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Using Revenue Sharing for Higher Risk and Return Business Ventures in Microfinance: An Experimental Study

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Using Revenue Sharing for Higher Risk and Return Business Ventures in Microfinance: An Experimental Study

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Abstract: We report a group liability microfinance lab experiment that tests a mechanism to raise repayment rates among borrowers whose business plans carry higher exogenous risk and return. The mechanism is optional revenue sharing among the group of borrowers, agreed to before their individual business outcomes are realized and loan repayment decisions are made. Such revenue sharing makes loan repayment optimal under more business outcome states, thus increasing the expected benefit to each borrower of repayment to qualify for future loans. We further test the effect of allowing the borrowers to renege on revenue sharing agreements after learning their business outcomes, prior to making their loan repayment decisions. Our results illustrate the problem that exogenously higher risk/return borrowing groups achieve lower loan repayment rates than lower risk/return borrowing groups. We then find that introducing optional revenue sharing significantly increases the high risk borrowers' repayment rates, but that most of this gain is lost when successful borrowers can renege on revenue sharing agreements.

Keywords: Microfinance; Revenue sharing; Profit sharing; Risk; Adverse selection

JEL Classifications: G21; O16; O17; O43

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I. Introduction

First advocated by Muhammad Yunus in the 1970's, microcredit has seen enormous growth as a means of lending to low income people in developing countries. Microfinance organisations such as the Grameen Bank in Bangladesh, Women's World Banking, Unitus, Opportunity International and others are estimated to have reached between 150 and 200 million borrowers (Banerjee and Duflo 2011, p. 166), with numbers continuing to climb rapidly. While the exact rules and objectives of microcredit vary greatly across countries and organisation, its principal objective has been to secure credit for low income people whom commercial banks will not serve, at interest rates far below what private money lenders would charge.

Much of the genius of joint liability microcredit lies in its ability to transfer the costs of information gathering regarding the credit worthiness of small scale borrowers from lending organisation to the borrowers themselves. Individuals who seek loans to start or expand businesses can form borrowing groups with others they know, and be jointly liable as a group for regular repayment of an aggregate loan. Groups who successfully repay one loan are eligible to receive future loans, again at interest rates far lower than they could access individually. Borrowing groups are often required to meet and make repayment regularly. They thus keep informed about each other's progress and can support each other; successful members can temporarily "bail out" unsuccessful members if they judge the reason for repayment shortfall to be legitimate (exogenous). For their part, microfinance lenders need only ensure that approved borrowing groups repay an aggregate amount on schedule, greatly reducing the costs of due diligence and monitoring, and spreading the fixed costs of lending over fewer, larger aggregate loans. The potential benefit of microcredit is particularly large in societies where conventional lenders cannot rely on courts or other third parties to enforce repayment contracts. Contract enforcement relies instead on the social pressure and social norms for repayment that are fostered within borrowing groups, combined with pecuniary incentives for groups to remain eligible for future loans.

Microfinance has been extensively described and analyzed in the development literature, both to determine its effects on low income borrowers, and to identify explanations for those effects. Examples include the survey articles by Morduch (1999) and Brau and Woller (2004), a symposium on microcredit summarized by Hermes and Lensink (2011), and rigorous programme evaluations by Karlan and Zinman (2011), Angelucci, Karlan and Zinman (2015), Attanasio et al. (2015), Augsburg et al. (2015), Banerjee, et al. (2015), Crépon et al. (2015) and Tarozzi, Desai, and Johnson (2015).

One drawback of microfinance noted by Glennerster and Kinnan (2015), Karlan and Zinman (2011) and Banerjee and Duflo (2011) has been its lack of use by new business start-ups that involve high risk and return. For example, from surveys of slum neighbourhoods of Hyderabad India, Banerjee and Duflo (2011) found that even in areas served by three or more microfinance institutions, only about one fourth of families borrowed from them, while more than one half borrowed instead from money lenders. Reflecting on these findings, Banerjee and Duflo (2011) identify a tension between 'the spirit of microcredit' and 'true entrepreneurship.' They identify as potential culprits the formal requirements of common microfinance joint liability schemes, such as requiring repayment to start immediately following a loan (see also Field, Pande, Papp and Rigol (2013)), and the informal social norms within groups of 'zero default' that may work against entrepreneurs whose business ideas involve more than negligible risk. Fischer (2013) predicts that when borrowers can privately choose the degree of risk to undertake in their business ventures, and only imperfectly monitor the choices of other borrowers, joint liability alone gives them an incentive to "free ride", taking on *excessive* risk without compensating other borrowers. However peer monitoring, that implicitly grants other borrowers approval rights over the risks a borrower takes, can overcompensate for this, reducing risk-taking below what would occur in the absence of group liability. In other words, *ex ante* moral hazard might account for a tension between microfinance and risk taking. Alternatively, if potential borrowers are viewed as having (exogenously) fixed risk/return business ideas, then even under full information, liquidity constraints may cause people not to be able to bail out those in their borrowing groups whose high risk/return ventures have failed spectacularly. Adverse selection could then result in only homogenous low risk/return borrowing groups enrolled in microfinance schemes, either because borrowers do not want high risk people in their groups, or because microfinance lenders fear higher default rates from groups containing such borrowers.[1] Focussing on this adverse selection problem, a mechanism that could raise loan repayment rates among (exogenously) higher risk/return borrowing groups could result in the benefits of microfinance being available to would-be entrepreneurs whose business ideas carry greater risk and return.

In this paper, we propose a partial revenue sharing mechanism that could raise loan repayment rates achieved by groups composed entirely of higher risk/return borrowers. We design and implement a lab experiment to see if we can first illustrate the problem that such groups achieve lower loan repayment rates than lower risk borrowing groups, and then test whether our proposed mechanism can succeed in raising repayment rates in the high risk groups. We specifically allow

[1] At higher loan default rates, the microfinance lender must charge higher interest rates to cover costs, eliminating the benefit of microfinance over conventional money lenders.

borrowers (after a few periods of borrowing together) to bind themselves to revenue sharing. We finally consider the case where they can renege on such agreements after learning their earnings.

Although independently derived under full information and exogenous risk type, our partial revenue sharing proposal under group liability is similar in spirit to an "equity-like contract," or 100% revenue sharing, proposed by Fischer (2013) when comparing several types of individual and joint liability microfinance contracts under moral hazard. Our proposal is to add an option to group liability microfinance for each member to commit to share a fraction (20%) of their revenues (net of all costs but loan repayment) with each of the other borrowing group members. The individuals then learn how all of their individual businesses perform, and then decide whether to repay the aggregate loan according to a fixed repayment rule. If revenue sharing is agreed to and honoured after business outcomes are realized, it increases the amount that unsuccessful members can repay towards the loan, reducing the repayment shortfall that successful borrowers have to make up on their behalf. For their part, more successful borrowers then have downward adjusted current revenues when contemplating loan repayment, lessening their relative incentive to abandon current repayment vs. maintaining access to future loans. Revenue sharing agreements that are binding on borrowers even after they learn of their business outcomes can thus create a "virtuous circle", where it becomes in all members' abilities and interests to repay the loan under more business outcome states. In a repeated setting, increasing the number of states under which the group loan will be repaid in one period increases the value to members of ensuring that they collectively repay the loan in prior periods. This dynamic strengthening of repayment incentives exists even if the borrowing group is not immediately asked for the stronger commitment of revenue sharing in its earliest borrowing periods, when members have less experience borrowing with each other. Unfortunately, these strengthened incentives for higher risk/return borrowing groups to repay a loan could unravel if borrowers can renege on their revenue sharing commitments after learning how their individual businesses have fared, before deciding whether to repay the loan.

In our lab experiment we find effects consistent with our theory. Throughout, we use exogenous group assignment, between-subject comparisons, full information between borrowers, and assortative matching such that each borrowing group is composed entirely of high risk/return or low risk/return borrowers. We first capture the issue that groups of high risk/return borrowers have lower loan repayment rates than groups of low risk/return borrowers. We then find that higher risk borrowers achieve significantly higher loan repayment rates when they can choose to share revenues in later borrowing periods. Sadly however, we also find much of this increase in loan repayment rates

is lost when borrowers gain the option to renege on revenue sharing agreements once they learn their business outcomes, prior to making loan repayment decisions.

The remainder of the paper is structured as follows. In Section 2 we review papers using experimental methods to improve the design of microcredit. In Section 3 we summarize a simple game theoretic model of the loan repayment incentives of assortatively matched high and low risk borrowing groups, and how these incentives are affected by the ability to renege on revenue sharing agreements. In Section 4 we describe our experimental design, while Section 5 provides our results. In Section 6 we draw some conclusions from our findings.

II. Lab Experiments and the Design of Microcredit

A number of researchers have used lab or field experiments to compare the performance of microfinance under different contractual rules. At a general level, group liability microfinance can be thought of as a type of threshold public good (Bagnoli and Lipman 1989, Croson and Marks 2000), for which there is an extensive experimental literature (see, for example, Marks and Croson (1998) and Cadsby and Maines (1999)). We shall focus here, however, on experiments designed explicitly with microfinance in mind. Most test the relative performance of group vs. individual liability for loans, and two focus on how a borrower's (endogenous) choice of risk/return is affected by altering contractual rules. Perhaps reflecting the great variety of microfinance schemes used in practice, the design of microfinance experiments varies considerably between studies.

Abbink, Irlenbusch and Renner (2006a) examine the effects of group vs. individual liability, as well as of group size and social ties, on loan repayment rates. Borrowers make finite repeated repayment decisions over periods, and have to sit out remaining periods following default. Along with varying group size over three group liability treatments, Abbink et al. include a fourth treatment where subjects in groups of size 4 already know each other. They find that group liability outperforms individual liability, that larger groups re-pay less, and that stronger pre-existing social ties make little difference. They also find that loan repayment rates are higher than predicted by backward induction rates from the final period. In a related paper, Abbink, Irlenbusch and Renner (2006b) investigate the effect of varying the implicit interest rate charged on group repayment. They find that a higher repayment burden intensifies free riding within groups, though this is offset by the reduced capacity of groups to "afford" free riding before repayment collapses.

Seddiki and Ayedi (2005) use a framework somewhat like Abbink et al. (2006a), but with private information on investment outcomes, and in some treatments allow borrowers to investigate

another's investment outcome, and punish free riders if repayment would have been possible. Seddiki and Ayedi also differ in varying the revenues generated by each project, and the repayment required. As with Abbink et al. (2006a), Seddiki and Ayedi struggle to test the effect of punishment because repayment rates are already surprisingly high compared to theoretical predictions without it. They find the investigation/punishment option only modestly raises repayment rates (from 70% to 74%).

More recently, Cason, Gangadharan and Maitra (2012) use a broader lab implementation of microfinance to test theories of Chowdhury (2005) and Ghatak and Guinnane (1999), regarding group vs. individual liability, sequential vs. simultaneous repayment decisions, and the cost of monitoring other borrowers. To capture the moral hazard of repayment under incomplete information, borrowers can choose between an investment with a larger return that is verifiable by monitoring, and so liable for loan repayment, or a hidden investment with a smaller return that is not externally verifiable, and not claimable for loan repayment. In group treatments, subjects are randomly re-matched with others and continue for 40 periods. Cason et al. find that group and individual loan liability work equally well when the cost of monitoring borrower behaviour is equivalent, but that group liability dominates when groups can monitor borrower behaviour more cheaply than lenders.

Moving away from joint vs. individual liability, Baland, Gangadharan, Maitra and Somanathan (2013) use lab experiments to investigate whether enabling borrowing groups to exclude repayment free riders from associated public goods raises loan repayment rates. They find that degree of gain from the associated public goods does indeed explain variation in individual repayment decisions.

More relevant to our study, two recent papers have considered variation in microfinance design to improve its ability to facilitate higher risk/return investments, though with incomplete information and endogenous choice of risk. The first, a field experiment by Field, Pande, Papp and Rigol (2013) varies the grace period between when group liability microfinance loans are made and repayment must start, to either two weeks or two months. Field et al. (2013) conduct the experiment in Kolkata, India, and find that the longer grace period increase microenterprise investment by 6.0 percent, and double the likelihood of borrowers starting new businesses. This resulted in substantially higher weekly profits and household income three years later. Conversely however, higher risk-taking by borrowers in the longer grace period treatment led to a tripling of their short run default rates.

