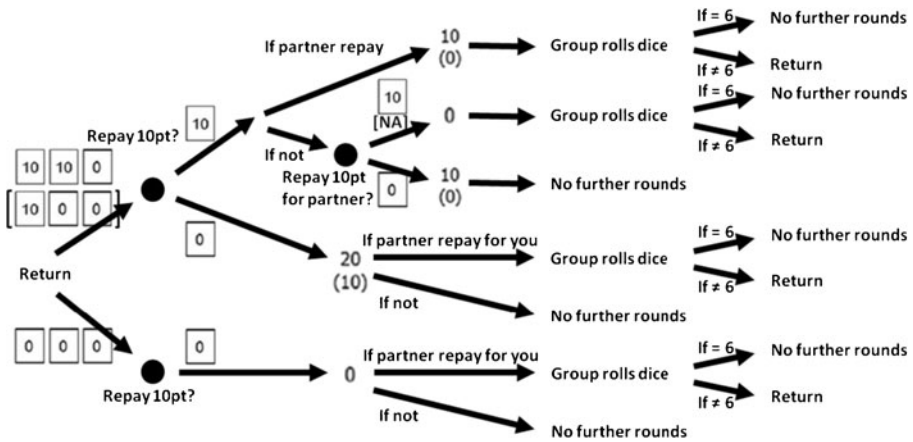


Fig. 1 Game tree

lending in Manikganj, hence it is rational to assume near homogenous terms of lending to treated groups.<sup>26</sup>

**Dataset**

The dataset records 430 players forming 215 groups sampling 10 % of the population by five villages in Manikganj. Treated groups make up 40 % which is upward biased given the willingness for microcredit borrowers to participate.<sup>27</sup> Summary statistics show a balanced range of observations. Gender is split male: female at 49: 51 overall, but 64 % female in the treated groups confirming preference toward female empowerment by lenders. Age follows a quadratic relationship with the majority of the sample between 21 and 40 years old<sup>28</sup>; treated groups contribute strongly as microcredit is directed toward the most able-bodied (86 % treated, 58 % control). Muslims make up 91 % with the Hindu 9 % minority predominantly from Shahapara.<sup>29</sup> No significant religious differences for treated groups suggests Islamic principles against lending are not practised due to necessity for credit.

Statistics document low financial-economic status with 31 % of workers earning below the poverty line of “\$1-a-day” (Ravallion et al. 2009).<sup>30</sup> Forty-four percent of treated individuals (22 % of control) live below the threshold, providing evidence of microcredit geared toward poverty alleviation. Agriculture is the predominant occupation (51 %) followed by garments (11 %) and labour (8 %) given proximity to garment factories and brick-fields. Socio-economic status is poor; 54 % report no education and 67 % are educated below expected literacy.<sup>31</sup> There has however been improvement as parental education

<sup>26</sup> The degree of non-economic factors (social ties and free riding) fostered are assumed to be positive and consistent across treated groups. In reality, joint-liability may have negative non-economic influence (Angelucci et al. 2013). This may be resultant of extortionate interest rates causing repayment pressures to damage social ties (Polgreen and Bajaj 2010).

<sup>27</sup> Proshikar’s database on Manikganj estimates microcredit penetration at approximately 35 %.

<sup>28</sup> Given the financial nature of the game, those below 18 were not ethically allowed to participate and randomly replaced.

<sup>29</sup> Problems of multicollinearity as a result are checked and corrected.

<sup>30</sup> Housewives excluded as they report zero income.

<sup>31</sup> Literacy is expected after studying beyond class 4.

records 76 % with none and 87 % below literacy. Households are large with the mean number of children, siblings and dependants at 2.1, 2.2 and 2.2 respectively. Smoking is reported by 3 %, however this is dropped due to misrepresentation given its negative connotation with lending is well-known. There are no significant group differences in age or education for the treated, although there is suggestion that gender, job and income differences are minimized in treated groups. The premise is improved social ties in homogenous groups.

## Theoretical Hypotheses

### Hypothesis 1

*Treated microcredit groups are more sustainable borrowers than control non-microcredit groups under joint-liability.*

Individuals in treated groups choose repayment and subsequently progress onto more rounds compared to control groups under joint-liability controlling for other characteristics. Theory hypothesises stronger social ties from past interactions to promote non-economic factors of cooperation and trust within treated groups, hence more rounds are played in the repeated games. This effect is forecasted to increase positively with the number of years the group has been together.

### Hypothesis 2

*Treated microcredit groups forego short-run gains from non-repayment in preference for long-run dynamic gains compared to control non-microcredit groups under joint-liability.*

Treated group individuals are predicted to earn less income in the short-run given rounds played as they choose repayment, but dynamic gains from participation in more total rounds as a consequence leads to higher total income overall compared to control groups. Theory anticipates treated groups show moral discipline; they forego short-run gains preferring that longer-term gains from future loans. The hypothesis also expects mutual gains from lending to treated groups: lenders are more likely repaid and treated borrowers make higher long-run gains.

### Hypothesis 3

*Developments in non-economic factors foster social ties which encourage shouldering and discourage free riding within treated microcredit groups compared to control non-microcredit groups.*

Treated groups show significant development of social ties which promote shouldering (supporting partners) and deter free riding as a consequence of non-economic factors increasing cooperation and relationships. Theoretically treated groups are significantly more likely to shoulder (support) their partner and less likely to free ride compared to control groups under joint-liability (Besley and Coate 1995; Ghatak and Guinnane 1999).



## Hypothesis 4

*Lenders can maximise repayment rates under joint-liability by selecting individuals/groups that meet optimal characteristics.*

Theory suggests various observable characteristics of individuals and groups that can maximise repayment decisions. Controlling for differences between treated and control groups, there are optimal physical, individual, relational, and group characteristics.<sup>32</sup>

Literature on physical characteristics supports female lending as females are risk averse with loan investment (Armendáriz de Aghion and Morduch 2010) and are genetically dutiful with payments (D'Espallier et al. 2011). Lenders also choose to lend to the able-bodied aged 20 to 30, who are most likely to earn repayment returns and to seize the initiative for future loans.

