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Microfinance Games[†]

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Microfinance banks use group-based lending contracts to strengthen borrowers' incentives for diligence, but the contracts are vulnerable to free-riding and collusion. We systematically unpack microfinance mechanisms through ten experimental games played in an experimental economics laboratory in urban Peru. Risk-taking broadly conforms to theoretical predictions, with dynamic incentives strongly reducing risk-taking even without group-based mechanisms. Group lending increases risk-taking, especially for risk-averse borrowers, but this is moderated when borrowers form their own groups. Group contracts benefit borrowers by creating implicit insurance against investment losses, but the costs are borne by other borrowers, especially the most risk averse. (*JEL* D82, G21, G31, O16)

Banking in low-income communities is a notoriously difficult business. Banks typically have limited information about their customers and often find it costly or impossible to enforce loan contracts. Customers, for their part, frequently lack adequate collateral or credit histories with commercial banks. Moral hazard and adverse selection, coupled with small transaction sizes, limit the possibilities for banks to lend profitably. Despite these obstacles, over the past three decades microfinance practitioners have defied predictions by finding workable mechanisms through which to make small, uncollateralized loans to poor customers. Repayment rates on their unsecured loans often exceed 95 percent, and by 2007—the year after Muhammad Yunus and Grameen Bank won the Nobel Peace Prize—microfinance institutions were serving about 150 million customers around the world. This achievement has been exciting to many, and advocates describe microfinance as a revolutionary way to reduce poverty (Muhammad Yunus 1999). From a theoretical perspective though, the success has puzzling elements. Many microfinance mechanisms rely on groups of borrowers to jointly monitor and enforce contracts

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themselves. However, group-based mechanisms tend to be vulnerable to free-riding and collusion. In the absence of "dynamic incentives," which raise the costs of default by denying borrowers in arrears access to future loans, it is not obvious that group lending mechanisms should out perform individual liability alternatives.

In this paper, we explore the impact of a variety of individual and group lending mechanisms on investment decisions within a controlled laboratory environment, conducting a series of experimental "microfinance games" which allow us to unpack microfinance mechanisms in a systematic way. We set up an experimental economics laboratory in a large, urban market in Lima, Peru, where we conduct a framed field experiment with microenterprise owners and employees.[1] Within the lab setting, we examine the ways that contracts affect default rates by enabling partners to insure one another, and by creating social costs to individual default. The idea that "joint-liability" contracts can mitigate moral hazard in project choice by creating social costs to default is central to the idea of group lending in microfinance (e.g. Joseph E. Stiglitz 1990, Timothy Besley and Stephen Coate 1995). Our experimental setting is inspired by Stiglitz's (1990) model of ex ante moral hazard in project choice in microfinance; we extend the model to consider the impact of introducing opportunities for monitoring, coordination, and enforcement. The closest work to this in terms of methodology is Greg Fischer (2008), who creates a laboratory experiment in Chennai, India, to test similar questions about how joint liability influences risk taking and informal insurance. He finds that joint liability facilitates informal insurance among borrowers, allowing them to make profitable but risky investments.[2]

The simulated microfinance transactions involved players receiving loans, choosing between risky and safe investments, and managing the risk of default. We made the risky investment choice socially optimal. Proponents of microcredit often claim that small loans *cause* the growth of businesses, but the evidence suggests such impacts are substantially smaller than proponents claim, if they exist at all (Abhijit V. Banerjee et al. 2009; Dean S. Karlan and Jonathan Zinman 2009a). Thus, it is a relevant policy question whether contract structure inhibits risk-taking, which could lead to transformative growth from the microentrepreneurial sector. Over 7 months of experimental sessions, we played each of ten variants of the microfinance game an average of 29 times. Subjects were small-scale entrepreneurs in an urban Peruvian market, and thus had demographic and economic profiles similar to those of microfinance customers. By working in Lima and designing the games to replicate actual microfinance scenarios, our aim was to explore behavioral responses to common components of micro-loan contracts in a population of individuals likely to participate in an actual microfinance program. Furthermore, by playing a sequence of games with the same individuals, we are able to control for innate risk preferences and isolate the impact of each lending mechanism on risk-taking and loan repayment.

[1] Glenn W. Harrison and John A. List (2004) coin the term "framed field experiment" to refer to experiments which use non-standard subject pools and add a "field context" familiar to the subjects to the commodity or task in the experiment. Early examples in other settings include John A. List (2004) and Abigail Barr and Bill Kinsey (2002).

[2] In a related paper, Alessandra Cassar, Luke Crowley, and Bruce Wydick (2007) conduct a series of repeated public goods games, framed as a decision to repay a loan, in South Africa and Armenia in order to relate contributions to likely behavior in a microfinance setting.