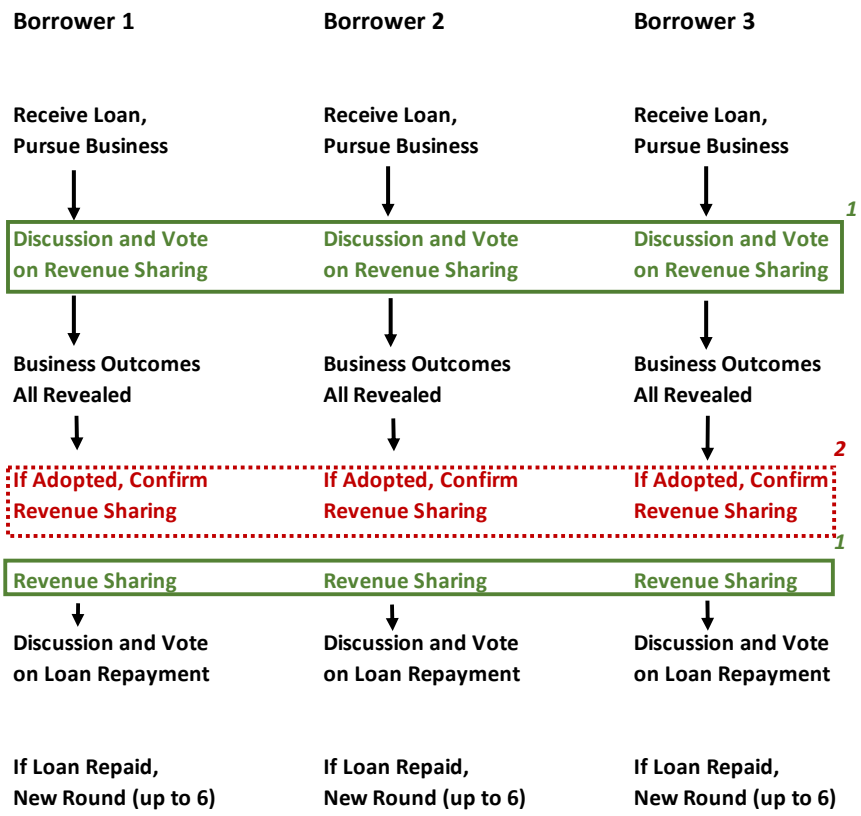
Second, a wide-ranging evaluation of microfinance liability design has been by conducted by Fischer (2013). Concerned by evidence that existing businesses funded by microfinance often do not grow in size or profitability, Fischer models the risk choice/investment and repayment decisions of borrowers under five increasingly intertwined loan contract structures: autarky, individual liability

with voluntary transfers (bail outs) to other borrowers, joint liability, joint liability requiring approval of other's investment decisions, and 100% revenue sharing (an "equity-like contract"). In exogenously assigned groups of two, each borrower/investor must decide 1) what fraction of his/her capital to invest in a safe investment, vs. one with higher risk and expected return, and 2) how much of the resulting returns to transfer to the other borrower (to help him or her repay loans, or to compensate for the sender's risk taking). Under Fischer's design, the riskiness of each borrowing group is determined endogenously by the decisions of the two people within it. He tests abstract versions of these 5 contract structures in an artefactual field experiment with women enrolled in microfinance programmes in Chennai, India. Relevant here, Fischer includes complete (100%) revenue sharing as a "counterfactual" to contrast with structures actually used in microfinance, but nonetheless he finds that it successfully induces borrowers to choose higher risk/return investments (and thus higher profits on average). It also results in the lowest loan default rates of his 5 contract designs. While Fischer's full revenue sharing mechanism makes the strong assumption that it is perfectly enforceable by a third party, he nonetheless finds the results promising enough to suggest that revenue sharing contracts merit further exploration. While differing in significant ways from Fisher's design (i.e. addressing adverse selection rather than moral hazard, with full information, exogenous risk/return, homogeneous groups, and partial revenue sharing), this is what we do here.

III. Partial Revenue Sharing

Consider borrowing groups containing N = 3 individuals whose business plans each require loan funding, and whose outcomes have independent but identically distributed risk and return profiles. Because we are focussed on revenue sharing's effect on repayment with liquidity constraints, rather than its effect on choice of risk, we assume individuals are risk neutral, with full information on the outcomes of their own and other's businesses and decisions as they become revealed. The sequence of decisions individuals face is illustrated in Figure 1. After receiving loan funding to pursue their businesses, each borrower *i*'s business will generate either high net benefits $b_{i,H}$ with probability p, or low net benefits $b_{i,L}$ with probability $(1-p)$. We assume an individual can fully repay his or her single loan if revenues turn out to be b_{iH}, but not if they turn out to be $b_{i,L}$. Groups contain either all 'high risk/return' or all 'low risk/return' borrowers, where each of the former has a lower probability of being successful p_{iH}, but a higher net benefit b_{iH} if successful and a lower net benefit b_{iL} if not.

With group liability for repayment, the three borrowers must pay back a combined amount W, equivalent to three individual loans. For both high risk and low risk borrowing groups, we assume



Baseline treatments include steps in unboxed sections.

[1] Revenue sharing treatments also include steps in solid boxes.

[2] Revenue sharing with renege treatments also include steps in solid and dashed boxes.

Figure 1: Sequence of Decision Making.

individual earnings in the high (b_{iH}) and low ($b_{i,L}$) cases are sufficiently high relative to W that the group can repay W if even one member earns b_{iH}. Successful borrowers in groups with unsuccessful borrowers would need to 'bail out' the latter out for group loan repayment to occur. That is, they would need to top up the loan repayment of less successful members to just achieve W repayment. If W is repaid by the group in period t, it is then eligible for another period of business activity at the favourable interest rate in t+1, and so on up to a known terminus T. If W is not repaid, each borrower retains b_i (and earnings from previous periods), but no further loans are made available, such that no further business activity is possible. We assume borrowers are liquidity constrained with a 'stationary repetition' design in which they can only use current period funds to repay the current period loan.

Intuitively, groups containing all high risk/return borrowers will be less likely to repay a total loan than groups containing all low risk/return borrowers. This is in part simply because the case is more likely where all borrowers 'fail' and so cannot afford to repay the loan $((1-p_{iH})^3 > ((1-p_{iL})^3)$. In addition, even when some borrowers succeed in their businesses, they would face a higher cost of

bailing out the larger repayment shortfalls of failed high risk borrowers than of failed low risk borrowers. Finally, compared to successful low risk borrowers, successful high risk borrowers could retain larger current period revenues by refusing loan repayment, so that the temptation to default and forgo future loans would also be higher. All three factors would lead to higher loan default rates in high- vs. low risk/return borrowing groups. Thus, even without asymmetric information and moral hazard, researchers might observe few high risk/return borrowing groups in microfinance.

To explore repayment incentives more formally, and to see how revenue sharing can change these incentives, we introduce some additional structure. We denote the net revenue that borrower *i* can expect to earn from his/her group accessing a group loan in period t as π_{it} , and the borrowers as Player 1, Player 2, and Player 3 (P1, P2, P3). We denote the business earnings outcome of the three borrowers as (HHH) if all earn high benefits, (LLL) if all earn low benefits, (HLL) if P1 succeeds while P2 and P3 fail, and so on. We assume that a borrowing group must unanimously agree to a specific loan repayment rule for it to be implemented. The repayment rule they accept or decline is that borrowers each pay w_i = W/3 if $b_i \geq$ W/3 for *i* = 1, 2, 3. Otherwise, liquidity constrained borrowers for whom b_i < W/3 repay all that they can (b_i), while borrowers for whom b_i > W/3 make up the shortfall, split symmetrically if there are two successful borrowers helping one failed borrower.

III.1 Expected Payoffs

The incentives to repay the loan depend on the business outcomes of the three borrowers in the group. There are eight possible outcome cases with associated probabilities which are listed in Table 1. We denote an indicator variable $c_i \in [0,1]$ for whether an individual votes to repay the loan, where *c=1* if he or she votes to repay, and 0 otherwise. c_i is assumed to depend on the group's business earnings outcomes for that period. With a unanimity voting rule, we denote a group indicator variable $C_{ijk} = \min(c_i, c_j, c_k)$, where *i,j* and *k* index the three individuals in the group and which we will often replace with their outcomes L or H. C_{ijk} will thus be equal to one if and only if all of the members of the group vote to pay back the loan, and zero otherwise.

Note that in the event that all three businesses yield low returns, (LLL), the group could not repay the loan and so each individual would just retain his or her business earnings. Before knowing business outcomes, the expected payoff to borrower i from accessing a loan in a period is

$$
\begin{aligned}
E\left(\pi_i(c_i, c_j, c_k)\right) &= p^3(b_{iH} - wC_{HHH}) + 2p^2(1-p)\left(b_{iH} - \left(w + \frac{w - b_L}{2}\right)C_{HHL}\right) \\
&+ p(1-p)^2\left(b_{iH} - \left(w + 2(w - b_L)\right)C_{HLL}\right) + p^2(1-p)(b_{iL} - b_{iL}C_{LHH}) \qquad (1) \\
&+ 2p(1-p)^2(b_{iL} - b_{iL}C_{LLH}) + (1-p)^3(b_{iL}).
\end{aligned}
$$

Table 1 Payoffs and Probabilities by Outcome

Outcome	Payoff	Probability
HHH	$b_{iH} - wC_{HHH}$	p^3
HHL or HLH	$b_{iH} - \left(w + \frac{w - b_L}{2}\right) C_{HHL}$	$2p^2(1-p)$
HLL	$b_{iH} - \left(w + 2(w - b_L)\right) C_{HLL}$	$p(1-p)^2$
LHH	$b_{iL} - b_{iL} C_{LHH}$	$p^2(1-p)$
LLH or LHL	$b_{iL} - b_{iL} C_{LLH}$	$2p(1-p)^2$
LLL	b_{iL}	$(1-p)^3$

Note that from the borrower's perspective, the group repayment indicator C always enters the expected payoff function (1) negatively, and so the solution to the one-shot game is to never vote to repay the loan. In our experiment, this would correspond to the subject's decision in the final (sixth) loan period. The expected payoff from accessing a loan at the start of period six then becomes:

$$E\left(\pi_{i6}(0)\right) = p^3(b_{iH}) + 2p^2(1-p)(b_{iH}) + p(1-p)^2(b_{iH}) + p^2(1-p)(b_{iL}) + 2p(1-p)^2(b_{iL}) + (1-p)^3(b_{iL}) \quad (2)$$

Social preferences or moral obligation aside, pecuniary incentives to repay the loan come from the repeated nature of the game, whereby individuals forfeit future period microfinance loans if they do not repay the current one. Equilibria can be identified by backwards induction. In period 5, given the business outcomes realized, an expected profit maximizing borrower will vote to repay the loan if and only if the expected payoff to the loan being repaid in the current period plus the expected payoff to continuing to period 6 exceeds the benefits from defaulting in period 5:

$$E\left(\pi_{i5}(1)\right) + E\left(\pi_{i6}(0)\right) > E\left(\pi_{i5}(0)\right) \quad . \quad (3)$$

Note that for borrowers the expected payoff to not repaying the loan is certain while the payoff to repaying the loan is uncertain.[2] Equation (3) can be rewritten to say borrower *i* will vote to repay if the cost of doing so in period 5 is less than the expected benefit of receiving a loan in period 6:

$$E\left(\pi_{i5}(0)\right) - E\left(\pi_{i5}(1)\right) < E\left(\pi_{i6}(0)\right) \quad . \quad (4)$$

[2] While we assume borrowers are risk neutral, the uncertainty that results from choosing loan repayment would in general make risk averse borrowers less likely to choose to repay the loan.

From (4), the decision to repay the period 5 loan depends crucially on the amount *i* is called upon to repay. As shown in Table 1, that repayment cost will be highest for a borrower who turns out to be successful, who is in a group with two other borrowers who turn out to be unsuccessful.

The repayment condition (4) can be generalized to earlier periods. In period 4 the required repayment must be less than the expected payoff of continuing to a fifth loan period. That expected payoff from reaching period 5 depends on the borrowers' expectation of whether the period 5 loan itself will be repaid, enabling continuation to period 6:

$$E\big(\pi_{i4}(0)\big) - E\big(\pi_{i4}(1)\big) < E(\pi_{i5}) \tag{5}$$

where: $E(\pi_{i5}) = \begin{cases} E(\pi_{i5}(0)) \\ E\big(\pi_{i5}(1)\big) + E(\pi_{i6}(0)) \end{cases}$.

This repayment decision rule generalizes to requiring in period t that:

$$E\big(\pi_{it}(0)\big) - E\big(\pi_{it}(1)\big) < \begin{cases} E\big(\pi_{it+1}(0)\big) \\ \sum_{k=t+1}^{5} E\big(\pi_{ik}(1)\big) + E\big(\pi_{i6}(0)\big) \end{cases}, t < 6 \tag{6}$$

Since the expected earnings in each period are non-negative ($E\big(\pi_{ik}(1)\big) > 0 \; \forall k$), the benefits from repaying the loan to secure continuation are increasing as we move backwards to period 1. Whether or not theory predicts that the group will repay the loan depends on the parameterization. Below we fix parameters under which groups who experience HLL/LHL/LLH in particular are never predicted to repay the loan in high risk/return borrowing groups, but always predicted to do so in low risk/return borrowing groups. Details underlying the demonstration are provided in Appendix A.

III.1a. High Risk vs. Low Risk Group Payoffs Without Revenue Sharing

We assume that for each member of a high risk borrowing group b_{iH} = 820, b_{iL} = 80, and the probability of business success is p = .5. We set the total group loan repayment for high risk groups at W = 900, ensuring loan repayment is possible for all group outcomes other than (LLL). With the probability of success independent across borrowers, repayment would be feasible on average 87.5% of the time (=1 - (1 – .5)^3). To illustrate how loan repayment would work with a key example, if earnings outcomes turn out to be (HLL), the repayment rule that borrowers would vote on would require unsuccessful P2 and P3 to repay the maximum they can, 80 each, while successful P1 must pay 300 + 220 + 220 = 740 from his earnings of 820.