From a relational perspective, blood relatives and neighbours likely have the strongest social ties, albeit at marginal risk that they anticipate a partner's bad repayment behaviour. Inconclusive evidence suggests that the group support mentality increases with marriage, children, siblings, and dependants. Conversely, emotional constraints may reduce the willingness to support additional others. Popular thought suggests that higher parental education is positively correlated with childhood teachings on right-and-wrong, and that village differences affect social ties.

Predictions regarding individual attributes are uncertain. Increased education increases repayment due to the strong positive correlation with good behaviour, however educated players may attempt to cheat the system. Similarly higher incomes and savings mean relative repayments are less of a burden, but also diminish the dynamic incentive for future loans. Optimal job guidelines are broad, allowing for any possibility that loan investment can be made into self-employment schemes.

Maximum repayment is anticipated from homogenous groups on the premise that they show improved social ties. Group members build stronger relationship when related in age, education and gender. Similar lifestyles and challenges from equal income, occupation and marital status also positively impact group repayment.

## Empirical Results

Empirical findings from the questionnaire and repeated experimental games are recorded and analysed. The field experiments are used to empirically test the four key theoretical hypotheses proposed in “*Theoretical Hypotheses*.” The cross-sectional data is econometrically analysed by ordinary least squares (OLS) regressions and maximum likelihood estimation (MLE) binary estimation.

The key dependant variables analysed are as follows: *rounds* measures sustainability of joint-liability, counting the number of rounds the group plays and repays. *Points* represent total earnings by the individual for the duration of the game (number of 10 cards accumulated and unused for repayment). Binary variables *shoul* and *free*

<sup>32</sup> The objective of the questionnaire used by MCIs to decide borrowers is to determine eligibility based on expected optimal characteristics for repayment. Recall that this paper bases its questions (variables) on those used by Proshikar.

determine whether an individual chose to shoulder or free ride respectively throughout the game.

**Preliminary Findings**

Preliminary analyses illustrated in Fig. 2 suggest treated groups perform differently than control groups as hypothesised. Treated groups have a 91 % higher mean rounds played at 4.18 rounds versus 2.20 rounds for control groups. They also score 53 % more points on average (1.90 versus 1.24 points) throughout the duration of the game. This provides evidence treated groups comparatively play more rounds and score more total points.

Of treated individuals, 79 % shouldered for partners compared to 59 % for the controls as in Fig. 3. Treated players are also significantly less likely to free ride at only 15 % compared to 40 % in control groups. There is the suggestion of comparatively stronger non-economic social ties encouraging shouldering and discouraging free riding.

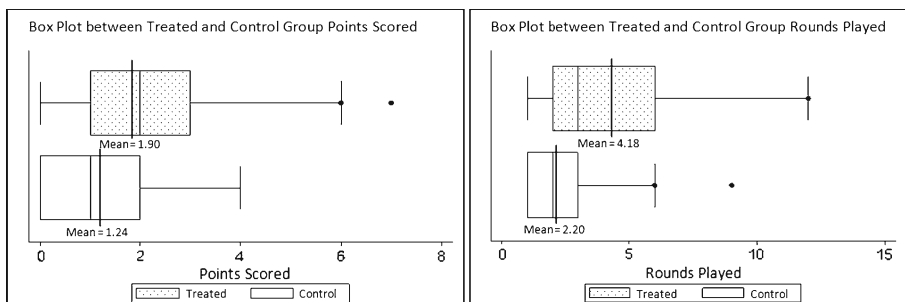
**Testing Hypothesis 1**

*Major Model: Rounds*

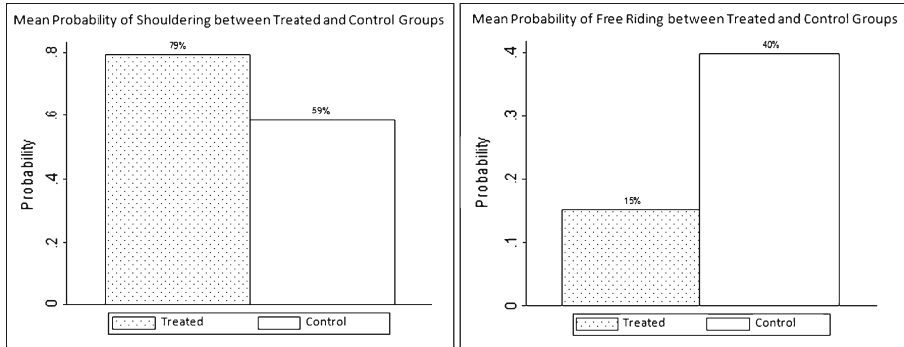
To determine sustainability under joint-liability between treated and control groups, an OLS regression with dependant variable *rounds* and the main explanatory variable *microcredit* is analysed. Model C in Table 1 shows the final output given by:

$$\begin{aligned}
 \text{rounds} = & \alpha + \beta_1 \text{microcredit} + \beta_2 \text{sex} + \beta_3 \text{blood\_rel} + \beta_4 \text{see\_house} + \beta_5 \text{i.vill} + \beta_6 \text{i.educ} + \beta_7 \text{i.job} \\
 & + \beta_8 \text{educ\_diff} + \beta_9 \text{job\_diff} + \varepsilon
 \end{aligned}$$

Model C provides evidence verifying that treated microcredit groups are significantly more sustainable borrowers than control groups. Treated groups play 1.771 more rounds compared to controls, all other significant covariates held constant. Robustness of the finding is confirmed as the hypothesis holds true when introducing further insignificant covariates based on the literature and on all observed variables with



**Fig. 2** Illustrations of preliminary findings: points scored and rounds played



**Fig. 3** Illustrations of preliminary findings: shouldering and free riding

treated groups partaking in 1.723 and 1.711 more rounds respectively compared to control groups.