We find that adding dynamic incentives to any loan contract decreases the rate of risky project choice and default. In contrast to many of the predictions from theoretical work on microfinance, we find that joint liability increases rates of risky investment choice when borrowers are able to communicate freely, and has little effect on behavior in the absence of communication. This result may seem counterintuitive, since several well-known models of joint liability lending predict a reduction in the rate of risky project choice under group lending. However, since borrowers investing in the safe project are more likely to have funds with which to repay their loans, they are also more likely to be forced to repay the loans of defaulting partners. For this reason, our model predicts that risk averse borrowers, who would choose low-risk, low-return investments under individual liability, will switch to the risky investment under joint liability whenever they are matched with a less risk-averse liability partner. Much of the behavioral change we observe occurs among the most risk-averse borrowers, who are significantly more likely to choose risky investments when matched with more risk-loving liability partners. However, in spite of these effects on project choice, joint liability increases the loan repayment rate by forcing borrowers to insure each other—passing the cost of limited liability back to the microfinance clients. These costs fall most heavily on the most risk averse, as they are the most likely to have to subsidize their partners' risk-taking. Consistent with this pattern, we find evidence of assortative matching when borrowing groups form endogenously; the most risk-averse borrowers, in particular, tend to form homogeneously conservative liability groups (as in Maitreesh Ghatak 1999).

The rest of the paper is organized as follows. Section I presents the theoretical underpinnings of the microfinance game and derives testable predictions under the different loan contracts explored in the experimental sessions. Section II describes our experimental design, protocol, and subject pool. Section III discusses our findings and Section IV concludes.

I. Theoretical Framework

Consider an extended version of the Stiglitz (1990) model of moral hazard in which agents make repeated project choice decisions. In every period that a borrower is active, she receives a loan of $L > 0$ which she can invest in one of two projects: a safe, low-return project which generates profit $Y_s > 0$ with certainty, or a profitable but risky venture which succeeds with probability p, yielding profit Y_r; with probability $1 - p$, the risky project fails and generates no income.

In Stiglitz's model, as in much of the theoretical work on microfinance, safer projects are assumed to have higher expected returns than riskier projects, and, consequently, the bank's optimum coincides with the social optimum.[3] In that context, an optimal contract induces safe project choice. We relax this assumption for several reasons. First, the assumption that risky projects have higher expected returns than safe projects is more realistic (David de Meza and David Webb 1990). One objective in expanding financial access is to enable borrowers to make risky but profitable

[3] See also Abhijit V. Banerjee, Timothy Besley, and Timothy W. Guinnane (1994), and Malgosia Madajewicz (2004).

investments—and the structure highlights this possibility. Second, it is reasonable to assume that microentrepreneurs must be compensated for bearing investment risk (Fischer 2008). Our pilot games suggested that when expected returns from both projects were equal, almost all subjects chose the safe one. We decided to calibrate the payoff to the risky project so that roughly equal numbers of participants would choose the safe and the risky project in the benchmark games.

ASSUMPTION 1: *The risky project is assumed to be socially optimal:* $pY_r > Y_s$.

There are three types of borrowers in the population, indexed by their degree of risk aversion. There is proportion λ_i of borrowers with risk aversion θ_i, where $\theta_1 > \theta_2 > \theta_3$. Proportions λ_i are common knowledge. Borrowers maximize their streams of expected utilities, discounting the future at rate $\delta < 1$. Individual preferences over payoffs in each period are represented by the utility function $u_i(y_i)$, where $u_i'(y_i) > 0$, $u_i''(y_i) < 0$, and $u_i(0) = 0$ for all i. Borrower i thus maximizes discounted utility: $\sum_{t=1}^{\infty} \delta^{t-1} E[u_i(y_i)]$.

We focus on individual project choice and abstract from ex post moral hazard and strategic default considerations: the success probability p is fixed, and the loan amount L is automatically deducted from the profits of successful projects. However, borrowers have no collateral, so the lender is not repaid if the project fails. Thus, while socially optimal, the bank may suffer a loss if the risky project is chosen.

Because the bank is uninformed about borrower types (as in Ghatak 1999, Maitreesh Ghatak 2000), borrower project choices (as in Stiglitz 1990), and actual profits obtained (as in Ashok S. Rai and Tomas Sjöström 2004), it cannot offer state and type contingent contracts which would be optimal under full information. In that case, banks would encourage borrowers to choose the risky project, regardless of type, and would provide insurance in case of default.[4] Even in the private information world we consider, the bank could simply set the interest rate high enough to make the safe project unattractive. All borrowers would then be induced to choose the risky project and would repay whenever their projects were successful. However, the bank cannot raise interest rates when faced with competition, since other lenders would undercut the interest rate until it coincided with the cost of funds, which we assume to be zero. Moreover, if potential borrowers had an alternative to borrowing, an increase in the interest rate could make borrowing unattractive for the most risk averse agents, who are likely to be the poorest and most marginalized.

The bank may, however, offer loan contracts with a joint-liability clause; the loan contract may also include a "dynamic incentive" clause which excludes defaulting borrowers from future borrowing.[5] In what follows, we examine the impact of dynamic incentives on project choice and bank repayment, first under individual liability and then in the joint-liability setting under different information structures.

[4] We thank an anonymous referee for pointing this out.

[5] Jonathan Morduch (1999) and Gwendolyn Alexander Tedeschi (2006) discuss the use of dynamic incentives in microfinance. Xavier Giné, Jessica Goldberg, and Dean Yang (2010) describe a randomized field experiment in rural Malawi that examines the impact of fingerprinting borrowers, allowing the lender to use dynamic incentives more effectively.