With these parameters, from (2) the expected profit from receiving a loan in period 6, $E(\pi_{i6}(0))$=450. For successful P1 of the (HLL) group, the equation (5) comparison is 740 vs. 450, indicating he will vote not to repay the loan in period 5. In contrast, if the group had instead had two successful borrowers in period 5, the cost to each of repayment (410) would be less than the expected profit from continuing to period 6, so that each would vote to repay the loan in period 5. Still more would individuals in groups with all successful borrowers vote to repay the loan, since the repayment cost would fall to 300. With groups containing two or more successful borrowers voting to repay the loan, the expected benefit to any individual of reaching the start of period 5 is 525. Returning our focus to (HLL) groups, working backwards to period 4, P1 will find 740 exceeds 525, and so will again vote not to repay the loan. Working analogously backwards to period 1, the expected benefit to borrowers of continuing to the start of period 2 is 595.3. Thus, even in period 1, where the expected benefits of continuation are greatest, the sole H in a high risk HLL group will find them insufficient to outweigh the immediate cost of loan repayment (740). In contrast, while the sole H in a HLL/LHL/LLH group is never predicted to vote for loan repayment, an H in an HHL/HLH/LHH group is always predicted to vote for repayment other than in the terminal period, since the benefit exceeds the cost in period 5 (450 vs. 410), and will further exceed it in earlier periods. Even stronger repayment incentives hold for an H in an (HHH) borrowing group, since the repayment cost (300) is in all periods 1 - 5 lower than the benefit of continuation. Similarly, in all but the terminal period, borrowers with L outcomes are always predicted to vote for loan repayment, since they face even lower costs (80) relative to the benefit of continuation. Thus, for all but period 6, under our parameters high risk borrowing groups containing two or more successful borrowers are predicted to achieve loan repayment, while groups containing two or more unsuccessful borrowers are predicted to default. See Appendix A for further detail.

Moving instead to low risk/return borrowing group parameters, we assume that for each individual b_{iL} = 270, b_{iH} = 420, and the probability of success is higher, at p = .6. With the probability of an (LLL) outcome reduced from 12.5% to 6.4%, we assume the microcredit lender can charge a lower implicit interest rate to cover costs, such that the group loan repayment costs W = 840.[3] Equal share loan repayment would then be W/3 = 280.

With these parameters, the expected payoff from reaching period 6, $E(\pi_{i6}) = 360$. Should an (HLL) outcome occur in period 5 for a low risk/return borrowing group, the successful P1 will face

[3] We originally set W = 840 for both low and high risk borrowing groups, but raised it for high risk groups to dampen surprisingly high loan repayment rates in our control. "Excess" loan repayment relative to expected payoff maximisation is a common finding in microfinance lab experiments (Seddiki and Ayedi (2005), Abbink et al. (2006a)).

a comparison in equation (5) of 300 vs. 360, indicating he will vote to repay the loan in period 5. With the benefits of continuation increasing in earlier loan periods, he will also vote to repay in all earlier periods. Successful borrowers in groups containing two H's are also predicted to vote for repayment in all cases, since the expected benefit of continuation is the same, while the individual cost of loan repayment is lower. Similarly, unsuccessful borrowers are always predicted to vote for repayment, as the cost of repayment is lower still. Thus, for all but period 6, under our parameters low risk borrowing groups containing one or more successful businesses are predicted to repay the loan. Again, see Appendix A for more detail. This leads us to our first hypothesis under these parameters:

Hypothesis 1: High risk borrowers are less likely to repay the loan than low risk borrowers. This is driven by H borrowers in high risk HLL outcome groups voting not to repay the loan, in contrast to H borrowers in low risk HLL outcome groups voting to repay the loan.

III.1b High Risk vs. Low Risk Group Payoffs With Revenue Sharing

One way to reduce the immediate loan repayment costs required of borrowers who turn out to earn high revenues when others do not is to introduce the option for groups to pre-commit to share revenues before knowing business outcomes, and then having revenues redistributed (as committed) before borrowers face the loan repayment decision. This is illustrated by the two additional boxed steps in Figure 1. In groups that have unanimously decided to revenue share *ex ante*, borrowers who turn out to receive low business revenues have them adjusted upward, and can thus repay more or all of their equal share of W, while those who turn out to receive high business revenues have them adjusted downward, but are then required to repay less on behalf of unsuccessful borrowers.

An interesting feature of revenue sharing in this dynamic setting is that it can increase the reward from loan repayment and continuation in early periods *even if it is not made available to borrowers until later periods*. This could be helpful if, for example, the members of newly formed borrowing groups do not trust each other enough to commit to share revenues until they gain some experience borrowing together, using the lesser commitment of the optional bailouts already described. We consider the case where borrowers can vote whether to share 20% of their earnings revenues with each of the other two borrowers, prior to periods 3, 4 and 5, but not periods 1 or 2, nor the terminal period 6. Note that this partial sharing differs from the full equity contract studied by Fischer (2013) where effectively all revenues are pooled and equally divided.

In more detail, in a group that has unanimously voted to share revenues, borrower 1 will share 40% of his business revenues, but receive 20% of borrower 2's and borrower 3's business revenues. This can be expressed as borrower *i*'s initial business revenues being adjusted by a scalar *a*, where

$$ab_i = b_i - .4b_i + .2b_j + .2b_k,\ i \neq j \neq k. \quad (7)$$

Clearly, this adjustment has no effect (or a = 1) in cases where all borrowers earn the same initial revenue (HHH or LLL). Thus (LLL) groups still cannot afford to pay back the loan even with profit sharing. After revenue sharing, unsuccessful borrowers may be able to fully pay back their equal share of the loan, or may still require a more limited bail out.

Revenue sharing reduces the required amount of further repayment from successful borrowers, which should increase the likelihood of their group repaying the loan and continuing to an additional period. Having repayment be optimal under more business outcomes states therefore raises the expected future profit from current loan repayment, and may thus increase equilibrium future expected profits, in which case revenue sharing will be unanimously adopted if available. To illustrate, for high risk/return borrowing groups who adopt revenue sharing prior to learning their outcomes in period 5, the lone successful P1 borrower in an (HLL) case will now have adjusted revenue of 820 - .4(820) + .2(80) + .2(80) = 524, while his unsuccessful colleagues' adjusted revenues will each be 80 - .4(80) + .2(820) + .2(80) = 228. The loan repayment cost demanded of the lone successful borrower would reduce to 300 + 72 + 72 = 444, which as in equation (4) is now less than the 450 expected payoff from continuation to the final period. Thus, if revenue sharing is adopted in period 5, even high risk HLL/LHL/LLH groups would now be expected to repay the loan in that period. With revenue sharing adopted at the start of period 5, the expected value of reaching that period is the expected payoff from within the period ($E(\pi_{i5})$) plus the expected payoff from period 6 ($E(\pi_{i5})$) multiplied by the probability of getting to period 6 ((1- (the probability of LLL))):

$$E(\pi_{i5}) + .875E(\pi_{i6}) = 0.125(520) + .25(372) + .125(80) + .125(76) + .25(0) + .125(80)$$

$$+.875(450) = 187.5 + 393.75 = 581.25 \quad (8)$$

Thus, before learning their period 5 business outcomes, high risk borrowers will all achieve higher expected profits by choosing to revenue share (581.25) rather than not (525, as we saw previously). Moving backwards to period 4, since the expected payoff from continuation increases in earlier periods, it is in subjects' best interests to vote for repayment in all of the cases they voted for repayment in period 5. And, since in each previous period the expected future profits are higher by voting to revenue share rather than not, revenue sharing will be unanimously chosen whenever available. As before, fuller details are provided in Appendix A. This leads us to Hypothesis Two:

Hypothesis 2: The option to revenue share will raise loan repayment rates for high risk borrowers. This is driven by high risk borrowers voting to revenue share, and then H borrowers in HLL/LHL/LLH outcome groups voting to repay the loan, unlike when revenue sharing is not available.

In contrast to high risk groups, revenue sharing may not offer much to low risk borrowers, at least under parameters where they already have incentives to repay the loan if at all possible. We include it for completeness, however. To illustrate, for low risk/return borrowing groups who adopt revenue sharing prior to learning their outcomes in period 5, a lone successful P1 borrower in an (HLL) case will now have adjusted revenues of 420 - .4(420) + .2(270) + .2(270) = 360, while the two failed borrowers will each have adjusted revenues of 270 - .4(270) + .2(420) + .2(270) = 300. The expected payoff from reaching period 6 would remain $E(\pi_{i6}) = 360$, while the loan repayment cost for the lone H of a group is only his own equal loan share 280. Thus with revenue sharing, the H of an (HLL) group will find it in his interest to vote to repay the loan, just as he would have without revenue sharing. Optimal loan repayment voting decisions would be identical in earlier periods, and in all cases the expected value from continuation would be identical, with or without revenue sharing. Under these parameters, we would expect low risk borrowers to vote to repay the loan whenever it is feasible to do so, and be indifferent between revenue sharing and not. See Appendix A for more details.

Hypothesis 3: The option to revenue share does not affect the repayment rate of low risk borrowers.

III.1.c Breaking of Revenue Sharing Agreements

A plausible objection can be raised that microfinance offers the greatest benefit to borrowers in precisely those developing countries where contracts are not readily enforceable by third parties. (Lack of contract enforcement is one of the reasons commercial banks will not lend to low income people.) In such environments, even with full information as to business outcomes, what is to stop borrowers from agreeing to revenue share *ex ante*, but then reneging on this agreement if it turns out they will have to be net contributors (a<1)? Unfortunately, the ability of revenue sharing agreements to strengthen loan repayment incentives for high risk borrowing groups may depend crucially on whether such agreements can be kept binding even after business outcomes are revealed.

The possibility of reneging on revenue sharing agreements should not be relevant for high risk borrowing groups when all members turn out to earn high revenues, since individual revenues are then unaffected by sharing. For successful borrowers in groups with HHL/HLH/LHH outcomes, in period 5 it will remain in their best interest to repay the loan and continue to period 6 whether they revenue share or not, since the expected payoff to repayment is 410+450=860 without revenue sharing, which is greater than retaining all current revenues 820, or 372+450=822 with revenue sharing, which is greater than retaining the downward adjusted 664. While in either case it remains in successful borrowers' interests to repay the loan, the expected benefit of continuation is now lower if revenue sharing is honoured than if it is not, giving successful borrowers an incentive to renege. The

same is true in earlier periods. Thus groups that turn out to have two successful borrowers should still repay the loan, but the two successful borrowers will both renege on revenue sharing agreements. Finally, for lone successful borrowers in groups with HLL/LHL/LLH outcomes, the option to renege remains not only attractive, but also changes loan repayment incentives. As we already saw, in period 5 without revenue sharing, the sole high revenue earner will opt not to repay the loan and earn 820. With revenue sharing agreed to and honoured, the high revenue earner would then opt to repay the loan but earn on average only 80+450=530 and so again be better off choosing to renege on revenue sharing and then voting not to repay the loan. That is, allowing high risk borrowing groups to renege on revenue sharing agreements undermines their value by returning loan repayment incentives to what they were in the absence of revenue sharing. There, high risk groups choose not to repay the loan in groups with only one high successful borrower. This leads to the two final hypotheses, with further details in Appendix A.

Hypothesis 4: The option to revenue share and renege reduces the repayment rate for high risk borrowers. This is driven by changes in repayment rates for groups with HLL/LHL/LLH outcomes.

Hypothesis 5: The option to revenue share and renege reduces the repayment rate for high risk borrowers to the levels observed without the option to revenue share.

Predictions from our theory, expressed at group outcome level, are summarized in Table 2.

IV. Experimental Design

We run five experimental treatments in a between-subject design.

1) low risk borrowing groups without revenue sharing (LR),

2) high risk borrowing groups without revenue sharing (HR),

3) low risk borrowing groups with revenue sharing available (LRRS),

4) high risk borrowing groups with revenue sharing available (HRRS),

5) high risk borrowing groups with revenue sharing available and renege (HRRSR).

Comparing LR to HR loan repayment rates for all group earnings outcomes, or the pivotal HLL/LHL/LLH case in particular, can verify whether our implementation can capture an adverse-selection type explanation for why high risk/return borrowing groups would have higher loan

Table 2: Summary of Theory Predictions for Group Outcomes Periods 1-5

Treatment	Loan Repayment	Overall Group Repay Rate (%)	Choose Rev Sharing?	Confirm Rev Sharing?
High Risk – Baseline	Yes for (HHH), (HHL/ HLH/LHH) Groups; No for (LLL), (LLH/ LHL/HLL) Groups	50.0%		
High Risk – Rev Share	Yes for (HHH), (HHL/ HLH/LHH), (LLH/LHL/ HLL) Groups; No for(LLL)	87.5%	Yes	
High Risk – Rev Share w Renege	Same as High Risk Baseline	50.0%	Indifferent	Renege if L's in group
Low Risk – Baseline	Yes for (HHH), (HHL/, (HLH/LHH), (HLL/LHL/ HLL) Groups; No for (LLL)	93.6%		
Low Risk – Rev Share	Same as Low Risk Baseline	93.6%	Indifferent	

default rates than low risk/return borrowing groups (Hypothesis 1). Comparing HRRS to HR repayment rates tests whether adding the option to revenue share raises loan repayment rates (Hypothesis 2). Comparing HRRSR to HRRS similarly tests whether the option to renege lowers repayment (Hypothesis 4). For completeness, comparing LRRS to LR can test whether revenue sharing leaves loan repayment unchanged for low risk borrowers (Hypothesis 3), while comparing HRRSR to HR can test whether the renege option specifically brings high risk group loan repayment rates to what they were without the revenue sharing option (Hypothesis 5).