*Minor Model: Rounds Controlling for Relationship over Time*

To isolate the difference in sustainability between treated and control groups controlling for relationship development from past interactions under the joint-liability setting in treated groups, the covariate *years\_partner* is added as a proxy for unobservable growth in cooperation and trust. The extended Model D in Table 1 shows the following:

$$\begin{aligned}
 \text{rounds} = & \alpha + \beta_1 \text{microcredit} + \beta_2 \text{years\_partner} + \beta_3 \text{sex} + \beta_4 \text{blood\_rel} + \beta_5 \text{see\_house} + \beta_6 \text{i.vill} \\
 & + \beta_7 \text{i. educ} + \beta_8 \text{i. job} + \beta_9 \text{educ\_diff} + \beta_{10} \text{job\_diff} + \varepsilon
 \end{aligned}$$

In line with theory, the coefficient on *years\_partner* dictates that treated groups play 0.486 more rounds for every additional year of having taken microcredit loans together, suggesting increasing social ties with past interactions. Introducing this proxy for relationship development over time explains 48.5 %<sup>33</sup> of the difference between treated and control groups in Model C; hypothesis 1 still holds true as treated groups nevertheless play 0.912 more rounds than controls *ceteris paribus*. This result unambiguously supports joint-liability, suggesting sustainable repayment by groups entrusted with loans comparable to otherwise controlling for relationship growth over time. This suggests success in passing responsibility onto borrowers and in lender initiatives such as group meetings and local ambassadors, although further research beyond the dataset is required.

Note the coefficient on *microcredit* is likely negatively biased as growth in social ties over time outside of borrowing situations may exponentially impact control groups more and is not controlled for as relationship measures are subjective. However the assumption that this affects all groups linearly (constant marginal returns to relationship

<sup>33</sup> This is calculated from the coefficient on microcredit between Model C and Model D, such that:  $\frac{\beta_{1, \text{Model C}} - \beta_{1, \text{Model D}}}{\beta_{1, \text{Model C}}} = 48.5\%$

**Table 1** Hypothesis 1 OLS regression results

Variables	Dependant Variable = rounds	
	(1) Model C	(2) Model D
<b>microcredit</b>	1.771***	0.912***
<b>years_partner</b>		0.486***
<b>sex</b>	0.934***	0.917***
<b>blood_rel</b>	0.641*	0.588*
<b>see_house</b>	0.915***	0.831***
<b>vill [borundi]</b>	***	***
<i>vill_koitta</i>	-0.173	-0.184
<i>vill_rajibpur</i>	0.572	0.659
<i>vill_shah</i>	-0.901	-0.842
<i>vill_kazi</i>	0.815***	0.606**
<b>save</b>		
<b>educ [none]</b>	***	***
<i>educ_c1</i>	-0.262	-0.163
<i>educ_c2</i>	-0.153	-0.214
<i>educ_c3</i>	-0.106	-0.0722
<i>educ_c4</i>	0.196	0.107
<i>educ_c5</i>	0.583	0.545
<i>educ_c6</i>	-0.0902	-0.0577
<i>educ_c7</i>	-1.565***	-1.818***
<i>educ_c8</i>	-0.430	-0.404
<i>educ_c9</i>	0.895	0.865
<i>educ_c10</i>	0.748	0.822
<i>educ_olevel</i>	-0.980**	-0.909**
<i>educ_alevel</i>	0.515	0.475
<i>educ_masters</i>	-1.535***	-2.081***
<b>job [agriculture]</b>	***	***
<i>job_messenger</i>	2.249***	2.353***
<i>job_housewife</i>	-0.314	-0.301
<i>job_business</i>	0.213	0.219
<i>job_fisherman</i>	1.962***	2.074***
<i>job_unemployed</i>	-0.0643	-0.0292
<i>job_mechanic</i>	-0.664	-0.510
<i>job_craftsman</i>	3.765**	2.958*
<i>job_labour</i>	-0.0201	-0.139
<i>job_driver</i>	0.486	0.530
<i>job_office</i>	0.960	0.769
<i>job_teacher</i>	-0.126	-0.108

**Table 1** (continued)

Variables	Dependant Variable = rounds	
	(1) Model C	(2) Model D
<i>job_garments</i>	-0.150	-0.117
<i>job_woodcutter</i>	1.593**	1.602**
<b>educ_diff</b>	-0.438*	-0.409*
<b>job_diff</b>	-0.450**	-0.440**
<b>Constant</b>	1.606***	1.667***
<b>Observations</b>	430	430
<b>R-squared</b>	0.367	0.387

- \*\*\*, \*\*, \* correspond to the coefficient being significant at the 1, 5 and 10 % significance levels respectively
- **Bold** correspond to main variable
- *Italics* correspond to binary (dummy) variables
- [square brackets] correspond to base level

Source: Author’s experimental data

development) means the bias should not significantly change the difference in rounds played between treated and control groups.

### Testing Hypothesis 2

#### *Major Model: Points*

To analyse long-run gains to joint-liability borrowers, an OLS regression is run on *points* from the experimental games with the main independent variable of *microcredit* among other covariates. Model C in Table 2 shows:

$$\begin{aligned}
 \text{points} = & \alpha + \beta_1 \text{microcredit} + \beta_2 \text{sex} + \beta_3 i.vill + \beta_4 i.parental\_educ + \beta_5 \text{relig} + \beta_6 \text{house\_income} \\
 & + \beta_7 \text{save} + \beta_8 i. \text{job} + \varepsilon
 \end{aligned}$$

Results validate the theoretical predictions under Hypothesis 2 as treated groups accumulate 0.589 more points than controls *ceteris paribus*. This is interpreted as earning a significantly higher total income of 5.89 taka comparatively from the experimental games. It is supported by findings in Hypothesis 1 where treated groups play more rounds as it is logical to assume additional rounds lead to more points accumulated given the nature of the game. Robustness checks including covariates based on theory and all observable variables find the hypothesis holds, with treated groups scoring significantly more points 0.607 and 0.612 respectively.