A. *Individual-Liability Borrowing*

We first consider the case of individual liability, wherein the borrower is only liable for the loan she takes. In the absence of the dynamic incentive clause, a borrower will invest in the risky project in a given period whenever

$$u_i(Y_s - L) \leq p u_i(Y_r - L). \tag{1}$$

Similarly, a borrower will always invest in the risky project when the loan contract includes a dynamic incentive whenever

$$\left(\frac{1 - p\delta}{1 - \delta}\right) u_i(Y_s - L) \leq p u_i(Y_r - L) \tag{2}$$

since a borrower who always chooses the risky project is still a client of the lender in period t with probability p^{t-1}.

Equation (2) implies equation (1), so if borrower i chooses to invest in the safe project in the absence of dynamic incentives, she will also do so when they are imposed. Similarly, if borrower i chooses to invest in the risky project under dynamic incentives, she will also do so when they are absent. Players that are particularly risk averse always invest in the safe project under individual liability. We refer to these individuals as θ_1-borrowers, and define them as borrowers for whom equation (1), and therefore equation (2), does not hold. We define θ_2-borrowers as those for whom equation (1) holds but (2) does not. Lastly, we define θ_3-borrowers as the least risk-averse group. For them, both equations hold. θ_3-borrowers never invest in the safe project under individual liability, while θ_2-borrowers do so only when defaulters are excluded from future loans.

The first row of Table 1 reports the expected rates of risky project choice and loan repayment for the individual liability contract. When dynamic incentives are imposed, we distinguish between *unconditional* rates, calculated with respect to the initial population (thus including participants who have defaulted and are excluded from the remainder of the game), and *conditional* rates among active borrowers who have not defaulted. Dynamic incentives increase the proportion of individuals who choose the safe project, and therefore the repayment rate, but the increase is not without cost. Half of the lender's active θ_3-borrowers are excluded from future borrowing in every period because of default. Moreover, θ_2-borrowers experience lower expected profits and utility because they switch to the safe but low return investment to avoid exclusion from future loans.

B. *Joint-Liability Borrowing*

In the benchmark joint-liability treatment, each borrower is randomly matched with another. When one of the two borrowers has an unsuccessful project, the successful one must repay both loans. A default only occurs when both members of a

Table 1—Theoretical Predictions

		Without dynamic incentives	With dynamic incentives	
Conditional/unconditional?		Both	Unconditional	Conditional
Panel A. Expected rate of risky project choice				
Individual liability	$t \geq 1$	$1 - \lambda_1$	$p^{t-1}(1 - \lambda_1 - \lambda_2)$	$\frac{p^{t-1}(1 - \lambda_1 - \lambda_2)}{p^{t-1} + (1 - p^{t-1})(\lambda_1 + \lambda_2)}$
Joint liability (JL)	$t = 1$	$1 - \lambda_1$		
JL	$t > 1$	$(1 - \lambda_1)[1 + \lambda_1(1 - p^{t-1})]$		
JL + M	$t = 1$	$1 - \lambda_1$	—	—
JL + M	$t > 1$	$1 - \lambda_1^2$	—	—
JL + M + C	$t \geq 1$	$1 - \lambda_1^2$	—	—
JL + M + C + PC	$t \geq 1$	$1 - \lambda_1$	—	—
Panel B. Expected repayment rate				
IL	$t \geq 1$	$\lambda_1 + p(1 - \lambda_1)$	$p^t + (1 - p^t)(\lambda_1 + \lambda_2)$	$\frac{p^t + (1 - p^t)(\lambda_1 + \lambda_2)}{p^{t-1} + (1 - p^{t-1})(\lambda_1 + \lambda_2)}$
JL	$t = 1$	$1 - (1 - \lambda_1)^2(1 - p)^2$	—	—
JL	$t > 1$	$1 - [(1 - \lambda_1)^2 + 2\lambda_1(1 - \lambda_1) \times (1 - p^{t-1})](1 - p)^2$	—	—
JL + M	$t = 1$	$1 - (1 - \lambda_1)^2(1 - p)^2$	—	—
JL + M	$t > 1$	$1 - (1 - \lambda_1^2)(1 - p)^2$	—	—
JL + M + C	$t \geq 1$	$1 - (1\ \lambda_1^2)(1 - p)^2$	—	—
JL + M + C + PC	$t \geq 1$	$1 - (1 - \lambda_1)^2(1 - p)^2$	—	—

Note: Rates of risky project choice and repayment in joint-liability games with dynamic incentives are predicted to be weakly lower and higher, respectively, than in analogous games without dynamic incentives.
See definition of (m, c, pc) in Figure 2.

borrowing group have unsuccessful projects. We assume that the return on the safe project exactly covers both loans:

ASSUMPTION 2: *Profits from the safe project satisfy:* $Y_s - 2L = 0$.

Under joint liability, the borrower's expected utility depends on both her own actions and those of her partner. Figure 1 shows the single period choice-contingent expected payoffs of a θ_i-type borrower matched with a θ_j-type partner.