For each treatment, (different) subjects are recruited for computerised sessions each containing 18 participants. We run three sessions for each treatment involving high risk borrowers (with 54 participants in each), and two sessions for treatments involving low risk borrowers (with 36 participants in each).

In a given session of any treatment, subjects read instructions and see a summary Powerpoint presentation, and are then randomly assigned into 6 borrowing groups of three members each. As in

Figure 1, the members of each borrowing group then receive a loan, which they put towards an individual "business venture" that may yield high or low revenues (420 vs. 270 tokens in low risk treatments, with a 60% probability of high revenues, and 820 vs. 80 tokens in high risk treatments, with a 50% probability of high revenues). After learning how their own and the other two's business ventures have performed, group members vote whether to repay 840 tokens (low risk) or 900 tokens (high risk) to qualify for an additional period of loans and business activities. Each 100 tokens accumulated corresponds to 80 New Zealand cents. Loan repayment costs are assigned to each subject using the fixed rule described earlier: borrowers pay back an equal share if possible, otherwise they pay all they can (from current period revenues), with successful borrowers making up any shortfall, equally borne if two succeed. Loan repayment required unanimous agreement, and borrowers could communicate within their groups by typed chat prior to voting. In all cases, loan repayment is possible for groups containing at least one successful earner. A given group can take part in up to 6 periods of loans/business activity, with the 6th period known *ex ante* to be terminal.

After one 'set' of up to 6 periods, subjects are reassigned to new groups such that each person now has two new people in his/her borrowing group. These new groups can again take part in up to 6 periods of activity in the second set. Subjects are then reassigned again, and the new groups take part in up to 6 periods of a third and final set. Subjects never have the same group member with them for more than one set.

This sequence of receiving a loan, learning business outcomes, and then chatting and voting on loan repayment holds true for all treatments, as in the unboxed steps of Figure 1. In treatments with revenue sharing, extra steps are added for periods 3, 4 and 5 of a set, with subjects first chatting and voting whether or not to "commit" to share 20% of their business revenues with each of the other two borrowers. As with loan repayment decisions, unanimity is required for revenue sharing to take place. If revenue sharing is rejected, a period proceeds just as if revenue sharing were not available. If revenue sharing is adopted, then after business outcomes are realized individual revenues are adjusted. The loan repayment required of each borrower is adjusted accordingly prior to the loan repayment chat and vote. Focussing on the pivotal case of high risk groups where only one business succeeds (e.g. P1's), loan repayment would look as follows without and with revenue sharing:

Without Revenue Sharing			
	P1	P2	P3
Revenue	820	80	80
Repayment	740	80	80
Period Profit	80	0	0

With Revenue Sharing			
	P1	P2	P3
Adjusted Rev	524	228	228
Repayment	444	228	228
Period Profit	80	0	0

Finally, in the HRRSR treatment where reneging is possible, if a group unanimously votes to revenue share, an additional "confirmation vote" is required after business outcomes are realized, as in the red step in Figure 1. There is no chat prior to the confirmation decision. In choosing the wording to describe this decision in the instructions, we tried to strike a balance between avoiding overly loaded language, yet still recognizing that reneging breaks an implicit contract. To do this, in all cases we describe the revenue sharing vote as "committing" to revenue share. In the HRRSE treatment with renege, we use the language of "confirming" the revenue sharing decision, and super-impose the words "Yes, Confirm" and "No, Refuse After All" on the voting buttons.

Before moving to results, we also describe several design features we added after running early pilot sessions not included in the results we report. Similar to some previous microfinance experiments (Seddiki and Ayedi (2005) and Abbink et al. (2006a)), we found an unexpectedly high proportion of lone successful borrowers voting to repay the loan even without revenue sharing. This is perhaps because revenue outcomes are randomly determined rather than 'earned' via effort. While this "excess cooperation" might be of interest in its own right, it provided no potential for revenue sharing to raise repayment rates. We therefore added the following design features to reduce baseline cooperation. First, we added a tournament component to subject earnings, such that the highest 6 of 18 token earners in each session would earn an additional $12. Second, we raised the total loan repayment cost for high risk groups from 840 to 900. Third, in the instructions we emphasized individual achievement in the business ventures, rather than group success in repaying loans. Finally, we reduced the "boredom cost" that subjects would impose on themselves and other group members if they vetoed loan repayment and sat out the remaining periods of a set. We provided a Word Search, two Sudoku puzzles, and a university student magazine at each workstation.

V. Experimental Results

Thirteen sessions of the experiment were run at the University of Canterbury in New Zealand, with 234 participants in total. Three sessions were conducted in September 2015, and the remaining ten in March and April of 2016. Treatment sessions were run in rotating order.[4] They took on average 75-90 minutes, and subjects earned NZ$23.38 on average (NZ$1 = US$.70).

We shall examine decisions at the level of individual voting, as well as at group outcome. As predicted by standard game theory, groups generally did not repay the loan in the terminal period,

[4] In particular, we ran sessions in the treatment order HR, HRRS, LR in 2015, then LRRS, HRRSR, HR, HRRS, LR, LRRS, HRRSR, HR, HRRS, HRRSR in 2016.

despite our use of "loan" and "repayment" language in our instructions. Across all treatments, of the 64 groups still making loan repayment decisions by period 6 of a set, only 3 repaid the loan (a 4.7% repayment rate).[5] Of the 192 individuals in these groups, a higher proportion voted to repay (36, or 18.8%), but were vetoed by others under the unanimity voting rule. We shall thus focus on subjects' behaviour in periods 1-5 of each set.

Our approach will be to present results first with regards to loan repayment, then to revenue sharing, and finally to reneging on revenue sharing agreements. We will formally test for differences between relevant treatments using Mann Whitney tests, and by comparing the coefficients on treatment dummies in pooled cross section regressions that are presented in Appendix B.[6]

V.1 Loan Repayment

A difficulty with analysing individual or group outcomes at period level is that those borrowing groups who are more cooperative in repaying the loan continue for more periods in each set, and thus become over-represented in later periods of each set. To avoid this problem, we construct loan repayment rates (or other outcomes of interest) for each group or individual at set level. For loan repayment rates for groups, for example, we divide the number of periods a given group in a given set unanimously voted to repay, by the number of periods where they could repay. To illustrate, a group who avoided (LLL) earnings outcomes for four periods, and repaid the loan for the first three of these before refusing on the fourth, would have a repayment rate of 3/4 =.75. Whereas a group who repaid the loan in the first three periods, but then could not repay in period 4 due to (LLL) business outcomes, would have a repayment rate of 3/3 = 1. In addition, given that group repayment rates are predicted to depend on group earnings composition in a way that is independent of period, we also construct repayment rates conditioned on earnings composition. For example, we define the repayment rate of a group experiencing HLL/LHL/LLH outcomes as the number of periods in a set that the group experienced such outcomes and repaid the loan, divided by the number of periods it experienced such outcomes. Similarly, for individual loan repayment voting decisions, we construct analogous set-averaged rates. These too can be contingent on the earnings status of the person casting the vote, as well as of the two other members in his/her group. For example, how many of the times in a set did subjects who experienced an H outcome when the two other group members experienced L outcomes, vote to repay the loan? We illustrate our group repayment rates in Figure 2, both for

[5] 6 additional groups "survived" to period 6 of a set, but earned (LLL) so could not repay or vote. Thus across all treatments and sets pooled, 70 out of a possible 234 groups, or 29.9% survived to the start of period 6.
[6] These regressions include set dummies and demographic variables. Some demographic variables furthest from significance were dropped. See Appendices 1 and 2.

groups overall and for those pivotal groups containing only one successful business. We also illustrate individual voting rates for sole successful borrowers when with two unsuccessful borrowers.

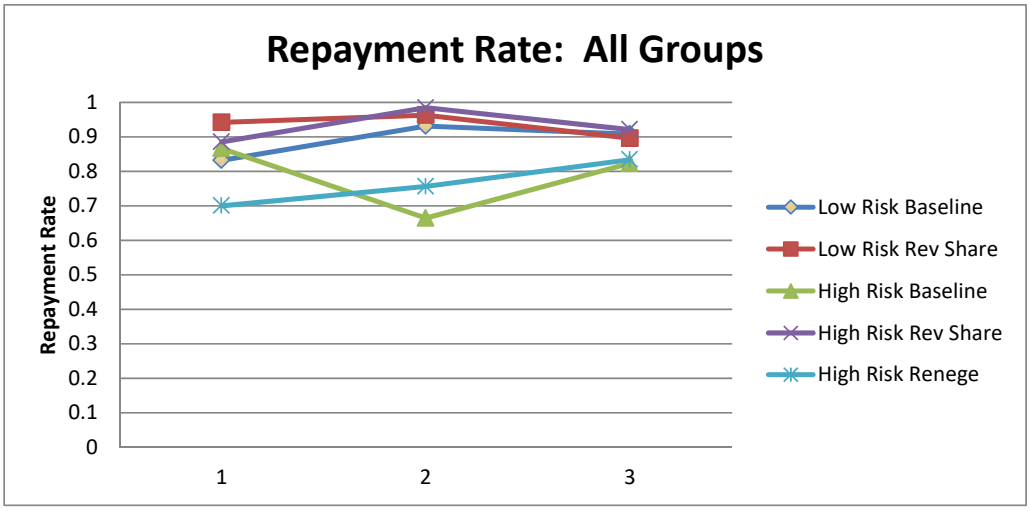
Figure 2 suggests both that high risk/return groups have lower loan repayment rates than low risk/return groups, and that this tendency can be cancelled when high risk borrowers can revenue share. As predicted by theory, the lower panels of Figure 2 indicate these suggestive differences are being driven by groups with one successful and two failed borrowers. Less in keeping with theory, all three panels indicate a surprisingly high proportion of HLL/LHL/LLH groups repaying the loan even in the high risk control, where selfish game theory predicts default by the sole successful borrower.

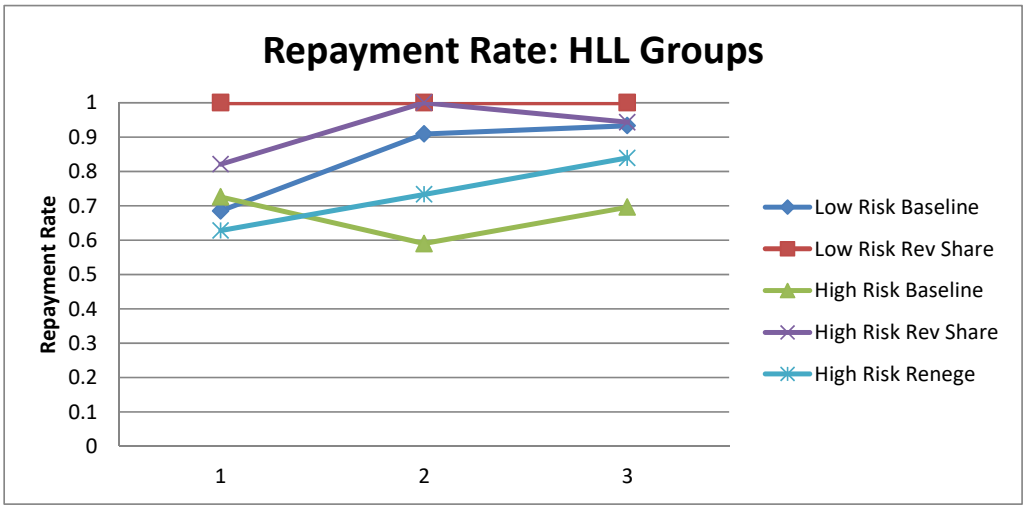
To see our results more precisely, Table 3 provides a numerical summary of loan repayment rates by group and votes by individuals. We focus here on results for groups/individuals overall, and for the theoretically pivotal case of HLL/LHL/LLH groups and individuals. As in Figure 2, Table 3 indicates that loan repayment rates are surprisingly high for high risk groups containing a sole successful borrower, even without the revenue sharing option. Such groups have a mean loan repayment rate of 72.6% in Set 1, 59.0% in Set 2 (with new group assignments), and 69.6% in Set 3 (again with new group assignments), or 67.3% overall. This is well above the predicted repayment rate of 0%. At the corresponding individual voting level, the sole H members of such groups voted to repay on average 71.9% of the time in Set 1, 66.7% in Set 2, and 81.5% in Set 3, or 72.8% overall. This 'excess repayment' echoes results found in previous microcredit lab experiments, particularly where high and low earning outcomes are known by the subjects to be randomly determined, and there is full information about others' earnings outcomes.