**Table 2** Hypothesis 2 OLS regression result

Variables	Dependant Variable = points		
	(1) Model C	(2) Model D	(3) Model D+
<b>microcredit</b>	0.589***	-0.160	-0.280***
<b>'control' rounds</b>		0.428***	0.428***
<b>sex</b>	0.369**		
<b>see_house</b>		-0.243*	-0.268**
<b>vill [borundi]</b>	***	***	***
<i>vill_koitta</i>	-0.383**	-0.269**	-0.212*
<i>vill_rajibpur</i>	0.174	-0.131	-0.274
<i>vill_shah</i>	-1.958***	-1.207***	-1.193***
<i>vill_kazi</i>	0.248	-0.168	-0.118
<b>par_educ [none]</b>	***	***	***
<i>peduc_c1</i>	1.769***	-0.191	0.258
<i>peduc_c2</i>	-0.198	-0.298	-0.291
<i>peduc_c3</i>	-0.595***	-0.236	-0.234
<i>peduc_c4</i>	-0.0406	0.181	0.247
<i>peduc_c5</i>	-0.379	-0.471	-0.277
<i>peduc_c6</i>	-0.114	-0.300	-0.324
<i>peduc_c7</i>	1.268***	0.622***	0.647***
<i>peduc_c9</i>	0.326	-0.0179	-0.0380
<i>peduc_c10</i>	0.00656	-0.255	-0.259
<i>peduc_olevel</i>	-0.137	-0.182	-0.140
<i>peduc_alevel</i>	-0.158	-0.860***	-0.941***
<b>relig</b>	0.963***	1.115***	1.045***
<b>house_income</b>	-2.69e-06*	-1.51e-06*	-1.71e-06**
<b>save</b>	3.15e-06*		
<b>educ [none]</b>		***	***
<i>educ_c1</i>		0.225	0.195
<i>educ_c2</i>		-0.193	-0.134
<i>educ_c3</i>		0.0159	0.0842
<i>educ_c4</i>		-0.196	-0.182
<i>educ_c5</i>		-0.187	-0.183
<i>educ_c6</i>		0.499**	0.450**
<i>educ_c7</i>		1.003***	1.192***
<i>educ_c8</i>		0.228	0.294
<i>educ_c9</i>		-0.228	-0.348
<i>educ_c10</i>		-0.212	-0.0266
<i>educ_olevel</i>		0.199	0.207
<i>educ_alevel</i>		0.296	0.351

**Table 2** (continued)

Variables	Dependant Variable = points		
	(1) Model C	(2) Model D	(3) Model D+
<i>educ_masters</i>		-1.026***	-0.980***
<b>job [agriculture]</b>	***		
<i>job_messenger</i>	0.939*		
<i>job_housewife</i>	-0.388		
<i>job_business</i>	0.185		
<i>job_fisherman</i>	0.500**		
<i>job_unemployed</i>	-0.315**		
<i>job_mechanic</i>	-0.403		
<i>job_craftsman</i>	0.0899		
<i>job_labour</i>	-0.0361		
<i>job_driver</i>	-0.347		
<i>job_office</i>	0.585		
<i>job_teacher</i>	0.437		
<i>job_garments</i>	0.111		
<i>job_woodcutter</i>	1.346***		
<b>married_diff</b>		0.251*	0.150
<b>Constant</b>	1.333***	0.595***	0.621***
<b>Observations</b>	430	430	396
<b>R-squared</b>	0.144	0.528	0.397

- \*\*\*, \*\*, \* correspond to the coefficient being significant at the 1, 5 and 10 % significance levels respectively
  - **Bold** correspond to main variable
  - *Italics* correspond to binary (dummy) variables
  - [square brackets] correspond to base level
- Source: Author’s experimental data

*Major Model: Points Controlling for Rounds*

To test if treated groups forego short-run gains, a similar OLS regression is modelled with *points* as the dependant variable and *microcredit* as the main independent variable, however this time including ‘controls’ for *rounds*. Model D in Table 2 shows the specification:

$$\begin{aligned}
 \text{points} = & \alpha + \beta_1 \text{microcredit} + \beta_2 \text{sex} + \beta_3 i.vill + \beta_4 i.parental\_educ + \beta_5 \text{relig} + \beta_6 \text{house\_income} \\
 & + \beta_7 \text{save} + \beta_8 i. \text{job} + \text{controls}' + \varepsilon
 \end{aligned}$$

By controlling for *rounds* the interpretation of coefficients is the difference in *points* scored for a fixed number of *rounds* played. Hypothesis 2 predicts a significantly negative coefficient on *microcredit* as treated groups are theoretically predicted to show moral discipline and repay in each round, thus earning less over rounds than had they shirked. Empirical findings confirm a negative coefficient of  $-0.160$ , however it is statistically insignificant. Further inspection of Fig. 4 infers a problem of lack of observations above six rounds played by control groups. The regression in Model D+ in Table 2 is run as a correction, restricting observations up to six rounds played.<sup>34</sup> *Microcredit* becomes significant and treated groups score 0.280 fewer points than controls for fixed rounds played as hypothesised; treated groups indeed forego 2.80 taka of short-run gains from non-repayment.

### Testing Hypothesis 3

#### Major Model: Shouldering

Maximum likelihood estimation is used focusing on probit<sup>35</sup> binary estimation results for the variable *shoul* to test if treated groups show a higher likelihood of shouldering compared to control groups. The main independent variable is *microcredit* as in Probit C in Table 3:

$$\begin{aligned} \text{shoul} = \alpha + \beta_1 \text{microcredit} + \beta_2 \text{age} + \beta_3 \text{sex} + \beta_4 \text{see.house} + \beta_5 \text{children} + \beta_6 \text{i.vill} + \beta_7 \text{relig} + \beta_8 \text{i.job} \\ + \beta_9 \text{school\_} \quad \text{school\_} \quad \text{school\_} \quad \text{school\_} \quad \text{school\_} \quad \text{school\_} \quad \text{school\_} \quad \text{school\_} \\ \text{diff} + \varepsilon \end{aligned}$$

Relatively stronger social ties in treated groups predict fostering of non-economic factors toward shouldering for a partner's repayment. Empirically, treated groups are indeed 26.6 % more likely to shoulder compared to control groups *ceteris paribus*. Results are consistent and significant applying alternative estimation methods of logit estimation (Logit C) and linear probability model (LPM C); 25.7 and 22.9 % more likely for the treated, respectively. Robustness checks are confirmed on Probit A and Probit B models.

#### Major Model: Free Riding

Econometric techniques are next applied to the variable *free* for which the hypothesis anticipates *microcredit* to have a significant negative coefficient. The interpretation is that treated groups have a lower likelihood of free riding compared to control groups. As in Probit C in Table 3:

$$\begin{aligned} \text{free} = \alpha + \beta_1 \text{microcredit} + \beta_2 \text{sex} + \beta_3 \text{blood\_rel} + \beta_4 \text{i.vill} + \beta_5 \text{house\_income} \\ + \beta_6 \text{i.job} + \varepsilon \end{aligned}$$

<sup>34</sup> Restricting observations is a second-best solution to gathering more data. Restricted observations are empirically analysed; there is no evidence of having removed a specific subset of the sample aside from treated groups.