	Safe	Risky
Safe	EU_i^{SS}, EU_j^{SS}	EU_i^{SR}, EU_j^{RS}
Risky	EU_i^{RS}, EU_j^{SR}	EU_i^{RR}, EU_j^{RR}

Figure 1. Per Period Joint-Liability Game Payoff Matrix

The different payoffs are defined as follows: $EU_i^{SS} = u_i(Y_s - L)$, $EU_i^{RS} = pu_i(Y_r - L)$, $EU_i^{SR} = pu_i(Y_s - L)$ and $EU_i^{RR} = p^2u_i(Y_r - L) + p(1 - p)u_i(Y_r - 2L)$. Throughout the analysis, we use the notation EU_i^{AB} to denote the period payoff to a

θ_i-type borrower that chooses project A when her partner chooses project B. Notice that $EU_i^{SS} > EU_i^{SR}$ and $EU_i^{RS} > EU_i^{RR}$ for all i.

In order to sharpen the predictions from the model, we make two additional assumptions about the types and the payoff structure:

ASSUMPTION 3: $Y_R > 3L$,

and

ASSUMPTION 4: $\nexists\, \alpha \in [0,1]$ *such that* $\alpha EU_i^{SR} + (1-\alpha)EU_i^{SS} > EU_i^{RR}$ *for* $i = 1$ *and* $\alpha EU_i^{RS} + (1-\alpha)EU_i^{SS} > EU_i^{RR}$ *for* $i \in \{2,3\}$.

Assumption 3 guarantees that investing in the risky project is the unique best response to a partner who invests in the risky project with certainty. Consequently, risky choice by all borrowers constitutes a Nash equilibrium of any joint-liability borrowing game without dynamic incentives, but one that is undesirable from the perspective of risk-averse θ_1-borrowers. We refer to this outcome as the "all-risky" equilibrium. θ_1-borrowers strictly prefer an "all-safe" outcome to any other and are not tempted to "defect" on their partners since $EU_1^{SS} > EU_1^{RS}$.[6] Assumption 4 guarantees that type θ_2- and θ_3-borrowers, on the other hand, invest in the risky project with probability one in any Nash equilibrium of any game without dynamic incentives.

Joint Liability without Dynamic Incentives.—We are now ready to characterize the Nash equilibrium of any joint-liability borrowing game with or without dynamic incentives. We focus on equilibria which are symmetric in the sense that borrowers of the same risk-aversion type employ the same strategy.

PROPOSITION 1: *Given Assumption* 4, *a* θ_2*- or* θ_3*-borrower invests in the risky project in all rounds in any subgame perfect equilibrium of a joint-liability game without dynamic incentives.*

PROOF:
See Appendix.

Anticipating the experimental treatments described in the next section, we consider three distinct informational structures in the joint-liability borrowing game. Much of the literature on joint liability argues that borrowers have a comparative advantage in monitoring one another, relative to the lender; costless and full information between borrowers facilitates punishment of risky project choice (Banerjee, Besley, and Guinnane 1994; Besley and Coate 1995) and coordination of actions within liability groups (Stiglitz 1990). We first consider the joint-liability borrowing game with communication, in which members of a liability group can communicate and observe each others' actions ex ante. This allows them to reveal their preferences and coordinate project choices. This information structure is motivated

[6] This expression is analogous to equation (1).

by (Stiglitz 1990), in which borrowers play a cooperative game. We then consider a monitoring game, motivated by Banerjee, Besley, and Guinnane (1994); Besley and Coate (1995); and Maitreesh Ghatak and Timothy W. Guinnane (1999) where borrowers cannot communicate ex ante but can observe each others' actions ex post. We contrast these two informational structures with the more restrictive imperfect information benchmark, where a borrower only learns that her partner chose the risky project when it fails and the partner defaults. This framework allows us to separate the direct impacts of the joint-liability contract from the informational structure often assumed to accompany group lending. Finally, motivated by the literature on adverse selection (Ghatak 1999; Ghatak 2000; Loïc Sadoulet 2000; Loïc Sadoulet and Seth B. Carpenter 2001), we consider a partner-choice game where borrowing groups form endogenously, as opposed to being randomly assigned. Players in the partner-choice games sit together and communicate freely, as in the communication treatment.

Communication: In the communication game, the partner's type and project choice are known ex ante. This allows θ_1-borrowers to coordinate on the all-safe outcome, and to avoid choosing the safe project when matched with θ_2- or θ_3-borrowers. Thus, there exists a subgame perfect Nash equilibrium in which θ_1-borrowers choose the safe project in every round if and only if they are matched with another θ_1-borrower, and all other borrowers choose the risky project in every round.[7] The expected repayment rate (reported in Table 1) highlights the fact that the probability of default when both borrowers in a group choose the risky project is only $(1 - p)^2$ because the probability of failure is uncorrelated across projects, and the joint-liability clause requires borrowers to insure each other.

Monitoring: Next, we consider the monitoring treatment, in which borrowers cannot communicate with each other but can observe one another's past actions. Since partners are randomly assigned, a borrower does not know her partner's type ex ante. For sufficiently high discount factors, a Nash equilibrium exists in which each θ_1-borrower plays the following "grim" trigger strategy: invest in the safe project until one's partner chooses the risky project, then switch to the risky project forever. If all θ_1-borrowers play this grim strategy, it will be optimal for them as long as the expected gain to choosing safe, and signaling a willingness to coordinate away from the all-risky equilibrium, is greater than the expected cost if one's partner is not type θ_1. This is true whenever the following expression holds:

$$\lambda_1\left(\frac{1}{1-\delta}\right)EU_1^{SS} + (1-\lambda_1)\left[EU_1^{SR} + \left(\frac{\delta}{1-\delta}\right)EU_1^{RR}\right] \geq \lambda_1\left[EU_1^{RS} + \left(\frac{\delta}{1-\delta}\right)EU_1^{RR}\right] + (1-\lambda_1)\left(\frac{1}{1-\delta}\right)EU_1^{RR}. \tag{3}$$

[7] Though other equilibria exist (such as the all-risky equilibrium, for example), a joint-liability group of two θ_1-borrowers strictly prefers the all-safe equilibrium to the all-risky one. We therefore predict that they will coordinate on the safe investment.