Table 3 also verifies that, notwithstanding this 'excess repayment', high risk groups still appear to have lower repayment rates than low risk groups under baseline conditions. The mean repayment rate for low risk HLL/LHL/LLH groups is 68.5%, 90.9% and 93.3% in Sets 1, 2, and 3, respectively, or 85.0% overall. The mean repayment vote rates by the lone H in such groups is 86.4%, 96.2%, 90.5%, and 92.6%. These differences in HLL/LHL/LLH group behaviour between high and low risk borrowing groups drive differences in overall repayment rates – 78.9% overall for high risk borrowers, vs. 89.0% for low risk borrowers. [7]

Is this difference in repayment rates statistically significant? Results from formal statistical tests are provided lower in Table 3, under Question 1 (Treatment 1 vs. 2). At group repayment level, two tailed Mann Whitney and fractional response logit regression-based tests comparing treatment

[7] For brevity of presentation we omit repayment results for groups or individuals of other earnings outcomes. These results are available from the authors upon request.





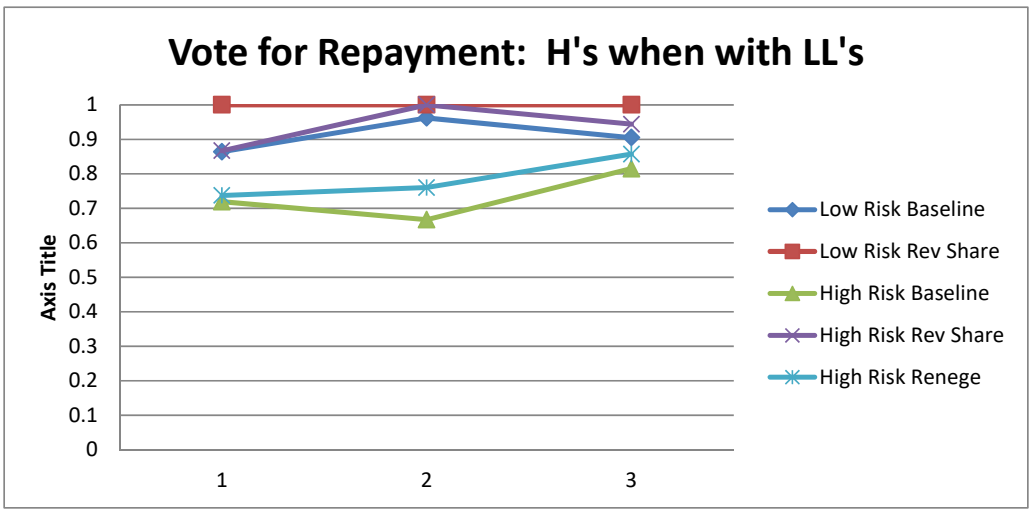


Figure 2: Repayment Rates by Set for All Groups, and for Pivotal HLL Groups and Individuals

Table 3: Loan Repayment Rates

Group Outcomes					Individual Voting								
I. All Groups (LLL excluded)					**H with Anyone**					**L with Anyone**			
Treatment	**Set**	**N**	**Repay Rate**	**Std. Dev.**	**Treatment**	**Set**	**N**	**Vote Repay**	**Std. Dev.**	**Set**	**N**	**Vote Repay**	**Std. Dev.**
1 Low Risk	1	12	.832	.132	1 Low Risk	1	33	.965	.098	1	33	.909	.264
Baseline	2	12	.931	.127	Baseline	2	34	.973	.089	2	28	.964	.189
	3	12	.908	.114		3	31	.933	.149	3	29	1.000	.000
	Overall	36	.890	.128		Overall	36	.959	.072	Overall	36	.961	.117
2 High Risk	1	17	.866	.269	2 High Risk	1	44	.941	.188	1	36	.977	.099
Baseline	2	15	.664	.386	Baseline	2	39	.862	.294	2	35	1.000	.000
	3	16	.823	.266		3	41	.950	.130	3	38	.947	.226
	Overall	48	.789	.315		Overall	52	.909	.185	Overall	52	.963	.168
3 Low Risk	1	12	.942	.151	3 Low Risk	1	34	.975	.081	1	28	.982	.094
Rev Share	2	12	.963	.088	Rev Share	2	35	.969	.107	2	29	.983	.093
	3	12	.896	.291		3	36	.963	.174	3	29	1.000	.000
	Overall	36	.933	.192		Overall	36	.951	.171	Overall	35	0.988	.050
4 High Risk	1	16	.885	.262	4 High Risk	1	40	.988	.055	1	34	.922	.247
Rev Share	2	16	.984	.063	Rev Share	2	44	.992	.050	2	40	1.000	.000
	3	17	.921	.112		3	45	.951	.121	3	42	.988	.054
	Overall	49	.930	.169		Overall	53	.976	.059	Overall	54	.978	.072
5 High Risk	1	16	.700	.385	5 High Risk	1	41	.907	.244	1	38	.945	.188
Renege	2	16	.756	.388	Renege	2	37	.860	.323	2	42	1.000	.000
	3	15	.834	.279		3	38	.908	.247	3	35	1.000	.000
	Overall	47	.762	.352		Overall	53	.903	.187	Overall	52	.970	.147
II. HLL/LHL/LLH Groups in Particular					**H with LL**					**L with HL**			
1.Low Risk	1	9	.685	.429	1 Low Risk	1	11	.864	.323	1	20	.900	.308
Baseline	2	11	.909	.202	Baseline	2	13	.962	.139	2	23	.957	.209
	3	10	.933	.141		3	14	.952	.121	3	24	1.000	.000
	Overall	30	.850	.288		Overall	26	.926	.209	Overall	31	.957	.136
2 High Risk	1	14	.726	.422	2 High Risk	1	16	.719	.446	1	30	.972	.108
Baseline	2	13	.590	.449	Baseline	2	18	.667	.454	2	30	1.000	.000
	3	14	.696	.351		3	18	.815	.296	3	32	.938	.246
	Overall	41	.673	.402		Overall	36	.728	.356	Overall	51	.962	.169
3 Low Risk	1	10	1.000	.000	3 Low Risk	1	14	1.000	.000	1	21	1.000	.000
Rev Share	2	8	1.000	.000	Rev Share	2	11	1.000	.000	2	19	1.000	.000
	3	10	1.000	.000		3	15	1.000	.000	3	25	1.000	.000
	Overall	28	1.000	.000		Overall	26	1.000	.000	Overall	33	1.000	.000
4 High Risk	1	13	.821	.376	4 High Risk	1	15	.867	.352	1	27	.914	.271
Rev Share	2	13	1.000	.000	Rev Share	2	18	1.000	.000	2	30	1.000	.000
	3	16	.943	.124		3	24	.944	.212	3	38	.991	.054
	Overall	42	.923	.229		Overall	38	.962	.124	Overall	51	.977	.088
5 High Risk	1	13	.628	.462	5 High Risk	1	19	.737	.452	1	32	.922	.257
2 + Renege	2	15	.733	.402	2 + Renege	2	25	.760	.436	2	37	1.000	.000
	3	14	.839	.304		3	21	.857	.322	3	34	1.000	.000
	Overall	42	.736	.393		Overall	40	.800	.346	Overall	50	.967	.158

Table 3 Cont'd: P Values for Treatment Comparisons (All Two Tailed)

1. Are Repayment Rates Lower for High Risk than Low Risk Borrowers? (Treatment 1 vs. 2)

	Group Outcomes		Individual Voting			
	Mann Whitney	Fractional Resp Logit[2]	Mann Whitney	Fractional Resp Logit[2]	Mann Whitney	Fractional Resp Logit[2]
All Groups			H with Anyone		L with Anyone	
Set 1	.158		.993		.302	
Set 2	**.044**		**.078**		.264	
Set 3	.591		.599		.213	
Combine	.469[1]	**.012**	.377[1]	**.032**	.390[1]	.716
HLL/LHL/LLH Groups			H with LL		L with HL	
Set 1	.746		.403		.614	
Set 2	**.056**		**.042**		.253	
Set 3	**.057**		.147		.216	
Combine	**.048**[1]	**.025**	**.019**[1]	**.003**	.546[1]	.601

2. Does Revenue Sharing Raise Repayment Rates for High Risk Borrowers? (Treatment 2 vs. 4)

All Groups			H with Anyone		L with Anyone	
Set 1	.783		.262		.345	
Set 2	**.001**		**.004**		.	
Set 3	.385		.917		.878	
Combine	**.009**[1]	**.000**	**.027**[1]	**.001**	.374[1]	.602
HLL/LHL/LLH Groups			H with LL		L with HL	
Set 1	.487		.265		.525	
Set 2	**.003**		**.004**		.	
Set 3	**.017**		**.045**		.440	
Combine	**.001**[1]	**.000**	**.001**[1]	**.002**	.743[1]	.316

3. Does Revenue Sharing Raise Repayment Rates for Low Risk Borrowers? (Treatment 1 vs. 3)

All Groups			H with Anyone		L with Anyone	
Set 1	**.026**		.645		.218	
Set 2	.515		.990		.960	
Set 3	.313		**.098**		.	
Combine	**.018**[1]	.246	.376[1]	.554	.371[1]	.234
HLL/LHL/LLH Groups			H with LL		L with HL	
Set 1	**.022**		.104		.142	
Set 2	.215		.358		.363	
Set 3	.146		.136		.	
Combine	**.004**[1]	**.000**	**.020**[1]	**.000**	**.069**[1]	**.000**

4. Does the Renege Option Lower Repayment Rates? (Treatment 4 vs. 5)

All Groups			H with Anyone		L with Anyone	
Set 1	.102		**.072**		.836	
Set 2	**.016**		**.012**		.	
Set 3	.556		.828		.194	
Combine	**.009**[1]	**.001**	**.053**[1]	**.000**	.579[1]	.561
HLL/LHL/LLH Groups			H with LL		L with HL	
Set 1	.223		.360		.839	
Set 2	**.012**		**.027**		.	
Set 3	.416		.281		.344	
Combine	**.009**[1]	**.000**	**.014**[1]	**.019**	.758[1]	.858

Table 3 Cont'd: P Values for Treatment Comparisons (Cont'd)

5. Does Revenue Sharing with Renege Raise Repayment from Baseline? (Treatment 2 vs. 5)

	Group Outcomes		Individual Voting			
	Mann Whitney	Fractional Resp Logit[2]	Mann Whitney	Fractional Resp Logit[2]	Mann Whitney	Fractional Resp Logit[2]
All Groups			H with Anyone		L with Anyone	
Set 1	.143		.454		.437	
Set 2	.321		.737		.	
Set 3	.777		.771		.172	
Combine	.900[1]	.784	.841[1]	.472	.725	.417
HLL/LHL/LLH Groups						
Set 1	.563		.833		.644	
Set 2	.362		.399		.	
Set 3	.176		.418		.142	
Combine	.373[1]	.250	.282[1]	.265	.993[1]	.473

[1] Combining sets is not strictly valid for Mann Whitney tests, as group outcomes and individual votes are not independent between sets.

[2] From Wald tests comparing coefficients on treatment dummies in fractional response logit pooled cross section regression using group outcomes or individual votes at set level, using set dummies and demographics. See Appendix B for the underlying regressions.

dummy coefficients find the repayment rates of pivotal low risk HLL/LHL/LLH groups to be significantly higher than analogous high risk groups in Sets 2, 3, and overall.[8] These results are partially confirmed at individual vote level, with significant differences in rates of voting for repayment by the lone H in HLL/LHL/LLH groups between high and low risk borrowing groups in Set 2 and overall by Mann Whitney, and overall using regression analysis. Our evidence that higher risk lowers loan repayment weakens only slightly when we pool all group compositions together. Here group repayment rates are significantly higher for low risk borrowers only in Set 2 (Mann Whitney), or overall according to regression-based comparisons of treatment coefficients (see Appendix B). Thus, we have been able to partially capture in a lab experiment one potential explanation for Banerjee and Duflo (2011)'s observation that group liability microcredit does not work as well for higher risk borrowers, consistent with our Hypothesis 1.

Table 3 also provides evidence regarding our key question in Hypothesis 2: does giving high risk borrowing groups the ability to bind themselves to optional revenue sharing agreements increase their loan repayment rates? (Treatment 2 vs. 4)? Again, despite the 'excess repayment' by pivotal

[8] Fractional response logit models allow the dependent variable to range between 0 and 1, including the bounds (see Papke and Wooldridge (1996) and Wooldridge (2010)). They are given in Appendix B.

HLL/LHL/LLH groups in the high risk baseline, we find evidence that the option of revenue sharing raises them further. The mean repayment rate for high risk HLL/LHL/LLH groups with revenue sharing climbs to 82.1%, 100.0% and 94.3% in Sets 1, 2, and 3, respectively, or 92.3% overall. The analogous votes for repayment by lone H subjects in LL groups rise respectively to 86.7%, 100% and 94.4% in Sets 1, 2, and 3, or 96.2% overall. In formal comparisons in Table 3 Question 2, Mann Whitney and regression based tests find these outcomes and voting rates to be significantly higher than without revenue sharing for Sets 2, 3 and overall. Our evidence that revenue sharing raises loan repayment weakens only slightly when we pool all group earnings outcomes together, with group repayment and H voting for repayment significantly higher in Treatment 4 in Set 2 and overall. Thus, we find evidence in support of Hypothesis 2 that the option to lock in revenue sharing *ex ante* raises loan repayment rates for high risk borrowers whose groups turn out to contain only one high earner, and for high risk borrowers overall.