<sup>35</sup> Probit estimation is chosen as adjudged by past literature. The assumptions of normally distributed error terms are made.



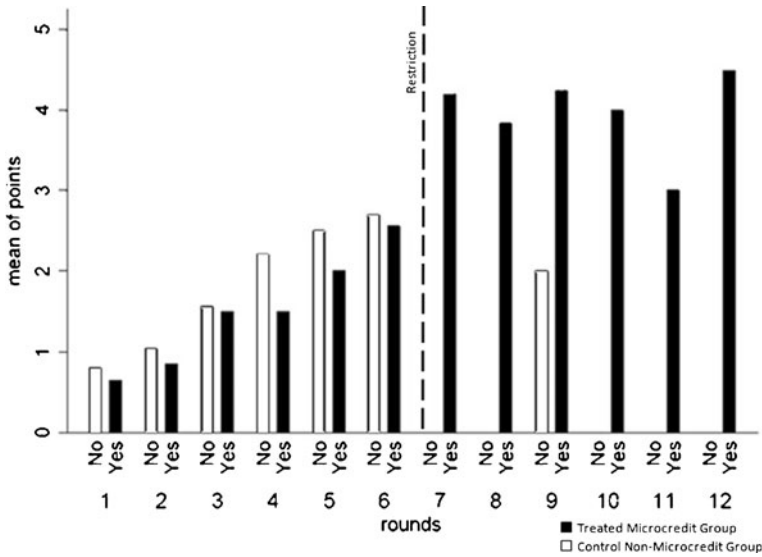


Fig. 4 Bar chart to show mean points scored between treated and control groups, over rounds

Results show individuals in treated groups are 27.4 % significantly less likely to free ride on their partner as hypothesised. This provides evidence toward stronger social ties within treated groups, and is further confirmed by consistent findings when applying alternative estimation methods of Logit C and LPM C, 25.8 and 26.2 % less likely respectively.

*Interpretation of Independent Variables for Shouldering and Free Riding*

Different factors variably influence non-economic social tie drivers of shouldering and free riding when comparing the significance of covariates<sup>36</sup> holding constant differences between treated and control groups.

Physically, females are 17.3 % more likely to shoulder and 10.1 % less likely to free ride than male counterparts as reconciled by gender economics (D’Espallier et al. 2011). Each additional year in age increases shouldering probability by 1 %. This suggests younger generations are less inclined to help partners, whether to avoid income loss or weaker social ties given fewer years in the community, yet this is not reflecting in free riding for which character dominates and is constant irrespective of age.

Relationship factors show neighbours are 20.3 % more likely to shoulder and blood relatives 18.2 %; less likely to free ride. Overlap whereby blood relatives locate in close proximity to neighbours distorts individual effects, but there is clear overall significance. Furthermore each additional child decreases the likelihood of shouldering by 8.9 % as parent’s face emotional constraints. For each additional child’s needs they are less inclined to help borrowing partners. Culturally, Hindus are 40.2 % more likely to shoulder than Muslims, all else constant, due to collectiveness among the religious minority in Manikganj.<sup>37</sup> There are also significant differences between villages, with

<sup>36</sup> See Table 3. Comparisons are distinguished from respective significant covariates in Probit C Models for *shoul* and *free*.

<sup>37</sup> 89.5 % of Hindus sampled reside in the village of Shahapara.

**Table 3** Hypothesis 3 free riding and shouldering binary estimation results

Variables	Dependant Variable = free riding (1) Probit C	Dependant Variable = shouldering (1) Probit C
<b>microcredit</b>	-0.274***	0.266***
<b>sex</b>	-0.101*	0.173*
<b>age</b>		0.010**
<b>blood_rel</b>	-0.182***	
<b>see_house</b>		0.203**
<b>children</b>		-0.089**
<b>vill [borundi]</b>	***	***
<i>vill_koitta</i>	-0.172***	0.183*
<i>vill_rajibpur</i>	-0.052	0.117
<i>vill_shah</i>	-0.317***	-0.942***
<i>vill_kazi</i>	-0.117**	0.051
<b>relig</b>		0.402***
<b>house_income</b>	-1.29e-06**	
<b>job [agriculture]</b>	***	***
<i>job_messenger</i>	-	-
<i>job_housewife</i>	-0.195**	0.146
<i>job_business</i>	0.028	-0.158
<i>job_fisherman</i>	-	-
<i>job_unemployed</i>	-0.115	-
<i>job_mechanic</i>	0.174	-0.103
<i>job_craftsman</i>	0.152	-
<i>job_labour</i>	-0.044	0.163
<i>job_driver</i>	0.119	0.222
<i>job_office</i>	-	0.027
<i>job_teacher</i>	0.531*	-
<i>job_garments</i>	0.179*	-0.182
<i>job_woodcutter</i>	0.853***	0.443***
<b>school_diff</b>		0.015**
<b>Constant</b>	0.219***	0.747**
<b>Observations</b>	383	183
<b>R-squared</b>	0.206	0.241
<b>Correctly Classified</b>	74.41 %	77.60 %

- \*\*\*, \*\*, \* correspond to the coefficient being significant at the 1, 5 and 10 % significance levels respectively
- Bold correspond to main variable
- Ital i cs correspond to binary (dummy) variables
- [square brackets] correspond to baselevel
- - dashes correspond to omitted variables because of colinearity
- Marginal effects are reported for maximum likelihood estimations (Probit and Logit Model s) in the space for coefficients

Source: Author's experimental data

inconclusive proof that smaller populations show comparatively stronger internal social ties. Free riding shows no difference given character is its main driver which is ambiguous over religion and children.

For individual variables, each additional taka of annual household income decreases the probability of free riding by 0.320 % as there is reduced necessity for guaranteed short-run earnings. Surprisingly this is not replicated for shouldering but the explanation is that relationship factors dominate. Occupation significantly explains shouldering and free riding. Of particular note are housewives and woodcutters compared to agriculture due to the prior fostering motherly behaviour and strong social ties in occupational community in the latter.

Group differences in age, gender, marital status, income and occupation to optimise non-economic factors is minimally significant contrary to popular thought regarding homogeneity. There is only a suggestion that each additional year gap in schooling between partners increases shouldering. This may be due to the highly educated pitying partners and the lowly educated supporting inferiority.