Assumptions 3 and 4, together with a high enough discount factor δ, guarantee that equation (3) holds even when θ_2- and θ_3-borrowers never invest in the safe project. Since a positive fraction of subjects chose the safe project in all monitoring treatments in our experimental sessions, we infer that the discount factor δ is such that equation (3) holds.[8]

Imperfect Information: Next, we consider the imperfect information treatment where one's partner's type and actions are unobservable. In this case, a borrower only learns that her partner has chosen the risky project when it fails and she has to repay the partner's loan (provided she has the funds to do so). When the following expression holds, a subgame perfect equilibrium exists wherein every θ_1-borrower chooses the safe project until her partner defaults:

$$(4)\quad \lambda_1\left(\frac{1}{1-\delta}\right)EU_1^{SS} + (1-\lambda_1)\left(\frac{1}{1-p\delta}\right)\left[EU_1^{SR} + (1-p)\left(\frac{\delta}{1-\delta}\right)EU_1^{RR}\right] \geq \lambda_1\left(\frac{1}{1-p\delta}\right)\left[EU_1^{RS} + (1-p)\left(\frac{\delta}{1-\delta}\right)EU_1^{RR}\right] + (1-\lambda_1)\left(\frac{1}{1-\delta}\right)EU_1^{RR}.$$

Intuitively, after every period without a default, a θ_1-borrower revises up her belief that her partner is also a θ_1-borrower. Thus, if it was optimal to choose safe in the first period, it will also be optimal in subsequent periods until a default is observed.

For a given discount factor δ, equation (4) is more likely to bind than equation (3). If equation (3) held but equation (4) did not, one would only observe risky project choices in the imperfect information game. Since safe project choices were observed in all of our experimental sessions, we assume that equation (4) also holds. The predicted rate of risky project choice and repayment in this equilibrium are reported in Table 1.

Partner Choice: When borrowers are allowed to choose their joint-liability partners, θ_1-borrowers will choose other θ_1-borrowers, because these individuals strictly prefer the all-safe equilibrium to any other. Consequently, as Table 1 shows, the predicted rate of risky project choice in a partner-choice game after the first period is the lowest among all joint-liability games without dynamic incentives considered.

Dynamic Incentives.—The cost of default increases under dynamic incentives, rendering the all-risky equilibrium less attractive. Simple symmetric strategies that constitute a Nash equilibrium exist for the communication game and the

[8] If this were not the case, no borrower would find it optimal to invest in the safe project in the initial period and, because beliefs would never be updated, it would remain sub-optimal in subsequent periods.

partner-choice game. Though similar strategies exist for monitoring and imperfect information games, there is a potential for coordination failure when partners cannot communicate.

Communication: Communication allows borrowers to coordinate actions ex ante, so individual borrowers can coordinate so as to invest in the risky project in specific periods without risking a group default. For a homogenous pair of θ_1-borrowers, this does not matter because the safe project is the preferred choice and one supported by a subgame perfect Nash equilibrium for any discount factor, as it is in the absence of dynamic incentives. For a pair of θ_2- or θ_3-borrowers with sufficiently high discount factors, however, a wide range of subgame perfect equilibria may exist under dynamic incentives which are not supported when dynamic incentives are absent. Two examples are the all-safe equilibrium and the "alternating equilibrium" in which borrowers take turns investing in the risky project. Type θ_2- and θ_3-borrowers prefer the alternating to the all-risky equilibrium whenever

$$(5)\quad \left(\frac{1}{1-\delta^2}\right)(EU_i^{SR}+\delta EU_i^{RS}) \geq \left(\frac{1}{1-\delta(2p-p^2)}\right)EU_i^{RR}, \quad \text{for } i=2,3.$$

This equation also characterizes the one deviation property that needs to be satisfied whenever θ_2- and θ_3-borrowers are paired with each other because the only profitable deviation involves choosing the risky investment when it is one's partner's turn to do so. Because $EU_1^{SS} > EU_1^{RS}$, the alternating equilibrium is not subgame perfect in heterogeneous pairs (θ_1-borrowers matched with either θ_2- or θ_3-borrowers); a θ_1-borrower's best response to an alternating partner is to invest in the safe project in every period. If θ_1-borrowers can still credibly commit to revert to the all-risky equilibrium, then an equilibrium may exist in which each θ_1-borrower matched with a θ_2 or θ_3 partner invests in the safe project in every period while the partner alternates between the safe and risky projects.[9]

Given the multiplicity of equilibria, it is impossible to precisely characterize the expected rate of risky project choice or default in the communication game with dynamic incentives. However, the existence of *any* subgame perfect equilibrium other than the all-risky one implies a (weakly) lower level of risky project choice. Moreover, since these alternative equilibria are supportable only because they reduce the probability of default and exclusion from future periods of borrowing, their existence clearly implies weakly higher expected repayment rates. All pairings of borrowers, that chose the safe project in the absence of dynamic incentives, continue to do so. Other borrowers that chose the risky project when dynamic incentives were absent, may now choose the safe project.