From Table 3 we can also test whether the option to revenue share indeed has no effect on repayment rates for low risk borrowing groups, who should already repay even when only one borrower succeeds. Surprisingly, we find weak evidence that the option to lock in revenue sharing may also raise loan repayment rates for low risk borrowing groups. The evidence is marginal, but the room for improvement for low risk borrowers is also limited because the overall loan repayment rate is already 89.0% in the baseline Treatment 1. From Table 3, the mean repayment rates for low risk borrowing groups overall by set are respectively 83.2, 93.1 and 90.8% without revenue sharing, and 94.2%, 96.3%, and 89.6% with. Mann Whitney tests in Table 3 Question 3 find these repayment rates to differ significantly for Set 1 and overall for group outcomes, but a regression based test of an overall difference does not, nor in most cases does either type of test for differences in individual voting rates. Thus our Hypothesis 3 that revenue sharing leaves repayment rates by low risk borrowing groups unaffected finds ambiguous support – there is slight evidence that revenue sharing might raise their loan repayment rates.

Lastly from Table 3, we can test our final two hypotheses that giving borrowers an opportunity to renege on revenue sharing agreements will lower repayment rates among high risk borrowing groups (Hypothesis 4), specifically back to the level observed when revenue sharing is not available (Hypothesis 5). Disappointingly, but in line with game theory, our results indicate that the renege option does indeed hollow out the gains of revenue sharing in raising repayment rates among high risk borrowing groups. Again focussing on the pivotal HLL/LHL/LLH groups in Table 3, mean group repayment rates by set fall from 82.1%, 100.0% and 94.3% without a renege option, to 62.8%, 73.3% and 83.9% with the option. Put another way, the binding revenue sharing option raises the overall

repayment rate of high risk HLL/LHL/LLH groups from 67.3% to 92.3%, but then allowing a renege option reduces it back most of the way, to 73.6%. Individual H voting patterns in groups with two L's tell a similar story; pooling over all three sets, repayment vote rates rise from 72.8% in the control, to 96.2% with the revenue share option, back down to 80.0% with the renege option. These results for HLL/LHL/LLH groups in particular carry over to high risk groups overall – pooling across sets, group repayment rates rise from 78.9% in the high risk baseline, to 93.0% with the revenue sharing option, back down to 76.2% when renege is possible.[9] Formal statistical tests in Table 3 Questions 4 and 5 confirm that the renege option significantly lowers pivotal HLL/LHL/LLH group repayment rates and associated votes for repayment by sole successful borrowers, rendering them in-distinguishable from Treatment 2 where revenue sharing is not even available. This result then carries over for high risk groups overall. Thus the gains of revenue sharing are undone when those who must share the most (H members of HLL groups) can renege on their commitment, confirming both Hypotheses 4 and 5.

V.2 Revenue Sharing Rates

So far, we have seen that the *option* to share revenue raises loan repayment rates for high risk borrowers so long as such commitments are binding once made. Here we ask whether high risk subjects actually take up revenue sharing to secure these gains as predicted, and whether low risk subjects are indifferent to taking it up or not. Similarly, we ask whether high risk subjects who can renege on revenue sharing commitments are indifferent to adopting them in the first place, since such commitments are no longer predicted to raise repayment incentives or future payoffs.

To measure uptake of revenue sharing, we again construct revenue sharing rates over the number of periods for each set where it was possible, analogous to our loan repayment rate construction. For group level uptake, we divide the number of periods a given group in a given set unanimously voted to share revenue, by the number of periods in which they were eligible to do so. Unlike when constructing loan repayment rates, here we can include periods in which groups turn out to have (LLL) earnings, since this is not known at the time sharing is decided upon. To illustrate, a group who unanimously votes to revenue share in periods 3 and 4 of a set, but then in period 4 either earns (LLL) or votes not to repay the loan, would still have a sharing rate of 2/2 = 1. For individual voting, we similarly divide the number of periods a person votes to revenue share over the number of periods he or she is eligible to make that decision.

[9] There is isolated evidence in a few non HLL groups of individuals punishing those who reneged on revenue sharing by then voting not to repay the loan, despite it being in their pecuniary interest to do so.

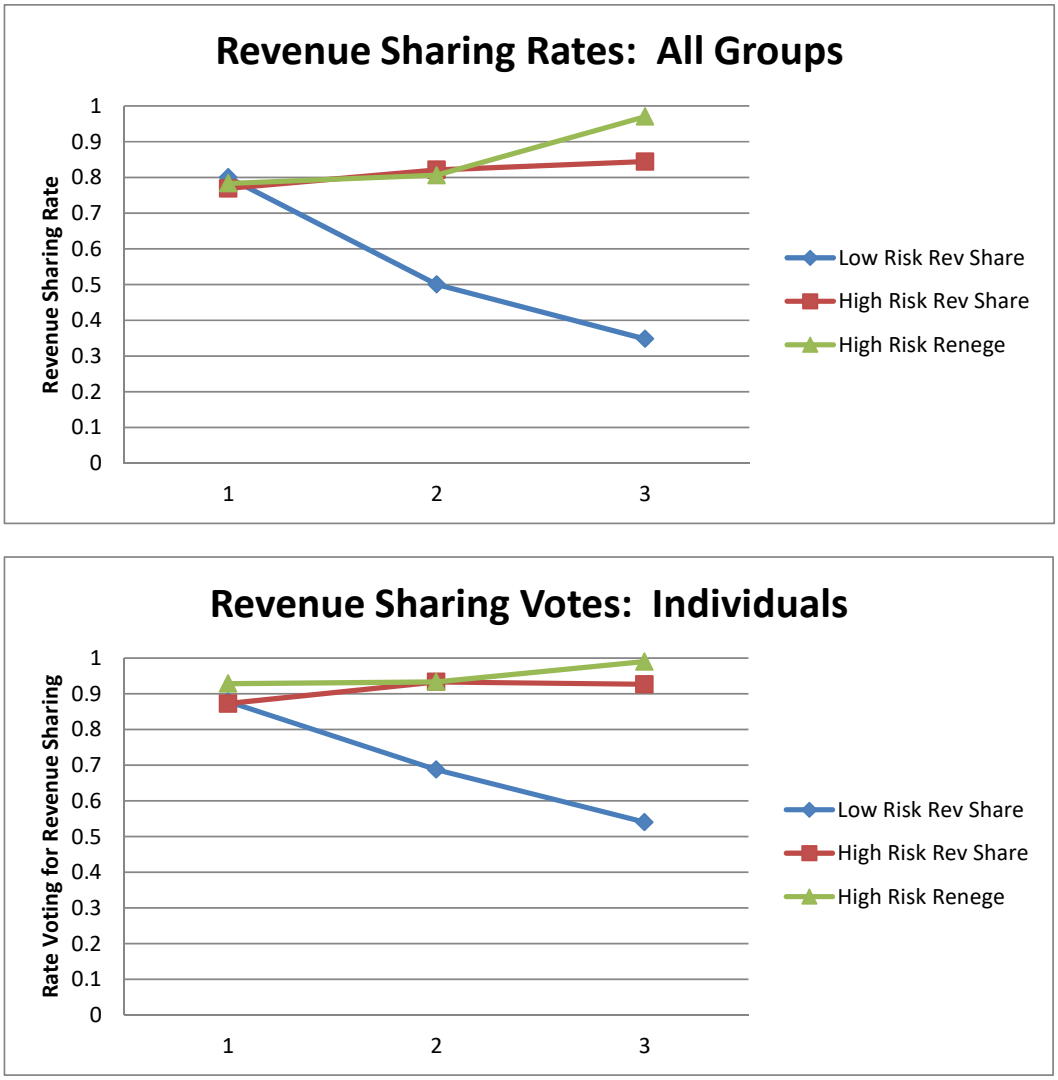


Figure 3: Revenue Sharing Rates by Set for All Groups, and Votes by Individuals

Figure 3 and Table 4 provide these sharing rates by group outcome and individual vote, both by set and by treatment. Consistent with our game theoretic predictions that revenue sharing would bring earnings gains for high- but not low risk borrowers, we find high risk borrowers are more likely to adopt it. For group results by set, revenue sharing rates were 76.9%, 82.1% and 84.4% for high risk borrowing groups (without a renege option), vs. 80.0%, 50.0% and 34.8% for analogous low risk groups. The noticeable downward trajectory in the proportion of low risk groups adopting revenue sharing over sets suggests the individuals in these groups are learning that revenue sharing does not help them with loan repayment. No such decline is observed with high risk groups. Mirroring these group results, corresponding individual votes by set for revenue sharing were 87.2%, 93.3%, and 92.6% in high risk groups, and 87.8%, 69.2% and 51.0% in low risk groups.

Table 4: Revenue Sharing Rates

Group Outcomes					Individual Voting				
Treatment	**Set**	**N**	**Mean Rev Share Rate**	**Std. Dev.**	**Treatment**	**Set**	**N**	**Mean Rev Share Rate**	**Std. Dev.**
3 Low Risk	1	10	.800	.233	3 Low Risk	1	30	.878	.205
Rev Share	2	11	.500	.453	Rev Share	2	33	.692	.387
	3	11	.348	.369		3	33	.510	.363
	Overall	32	.542	.402		Overall	35	.690	.261
4 High Risk	1	13	.769	.439	4 High Risk	1	39	.872	.319
Rev Share	2	14	.821	.296	Rev Share	2	42	.933	.191
	3	15	.844	.353		3	45	.926	.206
	Overall	42	.813	.357		Overall	52	.901	.191
5 High Risk	1	10	.783	.334	5 High Risk	1	30	.928	.213
RS + Renege	2	12	.806	.388	RS + Renege	2	36	.935	.237
	3	11	.970	.101		3	33	.990	.058
	Overall	33	.854	.305		Overall	49	.955	.125

1. Is Revenue Sharing Adopted More By High Risk Borrowers? (Treatment 3 vs. 4)

	Group Level Outcomes		**Individual Level Votes**	
	Mann Whitney	**Fractional Resp Logit[2]**	**Mann Whitney**	**Fractional Resp Logit[2]**
All Groups				
Set 1	.464		.294	
Set 2	**.065**		**.001**	
Set 3	**.001**		**.000**	
Combine	**.001**[1]	**.027**	**.000**[1]	**.000**

2. Is Revenue Sharing Adopted More Often When it Can Be Reneged On? (Treatment 4 vs. 5)

All Groups				
Set 1	.619		.707	
Set 2	.705		.459	
Set 3	.408		.107	
Combine	.769[1]	.747	**.049**[1]	.225

[1] Combining sets is not strictly valid for Mann Whitney tests, as group outcomes and voting rates are not independent between sets.

[2] From Wald tests comparing coefficients on treatment dummies in pooled cross section fractional response logit regression using group outcomes or individual votes at set level, using set dummies and demographics. See Appendix B for the underlying regressions.

More formally, Mann Whitney and regression based-tests in Table 4 Question 1 find these differences in uptake to be significant in Sets 2 and 3 or overall for both group outcomes and individual votes. More surprisingly, high risk borrowers were not indifferent to the revenue sharing option in Treatment 5 where the renege option was available. Across sets, high risk groups adopted revenue sharing 78.3%, 80.6% and 97.0% of the time when renege was an option, and individuals voted to revenue share 92.8%, 93.3% and 99.0% of the time. As a result, Mann Whitney and regression-based tests in Table 4 Question 2 generally do not find a significant difference in the proportion of high risk groups adopting revenue sharing with and without the renege option. In fact, a sole exception is the Mann Whitney comparison of the overall rate of individuals voting for revenue sharing, which finds it significantly *higher* when renege is an option (two tailed p value .049).

V.3 Reneging on Revenue Sharing

So far we have seen that loan repayment rates are higher when high risk borrowing groups can make a binding commitment to revenue share, and that indeed more of them choose to revenue share than do low risk borrowing groups. However, we have also seen that most of the increase in loan repayment rates is lost when high risk borrowers can renege on revenue sharing commitments once each borrower's earnings are revealed. Given that revenue sharing rates do not decline when reneging becomes an option, this implies that at least some borrowers are making a revenue sharing commitment, and then reneging on it, rather than declining to revenue share in the first place when agreements can be circumvented. Here we summarize what renege rates we find. Recall our selfish game-theoretical prediction that high risk groups will be indifferent to revenue sharing or not, but if revenue sharing is adopted, renege will occur in groups containing one or two failed borrowers.

We construct a renege rate in a way analogous to our repayment and revenue sharing rates. For group results, we take the number of periods a given group in a given set does not revenue share after having voted unanimously to do so, divided by the number of periods they have unanimously voted to revenue share. Here, groups who vote unanimously to revenue share but then experience (LLL) earnings are excluded from the numerator and denominator, since they do not advance far enough in a period to face a confirmation decision. We calculate a renege rate for groups overall, as well as conditioned by group earnings composition. Note that as fewer groups meet the criteria for inclusion in the renege rate, the number of observation can become more limited, particularly for groups where all businesses succeeded. For individual renege votes, we analogously take the number of periods an individual votes to renege on a unanimous agreement to revenue share, divided by the number of periods he or she is eligible to do so. Renege rates are provided in Figure 4 and in Table 5.