### Testing Hypothesis 4

OLS regression specifications in Table 4 with *rounds* as the dependant variable are used to identify optimal characteristics to maximise joint-liability repayment. *Rounds* are a measure of returns to lenders as further rounds are contingent on group repayment. Initial specifications on individual and group characteristics are refined for combination toward optimal characteristics<sup>38</sup> specified below. Note *microcredit* is retained to control for differences between treated and control groups.

$$\begin{aligned} \text{rounds} = & \alpha + \beta_1 \text{microcredit} + \beta_2 \text{sex} + \beta_3 \text{blood\_rel} + \beta_4 \text{see\_house} + \beta_5 \text{i.vill} + \beta_6 \text{i.educ} + \beta_7 \text{i.job} \\ & + \beta_8 \text{educ\_diff} + \beta_9 \text{job\_diff} + \varepsilon \end{aligned}$$

The physical optimum in favour of female empowerment is to lend to females who are more sustainable borrowers, playing 0.934 more rounds than male counterparts. Age is not seen to impact repayment choice, disproving the notion of young workers having stronger motivation to repay future loans to escape poverty. However this overlooks age affecting ability to work and generate income for repayment as game income is set exogenously independent of productivity.

Based on relationships, lenders maximizing repayment from blood relatives and neighbours depicts strong social ties as hypothesised, playing 0.641 and 0.915 more rounds than otherwise. Cooperation is higher and there is significant opportunity cost of punishment from losing trust in these groups. The data also find no significant evidence to select borrowers based on children, siblings, dependants or upbringing based on parental education affecting the helping mentality. There is however significant varying strength of cultural relationships between village groups, although further research is required to pinpoint drivers.<sup>39</sup>

<sup>0</sup> 89.5 % of Hindus sampled reside in the village of Shahapara.

<sup>38</sup> Notice the Optimal Characteristics specification is the same as Model C in Table 1, as expected.

<sup>39</sup> Duflo et al. (2013) indeed find evidence of MCIs targeting borrower groups based on village of residence.

**Table 4** Hypothesis 4 OLS regression results

Variables	Dependant Variable = rounds (1) Optimal characteristics
<b>microcredit</b>	1.771***
<b>sex</b>	0.934***
<b>blood_rel</b>	0.641*
<b>see_house</b>	0.915***
<b>vill [borundi]</b>	***
<i>vill_koitta</i>	-0.173
<i>vill_rajibpur</i>	0.572
<i>vill_shah</i>	-0.901
<i>vill_kazi</i>	0.815***
<b>educ [none]</b>	***
<i>educ_c1</i>	-0.262
<i>educ_c2</i>	-0.153
<i>educ_c3</i>	-0.106
<i>educ_c4</i>	0.196
<i>educ_c5</i>	0.583
<i>educ_c6</i>	-0.0902
<i>educ_c7</i>	-1.565***
<i>educ_c8</i>	-0.430
<i>educ_c9</i>	0.895
<i>educ_c10</i>	0.748
<i>educ_olevel</i>	-0.980**
<i>educ_alevel</i>	0.515
<i>educ_masters</i>	-1.535***
<b>job [agriculture]</b>	***
<i>job_messenger</i>	2.249***
<i>job_housewife</i>	-0.314
<i>job_business</i>	0.213
<i>job_fisherman</i>	1.962***
<i>job_unemployed</i>	-0.0643
<i>job_mechanic</i>	-0.664
<i>job_craftsman</i>	3.765**
<i>job_labour</i>	-0.0201
<i>job_driver</i>	0.486
<i>job_office</i>	0.960
<i>job_teacher</i>	-0.126
<i>job_garments</i>	-0.150
<i>job_woodcutter</i>	1.593**
<b>job_diff</b>	-0.450**
<b>educ_diff</b>	-0.438*
<b>Constant</b>	1.606***

**Table 4** (continued)

Variables	Dependant Variable = rounds (1) Optimal characteristics
<b>Observations</b>	430
<b>R-squared</b>	0.367
<b>AICc</b>	4.232

- **\*\*\*, \*\*, \*** correspond to the coefficient being significant at the 1, 5 and 10 % significance levels respectively
  - **Bold** correspond to main variable
  - *Italics* correspond to binary (dummy) variables
  - [square brackets] correspond to base level
- Source: Author's experimental data

Focusing on the individual, lower education promotes repayment, confirming the theory that better educated players attempt to 'cheat the system' by not repaying. Significant levels are at Class 7, O-Level and Masters who participate in 1.565, 0.980 and 1.535 rounds less than baseline no education, respectively. The financial variables of income and savings are insignificant in influencing repayment. The story may be that increases in income or savings lead to less repayment burden but also less dynamic incentive for future loans which trade-off perfectly in equilibrium. It is more likely, however, that by setting income exogenously and not incorporating the possibility of financial losses, borrowers do not act realistically based on financials. Against acceptance of a broad return on jobs, the analysis finds more significance should be placed on occupation. There are higher long-run repayments from workers in predominantly niche forms of employment that form small work-communities as they better cooperate: messengers (+2.245), fisherman (+1.962), craftsman (+3.765) and woodcutters (+1.593) play more rounds than baseline agriculture workers who make up 51 % of sampled treated borrowers.

Optimal group criteria suggest same sex groups perform better by 0.483 rounds compared to others, however, it is inconclusive when controlling for individual characteristics. Robustness checks confirm repayment differences due to individual gender explain the majority of the variation in group gender. Age difference is insignificant disproving less cooperation for bigger age gaps between partners. Partners with differing education levels play 0.450 less rounds than the identically educated. Highly educated players chose non-repayment to attempt to cheat lenders and their partners, particularly if educational differences exist with the latter. Group income disparity shows no significance which can be explained by similar lifestyles over the range of incomes observed. Negative non-economic factors such as jealousy are not problematic as the population has 90,413 taka mean annual household income with 48,058 standard deviation.<sup>40</sup> The availability of goods for conspicuous consumption is constrained and anyone with high income relocates away from rural villages. Moreover homogenous job groups outperform others by 0.450 rounds, placing importance on relationships within work communities.

<sup>40</sup> Augsburg et al. 2012 finds no income gains to microcredit borrowers in Bosnia suggesting no social jealousy toward them.