Monitoring and Imperfect Information: When borrowers cannot coordinate their project choices ex ante, the alternating equilibrium, and other potential equilibria

[9] If θ_1-borrowers cannot credibly commit to reverting to the all-risky equilibrium, then the unique subgame perfect equilibrium involves safe choices by the θ_1-borrower in all periods and risky choices by the partner.

involving coordinated timing of risky project choices, may be difficult to achieve. It is reasonable to assume that θ_1-borrowers continue to employ grim trigger strategies (if they are credible), although perhaps with higher thresholds for defection to risky project choice, that is, allowing θ_2- or θ_3-borrowers to choose the risky project in some rounds, but not too many consecutively. If equation (3) and equation (4) both hold when dynamic incentives are absent, they must also hold when they are imposed, because dynamic incentives reduce EU_1^{RR} without affecting the other expected payoffs. This suggests that rates of risky project choice (and repayment) should again be weakly lower (higher) than in the absence of dynamic incentives. However, there is no clear prediction for the behavior of θ_2- or θ_3-borrowers. Risk aversion might lead to safe project choice when the probability that one's partner chooses the risky investment is unknown, but the inability to coordinate might cause borrowers to revert to the all risky equilibrium.

Partner Choice: When borrowers can choose their partners, θ_1-borrowers will still prefer a partner of the same type, and thus homogeneous groups will be formed. As discussed above, however, pairs of θ_2 or θ_3-borrowers may choose an equilibrium other than the all-risky one.

Summary of Predictions.—We now summarize the predictions across liability and information structures using Table 1. When dynamic incentives are imposed, the rate of risky project choice is predicted to be weakly lower, and the repayment rate weakly higher.

A more nuanced set of predictions arises in the various joint-liability treatments without dynamic incentives. Under the communication treatment, participants know the investment strategies of their partners from the start of the game. In the monitoring and imperfect information treatments, there is no direct communication during the game and learning takes place over time. Thus, the theory predicts that in the first period of a given joint-liability game, risky project choice is higher under the communication treatment than under the monitoring or imperfect information and partner choice treatments. The first period choices under the latter games should all coincide with choices under individual liability. The reason is that under communication, θ_1-borrowers will never choose the safe project if their partner's *type* is θ_2 or θ_3, but under monitoring and imperfect information, all θ_1-borrowers choose the safe project in the first period even if matched with a θ_2 or θ_3-borrower. After the first period, the rate of risky project choice under communication and monitoring coincide since θ_1-borrowers switch to risky choice if matched with a θ_2- or θ_3-borrower. Under imperfect information, the rate of risky project choice will increase steadily over time and will converge to choices under the communication or monitoring treatments, as θ_1-borrowers matched with a θ_2- or θ_3-borrower eventually switch to the risky choice if they infer that their partner is choosing risky.[10] Finally, our model predicts that under partner choice, θ_1-borrowers will pair with other θ_1-borrowers, since these individuals have higher

[10] Note that players are not rematched after each round, so each individual updates her beliefs about her partner's type over the course of the game.

	Games without dynamic incentives	Games with dynamic incentives (D)
Individual liability (IL)	IL game	Dynamic × IL game
Joint liability (JL)	JL game	Dynamic × JL game
+ Monitoring (M)	JL + M game	Dynamic × (JL + M) game
+ Communication (C)	JL + M + C game	Dynamic × (JL + M + C) game
+ Partner choice (PC)	JL + M + C + PC game	Dynamic × (JL + M + C + PC) game

Figure 2. Experimental Treatments of the Microfinance Game

expected utility in homogeneous matchings, when they are able to coordinate on the all-safe equilibrium.

II. Experimental Design and Procedures

A. *The Microfinance Game*

To test the predictions of the model, we designed the "microfinance game," an economic experiment that mimics the essential features of the theoretical framework described above. Games consisted of multiple rounds of borrowing and repayment.[11] In each round, experimental subjects were given a "loan" of 100 points which they invested in one of two projects: a safe project, which yielded a return of 200 points with certainty; or a riskier project, which paid 600 points with probability one half and zero otherwise.[12] A borrower whose project succeeded had to repay her loan and the loan amount was automatically deducted from project earnings. A borrower whose project failed could not repay her loan, as wealth from prior rounds could not be used to pay off the current round's loan. Thus, limited liability introduces the possibility that risk averse borrowers might choose the risky project to reduce their individual repayment cost. In each round, the safe project had an expected (and certain) net return of 100 points after repaying the principal. The risky project had an expected net return of 250 points, but a fifty percent probability of default. Points accumulated over the course of all of the rounds determined individual game payouts.