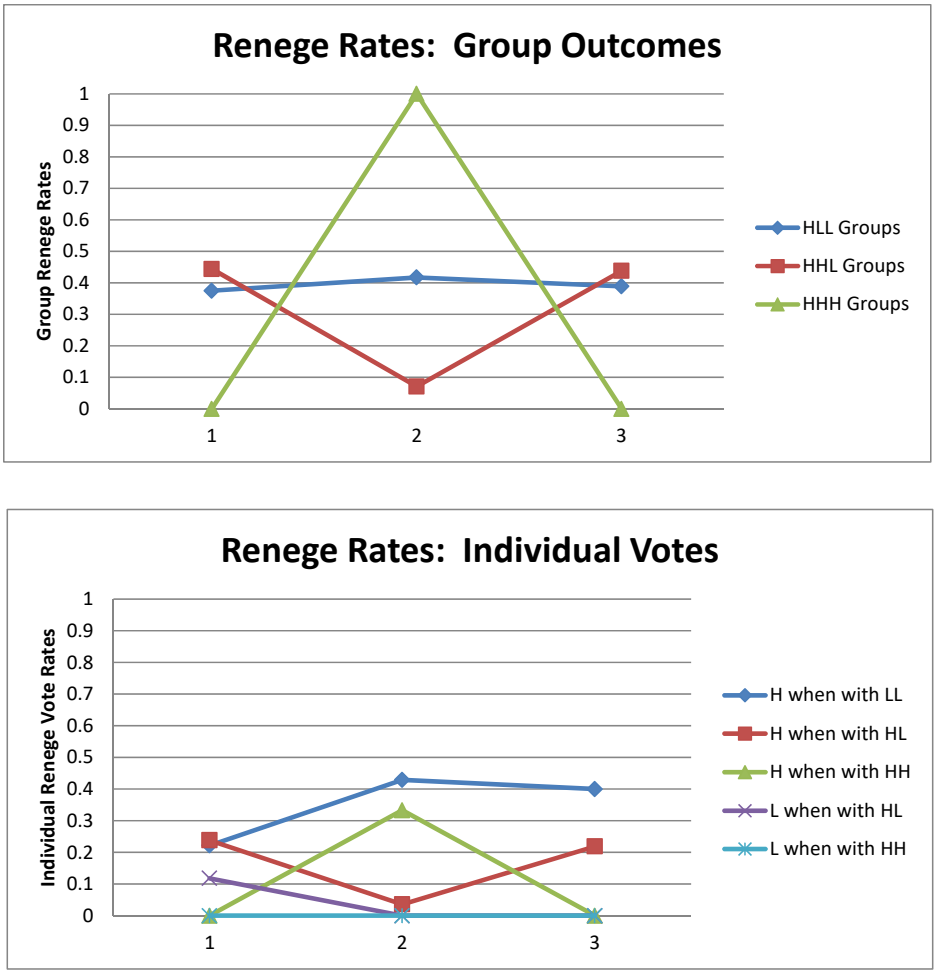


Figure 4: Renege Rates by Set for Group Outcomes and Individual Votes in Treatment V

As the Figure and Table indicate, group renege rates appear slightly higher in groups containing two or one low earners than in (rarer) groups with all high earners. Over all three sets, renege rates for these group compositions were 39.1%, 33.3%, and 25.0%, respectively, though none of these rates differ significantly in pair-wise Mann Whitney tests. At the individual level, high earners appear more likely to vote to renege on revenue sharing commitments as the number of failed earners increases, from 8.3% of the time with no low earners, to 21.7% of the time with one low earner, to 31.0% with two low earners, when all sets are pooled. However these differences are not significant (from (HHH) to (HLL/LHL/LLH) groups the Mann Whitney p value is .12). High earners also appear more likely to renege than low earners (18.7% vs. 3.8% overall, 31.0% vs. 5.6% in HLL groups, and 20.6% vs. 0.0% in HHL groups). These differences are for the most part statistically significant, and in

Table 5: Renege Rates[1]

Group Level Outcomes				Individual Level Voting							
I. All Groups (excl LLL)				**H with Anyone**				**L with Anyone**			
Set	**N**	**Renege Rate**	**Std. Dev.**	**Set**	**N**	**Vote Renege**	**Std. Dev.**	**Set**	**N**	**Vote Renege**	**Std. Dev.**
1	9	.352	.377	1	23	.188	.323	1	20	.075	.245
2	8	.250	.282	2	17	.157	.285	2	15	.000	.000
3	11	.348	.425	3	22	.220	.396	3	21	.000	.000
Overall	28	.321	.363	Overall	38	.184	.292	Overall	40	.038	.177
II. HLL/LHL/LLH Groups				**H with LL**				**L with HL**			
1	8	.375	.518	1	9	.222	.441	1	17	.118	.332
2	6	.417	.492	2	7	.429	.535	2	13	.000	.000
3	9	.389	.486	3	10	.400	.516	3	19	.000	.000
Overall	23	.391	.476	Overall	21	.310	.460	Overall	36	.056	.232
III. HHL/HLH/LLH Groups				**H with LH**				**L with HH**			
1	9	.444	.464	1	21	.262	.436	1	12	.000	.000
2	7	.071	.189	2	14	.036	.134	2	7	.000	.000
3	8	.438	.496	3	16	.219	.407	3	8	.000	.000
Overall	24	.333	.434	Overall	34	.217	.373	Overall	23	.000	.000
IV. HHH Groups				**H with HH**							
1	1	.000	.	1	3	.000	.000				
2	1	1.000	.	2	3	.333	.577				
3	2	.000	.000	3	6	.000	.000				
Overall	4	.250	.500	Overall	12	.083	.289				

[1] Only an option in Treatment 5. Renege Rate is conditioned on group composition, and excludes those who experienced (LLL), those who had not unanimously agreed to revenue share for a period, or those no longer receiving loans by period 3 of a set.

the direction predicted by theory.[10] Nevertheless, the absolute levels of reneging are much lower than would be predicted by theory. For example, in individual voting, pooled over all three sets, fully 69% of sole high earners decline to renege on unanimously adopted revenue sharing agreements upon learning they are in HLL groups, and 78.3% similarly refrain upon learning they are in HHL/HLH/LHH

[10] In particular, high earners are significantly more likely to renege than low earners for all three sets when unconditioned on the composition of the other two group members, and in Sets 2 and 3 of HLL groups, and in Set I of HHL groups.

groups. These are far above the 0% rates predicted by standard theory. At the same time, the reneging that does occur is enough to reduce loan repayment rates to the (surprisingly high) levels observed in the high risk group control treatment, where revenue sharing was not an option.

VI. Conclusion

Microfinance with group liability has been found to work well for advancing credit to low risk borrowers, but researchers have noted its limited use by borrowers with higher risk/return projects (Banerjee and Duflo 2011). Explanations for this have included moral hazard type arguments, where peer monitoring incentivizes borrowers to undertake excessively low risk/return business ventures. Alternatively, under adverse selection type explanations, even under perfect information group liability will not function well for people wanting to pursue high risk/return projects. Groups of high risk/return borrowers would have a higher risk of defaulting on aggregate repayment even when it is feasible, which itself would lower the benefits of group members bailing each other out to access future loans together. To cover lending costs in face of higher default rates, microfinance lenders would have to charge higher interest rates, bringing those rates closer to those charged by for-profit money lenders. Given that group liability microfinance also involves considerable time/meeting/ intrusion transactions costs, borrowers with higher risk/return projects might simply prefer to remain with money lenders given the microfinance interest rates that would be available to them.

We have proposed a partial revenue sharing mechanism that higher risk/return borrowers could use under group-liability microfinance to raise incentives for loan repayment, and thus addressing the issue of adverse selection. Those with higher risk/return business ideas could form borrowing groups in which they commit *ex ante* to share a fraction of their subsequent revenues with other group members, prior to learning their business outcomes. If binding once agreed to, revenue sharing can make it in high risk/return borrowers' interests to repay the group loan under more possible earnings states. In a repeated setting, this raises the expected value to group members of current repayment to qualify for future loans together. This dynamic improvement in repayment incentives can exist even if the revenue sharing option is only introduced after borrowing groups have had some opportunities to borrow together without it. On the other hand, a limitation of this mechanism is that its gains could unravel if borrowers whose high risk businesses turn out to succeed can renege on revenue sharing commitments *ex post*, if it turns out others in their group have failed.

As a first investigative step, we conduct a lab experiment to test this mechanism. Under a full information design, we assign homogeneously high risk/return or low risk/return borrowers into separate three person borrowing groups. Each borrower has a business that may yield a high or low

return with fixed probability. Both loan repayment, and the decision to share revenues if available, require unanimity among the three members of a group. Under this full information design where success and failure are randomly assigned, we find more loan repayment among high risk/return borrowing groups than would be predicted by theory. This is driven by groups that turn out to have only one successful borrower, who votes to bail out the two failed borrowers surprisingly often. Beyond that, however, the treatment effects we observe are consistent with the predictions of our theory. First, we are able to create conditions consistent with an adverse selection explanation for microfinance's "failure" for borrowers with high risk/return business ventures, with loan repayment rates lower in high risk/return borrowing groups than in low risk/return borrowing groups. Second, we find that including a 40% revenue sharing option raises loan repayment rates among a pivotal type of high risk borrowing group: those containing only one high earner. As predicted, that sole high earner is more likely to vote for loan repayment when revenue sharing is available. The reduction we find in loan default rates echoes that of Fisher (2013) in a different design with incomplete information and moral hazard, where full revenue sharing leads to lower default rates than mere joint loan liability. Unfortunately, we find that much of this increase in repayment rates among high risk groups is lost if they can renege on revenue sharing commitments once they learn how their businesses have done.

We find auxiliary results that are partly consistent with theoretical predictions: high risk borrowing groups are indeed more likely to adopt (and keep adopting) revenue sharing than low risk borrowing groups, since it should raise the expected earnings of the former, and make no difference to the latter. On the other hand, even for high risk borrowing groups revenue sharing should make no difference to expected earnings if renege is possible, yet such groups commit to revenue sharing just as often groups who cannot renege. Regarding renege rates, overall, 33% to 39% of groups who unanimously committed to revenue share had at least one member renege when the group contained at least one low earner. The unravelling of revenue sharing's benefits to loan repayment rates occurred because of these reneges, rather than because groups stopped voting to revenue share in the first place when renege became an option.

Thus our initial evidence is that revenue sharing does appear to have the potential to make group liability microfinance achieve lower loan default rates for high risk/return borrowers. However, the vulnerability of this mechanism to reneging is also evident. Unfortunately, microfinance has the greatest potential for good precisely in those settings where third parties such as courts may not be relied upon to enforce revenue sharing commitments or contracts *ex post*. Profitable future research could look for acceptable ways that higher risk borrowing groups could bind themselves to such commitments.

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Appendix A

A1. Loan Repayment Incentives For High Risk Borrowing Groups Without Revenue Sharing

With the given parameters, there is no incentive for any borrower to vote to repay the loan in the terminal period T=6. The loan repayment vote {NNN} is then a weakly dominant strategy voting equilibrium for players in groups of all possible earnings compositions. The expected profit from players accessing a loan at the start of period 6 is

$$E(\pi_{i6}) = p_H^3(820) + 2p_H^2(1-p_H)(820) + p_H(1-p_H)^2(820) + (1-p_H)p_H^2(80) +$$

$$2p_H(1-p_H)^2(80) + (1-p_H)^2(80) = 450. \qquad \text{(A.1)}$$

Relevant for all previous periods, Table A.1 summarizes the net period payoffs for the underlined borrower in each potential group outcome. In period 5, we assume an individual votes to repay the loan if his payoff from repaying plus the expected payoff from continuation to period 6 (450) exceeds the current payoff from not repaying the loan. As the Required Repayment column indicates in Table A.1, it is only the H subjects in HLL/LHL/LLH outcome groups who will vote not to repay the loan (740 vs. 450).

In period 4 the expected benefit from voting to repay is the expected payoff from continuing to period 5 plus the expected payoff from period 6 multiplied by the probability of getting to period 6. Notice that the group will not get to period 6 if in period 5 the group contains one or zero high earners, which occurs with probability .50. Thus the expected payoff to continuing to the start of period 5 is:

$$E(\pi_{i5}) + .5E(\pi_{i6}) = 0.125(520) + .25(410) + .125(820) + .125(0) + .25(80) + .125(80)$$

$$+.5(450) = 300 + 225 = 525 \qquad (A.2)$$

Since this expected payoff has increased from 450 it remains in the subject's best interest to vote for repayment in period 4 as in period 5. Yet for the sole H in HLL/LHL/LLH groups, 525 is still not enough to overcome the benefit of not repaying the loan (saving 740).

The expected payoff to continuing to the start of period 4 is:

$$E(\pi_{i4}) + .5E(\pi_{i5}) + .5^2E(\pi_{i6})$$

$$= 0.125(520) + .25(410) + .125(820) + .125(0) + .25(80) + .125(80)$$

$$+.5(300) + .5^2(450) = 300 + 150 + 112.5 = 562.5 \qquad \text{(A.3)}$$

Table A.1 Period Payoffs and Probabilities by Outcome for Underlined High Risk Borrower

Group Outcome	Period Net Earnings		Required Repayment	Probability
	Repay	Do Not Repay		
HHH	520	820	300	0.125
HHL or HLH	410	820	410	0.25
HLL	80	820	740	0.125
LHH	0	80	80	0.125
LLH or LHL	0	80	80	0.25
LLL	80		NA	0.125

Thus it remains the case in period 3 that for the sole H in an HLL/LHL/LLH group, 562.5 is less than the 740 benefit of not repaying the loan. The process continues backward such that the expected payoff to continuing to the start of period 2 is:

$$E(\pi_{i1}) + .5E(\pi_{i2}) + .5^2E(\pi_{i3}) + .5^3E(\pi_{i4}) + .5^4E(\pi_{i5}) + .5^5E(\pi_{i6})$$
$$= 300 + .5(300) + .5^2(300) + .5^3(300) + .5^4(300) + .5^5(450) = 595.3\,. \quad \text{(A.4)}$$

This again is not high enough to offset the 740 loss to a high net benefit borrower from bailing out two low net benefit borrowers. Thus, in any of the first five periods where a group turns out to have only one successful earner, that earner is predicted to vote not to repay the loan.[11] In contrast, voting to repay the loan is optimal for successful borrowers in groups with one or two other successful borrowers in periods 1 to 5 (because the loan repayment cost falls below 450), as it is also for unsuccessful borrowers (with an even lower repayment cost of 80).