## Concluding Remarks

Pioneering repeated experimental games are modelled to evaluate social ties and free riding under practical joint-liability microcredit borrowing in Bangladesh. Focus is given to repayment decisions by treated microcredit borrower-groups compared to control non-microcredit groups. The paper hypothesises and empirically challenges key theories.

Empirical evidence supports theoretical predictions of more sustainable treated groups likely repaying loans and participating in more *rounds* compared to control groups. Treated groups foster positive non-economic social ties from repeated interactions. This holds controlling for past joint-liability interactions over time, but relationship growth outside of this is assumed to equally affect all groups. Partial solutions would be to measure number of years groups have known each other or to include subjective measures of relationship strength.

Treated individuals in the experiments show moral discipline as hypothesised, foregoing short-run gains from non-repayment to benefit from higher dynamic long-run total earnings. A second-best policy of restricting *rounds* is however essential to conclude significantly lower short-run earnings for treated group. First-best policy would be to expand the dataset, sampling 20 % of all populations or exploring more villages, particularly because of multicollinearity problems from the Hindu village of Shahapara.

Hypothesis 3 states stronger social ties in treated groups encourages shouldering and discourages free riding compared to control groups. Empirically this is well-proven with treated groups 26.6 % more likely to shoulder and 27.4 % less likely to free ride compared to control groups holding all else constant. By extension, different observable characteristics affect the likelihood of shouldering or free riding differently. Findings of shouldering being sensitive to physical and relational characteristics and free riding to individuals' situation are suggested.

The story for lenders, when selecting optimal borrowers in joint-liability, is to choose predominantly women that are blood relatives and neighbours. To maximise repayments, lenders must select those educated below Class 7 and in niche forms of employment so they benefit from stronger work-community social ties. Homogenous groups in sex, education and occupation should be formed. Optimum values based on income and village are uncertain because of exogenously setting income outside of the loss domain and inability to identify cultural differences between villages respectively.

The contemporary game theoretical application to joint-liability microcredit lending is novel. There remains expansive scope for future literature. Extensions to this paper include but are not limited to allowing observation of group incomes to a degree of certainty to better replicate signals of repayment ability,<sup>41</sup> and finding proxy variables to measure unobservable behavioural characteristics which limit all empirical research in microcredit.<sup>42</sup> Alternative application of the experimental games can be made to test social ties in solving moral hazard by setting income endogenously or in solving adverse selection by comparing microcredit borrowers to those only deterred by high

<sup>41</sup> This however raises ethical concerns, hence why it was avoided in this paper.

<sup>42</sup> At best 38.7 % of the variability (R-squared) through observable characteristics for sustainability is explained (*rounds*).

interest rates. Experimental games can also be adapted to model comparisons between joint-liability and other lending models such as individual-liability.

The paper finds significant evidence supporting theoretical hypotheses in joint-liability microcredit lending. Nevertheless whether joint-liability is the optimal lending model for alleviating world poverty remains undetermined.<sup>43</sup>

**Acknowledgments** I am indebted to Dr. Robert Akerlof for his support and comments as supervisor, Dr. Jeremy Smith for his knowledge on empirical techniques, Dr. Md. Kayes Samim Polash of Proshikar with whom I conducted the field experiments, Dr. Robert Akerlof and Dr. Gianna Boero for nominating this paper for the Carroll Round (for which it earned *Outstanding Participation*), British Conference of Undergraduate Research and the Best Undergraduate Paper Competition organised by the International Atlantic Economic Society (for which it was awarded *Winner*), Mr. Shakhawat Hossain of Jai Jai Din for bringing media attention to my field work, Dr. Katherine Virgo for her support as Managing Editor of the *Atlantic Economic Journal* and numerous others. Any remaining errors are my own.

**Open Access** This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.

## References

- Abbink, K., Irlenbusch, B., & Renner, E. (2006). Group size and social ties in microfinance institutions. *Economic Inquiry*, 44(4), 614–628.
- Adams, D. W., & Vogel, R. C. (1986). Rural financial markets in low-income countries: recent controversies and lessons. *World Development*, 14(4), 477–487.
- Ahlin, C., & Townsend, R. M. (2007). Using repayment data to test across models of joint liability lending. *The Economic Journal*, 117(517), F11–F51.
- Akerlof, G. A. (1970). The market for “lemons”: quality uncertainty and the market mechanism. *The Quarterly Journal of Economics*, 488–500.
- Allen, T. (2012). *Optimal (Partial) group liability in microfinance lending*. Princeton University, Department of Economics.
- Angelucci, M., Karlan, D., & Zinman, J. (2013). *Win some lose some? Evidence from a randomized microcredit program placement experiment by Compartamos Banco (No. w19119)*. National Bureau of Economic Research.
- Armendáriz de Aghion, B., & Morduch, J. (2010). *The economics of microfinance*. MIT press.
- Attanasio, O., Augsburg, B., De Haas, R., Fitzsimons, E., & Harmgart, H. (2001). The impacts of microfinance: evidence from joint-liability lending in Mongolia. *American Economic Journal: Applied Economics*, 7(1), 90–122.
- Augsburg, B., De Haas, R., Harmgart, H., & Meghir, C. (2012). *Microfinance at the margin: experimental evidence from Bosnia and Herzegovina*. Leibniz Information Centre for Economics, SSRN 2021005.
- Banerjee, A. V., Besley, T., & Guinnane, T. W. (1994). The neighbor’s keeper: the design of a credit cooperative with theory and a test. *The Quarterly Journal of Economics*, 109(2), 491–515.
- Besley, T., & Coate, S. (1995). Group lending, repayment incentives and social collateral. *Journal of Development Economics*, 46(1), 1–18.
- Bhole, B., & Ogden, S. (2010). Group lending and individual lending with strategic default. *Journal of Development Economics*, 91(2), 348–363.
- Bó, P. D. (2005). Cooperation under the shadow of the future: experimental evidence from infinitely repeated games. *American Economic Review*, 1591–1604.

<sup>43</sup> Recent studies have shown variation in joint and individual liability with differing degrees of success (Maitra et al. 2013).