We conducted ten experimental treatments, summarized in Figure 2, which mimic the contract and information structures described in Section I. Treatments differ both in terms of the "loan contract" characterized by the rules of the experimental session—individual or joint liability, with or without dynamic incentives—and the extent to which borrowers within joint-liability groups were allowed to communicate

[11] Players were informed that games would consist of at least two and no more than ten rounds, and that the probability of a game ending after any round depended on chance. Thus, the probability that the game ended after any round was ambiguous. This was done to avoid games that continued for an unreasonably long period of time. An alternative would be to announce a specific probability that the game ends after each round, and adhere to that strictly regardless of the outcome. This, however, has the advantage of being more explicit analytically. Fischer (2008) adopts this approach.

[12] At no time during the games did we refer to the choices as "safe" and "risky"—within the experiment, the projects were referred to as "Project Square" and "Project Triangle," respectively.

Project choices (safe/risky)		Project outcomes (success/failure)				
Borrower's	Partner's	Borrower's	Partner's	Probability	Borrower's net payout	Default? (Y/N)
Safe	Safe	Success	Success	1	100	N
	Risky	Success	Success	0.50	100	N
			Failure	0.50	0	N
Risky	Safe	Success	Success	0.50	500	N
		Failure		0.50	0	N
	Risky	Success	Success	0.25	500	N
			Failure	0.25	400	N
		Failure	Success	0.25	0	N
			Failure	0.25	0	Y

Figure 3. Payouts, Outcomes in Joint-Liability Treatments

or observe each others' actions. In games without dynamic incentives, subjects were allowed to continue playing whether or not they repaid their loans in all previous rounds. In games including a dynamic incentive, subjects who defaulted in any round were forced to sit out the remaining rounds of the game.[13]

As Figure 2 indicates, we conducted two individual liability treatments: one with dynamic incentives and one without dynamic incentives. Payoffs in the individual liability treatments depended only on player choices and chance. We also conducted nine joint-liability treatments, reflecting the range of information structures considered in Section I. In each joint-liability treatment, subjects were randomly matched with anonymous borrowing partners;[14] players were then made liable for the loans of their defaulting partners. The structure of payouts within these treatments is described in Figure 3. For each of the main information structures described in Section 1—imperfect information, monitoring, communication, and partner choice—we conducted two experimental treatments, one with and one without dynamic incentives. The distinct treatments allow us to "unpack" the relative impact of the distinct components of the information structure in joint-liability settings with and without dynamic incentives.

In the imperfect information and monitoring treatments, subjects were not allowed to communicate during the game. In the imperfect information treatments, players learned the outcome of their chosen project and their net earnings at the end of each round. They were consequently able to infer that their partner had chosen the risky project and defaulted when 200 points (rather than 100) were deducted from their earnings. In monitoring treatments, each player was informed which project her partner had chosen at the end of each round—this information was reported with an individual's project outcome and net earnings. In the communication treatments,

[13] Defaulters were asked to indicate the fact that they had defaulted on their experimental decision sheets, just as other players indicated their project choices. Hence, whether a subject had defaulted was not publicly observable.

[14] Except in communication and partner choice treatments (discussed below), subjects did not learn the identities of their partners during or after the experiment.

players were assigned to seats so as to be situated next to their partners. They were then allowed to talk (quietly) during the experiment and could observe partners' decision sheets. Finally, in the partner-choice treatments, players were instructed to form joint-liability pairs before the game began. They were given time to circulate the room while the matching process took place, so that they could exchange information with potential partners.

B. *Experimental Procedures*

We conducted the microfinance games as a framed field experiment which we played with owners and employees of microenterprises in Lima, Peru. We set up an experimental lab in an isolated room in a large consumer market, Polvos Azules, located in the center of the city. Each experimental session consisted of two or three game treatments played in random order and followed by a social networks survey. At the beginning of each treatment, subjects were given decision sheets marked with spaces for each of the rounds. The rules for each game were explained to all the participants simultaneously. Instructions were presented orally, in Spanish, with the aid of posterboards highlighting the key points specific to the particular experimental treatment. In each round, subjects indicated their project choices on their game sheets. Game sheets were then collected by members of the research team, who entered project choices into a computer, which then calculated payouts for the round. Game sheets were returned to players at the end of the round. Payouts were made at the end of each experimental session, after all the games were completed. Subjects were paid a show-up fee plus their total earnings from all of the days experimental treatments.[15]

In all treatments, game decision sheets indicate whether a subject's project in the previous round was successful, and report net earnings for the round. In individual liability and (joint liability) imperfect information treatments, this is the only information that players receive. In contrast, in monitoring treatments, each participant also receives complete information about her partner's project choice and outcome at the end of each round—these are also included on each player's game sheet. Hence, ex post monitoring is costless and automatic. As in the other joint-liability treatments with imperfect information, partner identities are never revealed during or after the game. In communication treatments, participants still have no choice in group formation because partners are randomly assigned, but partners sit together and are allowed to talk during the course of the game. Joint-liability groups are announced at the beginning of the game, and seats are rearranged accordingly. Each participant knows both the identity of her partner and the action that her partner takes in every round. Finally, in partner-choice treatments, players are instructed to

[15] The show-up fee was 10 Peruvian nuevos soles, worth approximately $2.98 in July 2004. Observed earnings ranged from 10 to 20 soles. Subjects were paid their total earnings over the course of the game, rather than earnings from a single randomly chosen round. Susan K. Laury (2005) provides evidence that paying for all rounds, rather than a single randomly-chosen round, does not influence individual risk-taking. This is consistent with the hypothesis that subjects consider decisions within experiments in isolation, even when payouts are made at the end of the lab session.