A2. Loan Repayment Incentives For Low Risk Borrowing Groups Without Revenue Sharing

With the given parameters, repayment incentives are more favourable for lone successful borrowers in low risk borrowing groups. Failed borrowers in the low risk case are able to repay 270 of their (equal) 280 share of a group loan, so less bailout is demanded of the sole successful earner. All outcome state period earnings are given in Table A.2.

As with high risk borrowers, non-repayment is the weakly dominant strategy equilibrium in the terminal period for all group. The expected payoff from reaching period 6 is $E(\pi_{i6}) = 360$, from

[11] The expected gains to continuation grow at a decreasing rate moving back, so that in fact the predictions regarding repayment become very similar for finite or infinite horizon games for otherwise similar parameters.

Table A.2 Period Payoffs and Probabilities by Outcome for Underlined Low Risk Borrowers

Group Outcome	Period Net Earnings		Required Repayment	Probability
	Repay	Do Not Repay		
HHH	140	420	280	0.216
HHL or *H*LH	135	420	285	0.288
HLL	120	420	300	0.096
LHH	0	270	270	0.144
LLH or LHL	0	270	270	0.192
LLL	270		NA	0.064

$$E(\pi_{i6}) = .6(420) + .4(270) = 360 \quad \text{(A.5)}$$

In period 5 the cost of repayment to a sole successful borrower is 280 + 10 + 10 = 300, which is clearly less than $E(\pi_{i6})$. With the benefit of continuation even higher in earlier periods, voting for loan repayment is always optimal for the sole successful borrower. With the cost of loan repayment lower for successful borrowers in groups with other outcomes, and lower still for failed borrowers, they too will vote for repayment wherever possible in periods 1 to 5.

A3. Loan Repayment Incentives for High Risk Borrowing Groups with Revenue Sharing

Here, before knowing their business outcomes, if the three members of the group all agree to do so, they can each commit to share 20% of their business venture revenues with each of the other two people in their group. The business outcome parameters for this treatment are the same as without revenue sharing. The period payoffs from all possible group business outcomes are given in Table A.3, and the specific payoffs under our parameters are given in Table A.4.

Focussing on the pivotal lone successful borrower in a group that has the HLL/LHL/LLH outcome, the successful borrower's adjusted revenue is 524 and the two failed borrowers adjusted revenues are 228. Loan repayment in period 5 would require the successful borrower to pay 300 + 72 + 72 = 444, less than the expected benefit from continuation (450). Thus if revenue sharing has been adopted, the sole successful borrower will join his group partners in voting for loan repayment.

The relevant expected payoff at the start of period 5 is:

$$E(\pi_{i5}) + .875E(\pi_{i6}) = 0.125(520) + .25(372) + .125(80) + .125(76) + .25(0) + .125(80)$$

$$+.875(450) = 187.5 + 393.75 = 581.25 \quad \text{(A.6)}$$

Table A.3 General Period Payoffs by Group Outcome for Underlined Borrower after Revenue Sharing.

GroupOutcome	Revenues After Sharing	Period Net Earnings	Probability
HHH	b_H	$b_H - wC_{HHH}$	p^3
HHL or HLH	ab_{HHL} $= b_H - .4b_H + .2b_H$ $+ .2b_L = .8b_H + .2b_L$	$ab_{HHL} - \left(w + \frac{\min(w - ab_{LHH}, 0)}{2}\right) C_{HHL}$	$2p^2(1-p)$
HLL	$ab_{HLL} = .6b_H + .4b_L$	$ab_{HLL} - \big(w + 2min(w - ab_{LLH}, 0)\big)C_{HLL}$	$p(1-p)^2$
LHH	$ab_{LHH} = .6b_L + .4b_H$	$\max(ab_{LHH} - wC_{LHH}, 0)$	$p^2(1-p)$
LLH or LHL	$ab_{LLH} = .8b_L + .2b_H$	$\max(ab_{LLH} - wC_{LLH}, 0)$	$2p(1-p)^2$
LLL	b_L	b_{iL}	(1-p)^3

Table A.4 Period Payoffs and Probabilities by Outcome for Underlined High Risk Borrowers

Group Outcome	Period Net Earnings		Required Repayment	Probability
	Repay	Do Not Repay		
HHH	520	820	300	0.125
HHL or HLH	372	672	300	0.25
HLL	80	524	444	0.125
LHH	76	376	300	0.125
LLH or LHL	0	228	228	0.25
LLL	80		NA	0.125

Thus, before learning their period 5 business outcomes, high risk borrowers can expect to achieve 581.25 by voting to revenue share in period 5 vs 525 if they do not. Moving backwards to period 4, since the expected payoff from continuation increases in earlier periods, it remains in subjects' best interests to vote for repayment in all of the cases they voted for repayment in period 5. And, since in each previous period the expected future profits are higher by voting to revenue share and repay the loan in more outcome cases, revenue sharing will be unanimously chosen whenever available.

A4. Loan Repayment Incentives for Low Risk Borrowing Groups with Revenue Sharing

With the parameters given, the weakly dominant strategy equilibrium remains to vote {NNN} to loan repayment in the terminal period for all group compositions. The expected payoff from reaching period 6 is

$$E(\pi_{i6}) = .6(420) + .4(270) = 360 \qquad (A.7)$$

Table A.5 Period Payoffs and Probabilities by Outcome for Underlined Low Risk Borrowers

Outcome	Period Net Earnings		Required Repayment	Probability
	Repay	Do Not Repay		
HHH	140	420	280	0.216
HHL or HLH	110	390	280	0.288
HLL	80	360	280	0.096
LHH	50	330	280	0.144
LLH or LHL	20	300	280	0.192
LLL	270		NA	0.064

Starting with period 5 it is in an individual's best interest to pay back the loan in each case as the expected payoff from continuing to period 6 (360) exceeds the difference between repaying the loan and not repaying the loan for all group earnings outcomes, as shown in Table A.5. As a result, for this treatment repayment is a dominant strategy in period 5, and in all earlier periods. This is not surprising as repayment is a dominant strategy in the treatment without revenue sharing.

Since revenue sharing is not predicted to affect future repayment rates, it will not affect the expected benefits of continuation for low risk borrowers in any period. They should therefore be indifferent to adopting it or not in all periods in which it is available.

Appendix B: Fractional Response Logits Underlying Tests for Treatment Effects, Group Outcomes
Average Marginal Effects Shown (dy/dx)

	Pooled Group Loan Repay Rate	HLL Group Loan Repay Rate	HHL Group Loan Repay Rate	HHH Group Loan Repay Rate	Rev Share Adoption Rate
Treatment 2 (HRRS)	.224***	.379***	.041	-.468***	Omitted
	(.061)[1]	(.075)	(.063)	(.157)	Baseline
Treatment 3 (LR)	.115**	.152**	-.012	-.507***	
	(.048)	(.066)	(.055)	(.147)	
Treatment 4 (LRRS)	.205***	2.053***	.054	-.542***	-.181**
	(.072)	(.168)	(.074)	(.173)	(.079)
Treatment 5 (HRRSR)	.012	.062	-.034	-.000	.033
	(.045)	(.054)	(.053)	(.022)	(.102)
Set 2	.014	.064	.035	-.034	-.068
	(.040)	(.053)	(.038)	(.047)	(.080)
Set 3	.025	.106**	.035	-.070	-.041
	(.039)	(.049)	(.039)	(.043)	(.079)
Male/Male/Fem	.004	.013	-.052	.063	.107
	(.046)	(.055)	(.053)	(.041)	(.118)
Male/Fem/Fem	-.086*	-.091	-.072	.034	.224*
	(.050)	(.062)	(.057)	(.042)	(.120)
Fem/Fem/Fem	-.109*	-.176**	-.061	.062	.107
	(.063)	(.077)	(.066)	(.062)	(.141)
Taken Econ (ave)	.086	.159*	-.002	.000	-.209
	(.066)	(.094)	(.064)	(.061)	(.129)
Taken Stats (ave)	-.049	-.112	-.022	.076	.129
	(.068)	(.098)	(.061)	(.098)	(.146)
English 1st Lang (ave)	.132*	.241***	.120	-.073	.406***
	(.072)	(.093)	(.074)	(.047)	(.130)
Trust Others (ave)	-.033***	-.034**	-.033***	.016	-.008
	(.012)	(.015)	(.013)	(.011)	(.025)
Age (ave)	-.005	-.015	.001	-.002	.020*
	(.006)	(.010)	(.008)	(.006)	(.011)
No. Others Recognized (ave)	.014	-.004	.013	-.003	-.008
	(.011)	(.012)	(.009)	(.006)	(.018)
N[2]	216	183	175	126	107
Pseudo R^2	.111	.234	.145	.375	.198

[1] Robust standard errors in parentheses.

[2] N is less than 234 in loan repayment regressions because some groups experienced LLL earnings in period 1 of a set, or did not experience a given earnings configuration during a set, or demographics are missing.

Appendix B (Cont'd): Fractional Response Logits Underlying Tests for Treatment Effects, Individual Voting, Average Marginal Effects Shown (dy/dx)

	H with Anyone Repay	H with LL Repay	H with HL Repay	H with HH Repay	L with Anyone Repay	L with HL Repay	L with HH Repay	Voting to Share Revenue
Treat 2 (HRRS)	.080***	.202***	.036	-.474***	.010	.021	-.261***	Omitted
	(.027)[1]	(.061)	(.025)	(.132)	(.019)	(.022)	(.087)	Baseline
Treat 3 (LR)	.052**	.192***	-.002	-.475***	.008	.011	-.242***	
	(.025)	(.060)	(.016)	(.135)	(.021)	(.022)	(.081)	
Treat 4 (LRRS)	.070**	1.709***	.285***	-.497***	.031	.350***	-.252***	-.152***
	(.030)	(.184)	(.085)	(.143)	(.026)	(.089)	(.086)	(.036)
Treat 5 (HRRSR)	-.015	.047	-.016	.011	.019	.018	-.243***	.070
	(.020)	(.041)	(.015)	(.017)	(.023)	(.024)	(.084)	(.057)
Set 2	-.025	.024	-.012	-.014	.046**	.053**	.045	-.034
	(.019)	(.044)	(.013)	(.018)	(.020)	(.026)	(.028)	(.041)
Set 3	-.016	.072	-.008	-.038	.033**	.034**	.040*	-.068*
	(.017)	(.049)	(.014)	(.025)	(.015)	(.017)	(.024)	(.039)
Female	-.015	-.014	-.014	-.001	-.035**	-.038*	-.032	.055*
	(.017)	(.039)	(.013)	(.016)	(.018)	(.022)	(.021)	(.033)
English 1st Lang	.038*	.063	.032	-.020	.015	.006	.003	.082**
	(.021)	(.048)	(.020)	(.019)	(.016)	(.019)	(.023)	(.038)
Grade "B" range	.032*	.040	.022	.001	-.009	-.011	.000	.012
	(.017)	(.040)	(.014)	(.018)	(.012)	(.017)	(.010)	(.030)
Grade "C" range	.037	.173**	.003	.001	-.004	-.028	.280***	.036
	(.030)	(.088)	(.011)	(.038)	(.021)	(.021)	(.094)	(.078)
Trust Others	-.004	-.008	-.003	.005	.001	.002	-.002	.006
	(.003)	(.008)	(.004)	(.005)	(.002)	(.003)	(.004)	(.006)
Age	-.000	-.005	.000	.004	.000	-.001	.001	.001
	(.002)	(.003)	(.002)	(.004)	(.001)	(.002)	(.001)	(.003)
No. Others	.005	.022	.001	-.004*	.005	.004	.013	-.003
Recognized	(.003)	(.016)	(.001)	(.002)	(.003)	(.004)	(.010)	(.003)
Taken Econ	-.006	.002	.002	.003	-.031	-.043	-.030	-.043
	(.022)	(.047)	(.016)	(.022)	(.020)	(.024)	(.032)	(.042)
Taken Stats	.008	.013	.007	.024	.012	.023	-.013	.063
	(.020)	(.043)	(.011)	(.022)	(.016)	(.019)	(.023)	(.048)
N[2]	572	252	422	294	516	422	262	321
R Square	.082	.197	.230	.203	.190	.269	.298	.152

[1] Standard errors clustered to the individual.

[2] N is less than 702 in loan repayment regressions because some individuals experienced LLL earnings in period 1 of a set, or did not experience a given earnings configuration during a set, or demographics are missing.