- Bono, P. (2010). Quotes on Microfinance. *World Vision Micro*. Available at <http://www.worldvisionmicro.org/downloads/quotes.pdf>. Web accessed on 31/11/14.
- Braverman, A., & Guasch, J. L. (1986). Rural credit markets and institutions in developing countries: lessons for policy analysis from practice and modern theory. *World Development*, 14(10), 1253–1267.
- Breza, E. (2012). Peer effects and loan repayment: Evidence from the krishna default crisis. Job Market Paper MIT.
- Cason, T. N., Gangadharan, L., & Maitra, P. (2012). Moral hazard and peer monitoring in a laboratory microfinance experiment. *Journal of Economic Behavior & Organization*, 82(1), 192–209.
- Cassar, A., Crowley, L., & Wydick, B. (2007). The effect of social capital on group loan repayment: evidence from field experiments. *The Economic Journal*, 117(517), F85–F106.
- Chu, M., & Cuellar, R. G. (2008). *Banco Compartamos: Life after the IPO*. Boston: Harvard Business.
- D'Espallier, B., Guérin, I., & Mersland, R. (2011). Women and repayment in microfinance: a global analysis. *World Development*, 39(5), 758–772.
- Daley-Harris, S. (2012). State of the Microcredit Summit Campaign Report. *Microcredit Summit Campaign*. Available at: <http://stateofthecampaign.org/2012-data/> Web accessed on 31/11/14.
- Duflo, E., Banerjee, A., Glennerster, R., & Kinnan, C. G. (2013). *The miracle of microfinance? Evidence from a randomized evaluation (No. w18950)*. National Bureau of Economic Research.
- Freixas, X., & Rochet, J. C. (1997). *Microeconomics of banking (Vol. 2)*. Cambridge: MIT Press.
- Gangopadhyay, S., Ghatak, M., & Lensink, R. (2005). Joint liability lending and the peer selection effect\*. *The 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., & Guinnane, T. W. (1999). The economics of lending with joint-liability: theory and practice. *Journal of Development Economics*, 60(1), 195–228.
- Giné, X., & Karlan, D. (2009). Group versus individual liability: Long term evidence from Philippine microcredit lending groups. Center Discussion Paper, Economic Growth Center.
- Giné, X., & Yang, D. (2009). Insurance, credit, and technology adoption: field experimental evidence from Malawi. *Journal of Development Economics*, 89(1), 1–11.
- Giné, X., Jakiela, P., Karlan, D., & Morduch, J. (2010). Microfinance games. *American Economic Journal: Applied Economics*, 2(3), 60–95.
- Guinnane, T. W. (1994). A failed institutional transplant: Raiffeisen's credit cooperatives in Ireland, 1894–1914. *Explorations in Economic History*, 31(1), 38–61.
- Hossain, M. (1988). *Credit for alleviation of rural poverty: The Grameen Bank in Bangladesh (No.65)*. International Food Policy Research Institute.
- Karlan, D. S. (2005). Using experimental economics to measure social capital and predict financial decisions. *American Economic Review*, 1688–1699.
- Karlan, D. S. (2007). Social connections and group banking. *The 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 (No. 61). IDE Discussion Paper.
- Kono, H. (2013). *Is Joint-liability a good enforcement scheme for achieving high repayment rates?: Evidence from framed field experiments in Vietnam*. Institute of Developing Economics: Mimeo.
- Kono, H. (2014). Microcredit games with noisy signals: contagion and free-riding. *Journal of the Japanese and International Economies*, 96–113.
- Kurosaki, T., & Khan, H. U. (2012). Vulnerability of microfinance to strategic default and covariate shocks: evidence from Pakistan. *The Developing Economies*, 50(2), 81–115.
- Laffont, J. J., & Rey, P. (2003). Moral hazard, collusion and group lending. IDEI Working Paper, 122.
- Lapenu, C., & Zeller, M. (2002). Distribution, growth, and performance of the microfinance institutions in Africa, Asia and Latin America: a Recent inventory. *Savings and Development*, 87–111.
- Maitra, P., Mitra, S., Mookherjee, D., Motta, A., & Visaria, S. (2013). *Agent Intermediated Lending: A New Approach to Microfinance (No. 16–13)*. Monash University, Department of Economics.
- Morduch, J. (1999). The microfinance promise. *Journal of Economic Literature*, 1569–1614.
- Olson, M. (1965). *The logic of collective action: Public goods and the theory of groups*. Harvard University Press.
- Polgreen, L., & Bajaj, V. (2010). India microcredit faces collapse from defaults. *New York Times*, 17.
- Putnam, R. D., Leonardi, R., & Nanetti, R. Y. (1994). *Making democracy work: Civic traditions in modern Italy*. Princeton University Press.
- Rahman, A. (1999). *Women and microcredit in rural Bangladesh: anthropological study of the rhetoric and realities of Grameen Bank lending*. Westview Press, Inc.
- Ravallion, M., Chen, S., & Sangraula, P. (2009). Dollar a day revisited. *The World Bank Economic Review*, lhp007.



- Schaefer-Kehnert, W. (1980). Success with group lending in Malawi. *Quarterly Journal of International Agriculture*, 19(4), 331–337.
- Stiglitz, J. E. (1990). Peer monitoring and credit markets. *The world bank economic review*, 4(3), 351–366.
- Stiglitz, J. E., & Weiss, A. (1983). Incentive effects of terminations: applications to the credit and labor markets. *The American Economic Review*, 912–927.
- Swibel, M. (2007). The world's top 50 microfinance institutions. *Forbes*. Available at: [http://www.forbes.com/2007/12/20/topphilanthropy-microfinance-biz-cz\\_1220land.html](http://www.forbes.com/2007/12/20/topphilanthropy-microfinance-biz-cz_1220land.html). Web accessed on 31/11/14.
- Todd, H. (1996). *Women at the centre*. Dhaka: University Press Limited.
- Townsend, R. M. (2003). Microcredit and mechanism design. *Journal of the European Economic Association*, 1(2–3), 468–477.
- Varian, H. R. (1990). Monitoring agents with other agents. *Journal of Institutional and Theoretical Economics*.
- Wydick, B. (1999). Can social cohesion be harnessed to repair market failures? Evidence from group lending in Guatemala. *The 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.
- Yunus, M. (1999). The Grameen Bank. *Scientific American*, 281(5), 114–119.
- Zeller, M. (1998). Determinants of repayment performance in credit groups: the role of program design, intra-group risk pooling and social cohesion. *Economic Development and Cultural Change*, 46(1), 599–620.