Table 2—Summary Statistics: Experimental Sessions

	Games played		Average players/game	
Dynamic incentives?	No	Yes	No	Yes
Individual liability	34	36	17.00 (6.633)	18.47 (6.134)
Joint liability (JL)	31	33	18.65 (6.46)	17.49 (6.54)
JL + monitoring (M)	32	28	16.38 (6.86)	17.36 (5.99)
JL + M + communication (C)	22	25	17.73 (6.66)	17.20 (7.42)
JL + M + C + partner choice (PC)	25	23	18.24 (6.51)	15.74 (6.42)

Note: Standard errors in parentheses.

form borrowing groups of two prior to the start of the game, after the instructions are explained.

We played ten different game treatments an average of 29 times each over the course of 7 months (from July of 2004 to February of 2005). Our sample includes data from 321 games played over the course of 81 days. 493 participants played an average of 11 games each. Table 2 describes the allocation of players across games. 238 participants attended only one game session, while 23 participants attended more than ten sessions.

C. *Lab Setting and Subject Pool*

All of our experimental subjects either owned or were employed by a microenterprise in Polvos Azules. The market has approximately 1,800 stalls where vendors sell clothes, shoes, personal items, jewelry, and consumer electronics. We used two methods to recruit participants. First, we hired delegates from the local association of micro-entrepreneurs to invite vendors to specific game sessions. We also allowed participants to return for subsequent experimental sessions, and to invite their friends and neighbors from the market to accompany them.

We also conducted a census of vendors working in Polvos Azules. The market census serves several purposes. First, it allows us to control for demographic and socioeconomic characteristics in our analysis, and to test for heterogeneity in the "treatment effects" of microfinance contract structures across groups. We also use the census data to learn about the matching process in the partner choice treatments. Finally, the census allows us to examine sample selection to determine whether the individuals who participate in our experiments are truly representative of the broader population of micro-entrepreneurs in Polvos Azules. Specifically, we are able to test whether the nature of the games specifically attracts risk-seeking individuals.[16]

[16] Steven D. Levitt and John A. List (2007) discuss the possibility that nonrandom selection into lab experimental subject pools introduces bias. Edward Lazear, Ulrike Malmendier, and Roberto Weber (2006) also consider selection into lab experiments as a possible source of bias.

Table 3—Summary Statistics: Subject Characteristics

	Non-subjects		Subjects		
Variable	Mean	SE	Mean	SE	*P*-value
Female	0.58	(0.01)	0.57	(0.01)	0.68
Age	28.54	(0.29)	34.40	(0.36)	0.00
Married	0.36	(0.01)	0.49	(0.02)	0.00
Years of education	5.55	(0.03)	5.57	(0.03)	0.76
Spanish is second language	0.08	(0.01)	0.11	(0.01)	0.11
Born in Lima	0.53	(0.02)	0.50	(0.02)	0.36
Household size	4.99	(0.07)	4.88	(0.06)	0.43
Assets, appliances owned	3.13	(0.05)	2.86	(0.05)	0.01
Cooks with kerosene	0.06	(0.01)	0.11	(0.01)	0.01
Played lotto, casino past month	0.19	(0.01)	0.18	(0.01)	0.75
At least 2 positive GSS answers	0.05	(0.01)	0.07	(0.01)	0.07
Work experience	7.28	(0.22)	11.37	(0.28)	0.00
Owns microenterprise	0.30	(0.01)	0.50	(0.02)	0.00
Hours worked per week	66.47	(0.43)	63.28	(0.59)	0.01
Number of workers in business	1.74	(0.02)	2.25	(0.03)	0.00
Has government business license	0.76	(0.01)	0.62	(0.01)	0.00
Saves in a commercial bank	0.09	(0.01)	0.07	(0.01)	0.37
Has been involved in a ROSCA	0.60	(0.01)	0.65	(0.01)	0.12
Has had a joint liability loan	0.02	(0.00)	0.06	(0.01)	0.00
Received a loan in past year	0.25	(0.01)	0.39	(0.01)	0.00
Most risk averse (census)	0.38	(0.01)	0.36	(0.01)	0.49
Most least risk averse (census)	0.30	(0.01)	0.33	(0.01)	0.28
Observations	1,104		323		

Note: Standard errors in parentheses.

Demographic summary statistics of our subject pool are provided in Table 3.[17] Approximately half of our subjects own a microenterprise in Polvos Azules; the rest are microenterprise employees. Only 6 percent have experience with group lending, but 65 percent have participated in an informal rotating and saving and credit association (ROSCA). Overall, the data suggest that our participants are not a representative sample of vendors in the market. They are older, more likely to be business owners, poorer (measured by asset ownership and the probability of using kerosene to cook), and more experienced with borrowing. However, there is no evidence that they are more risk-loving than average: both answers to a hypothetical lottery choice question designed to calibrate risk aversion and the probability of gambling or playing the lottery in the past month are similar across the two groups. Relative to the broader population of Polvos Azules, participants score somewhat higher on questions designed to elicit a sense of trust, fairness, and altruism.[18]

[17] Because many market stalls are often closed, we were only able to survey active market stall owners and employees. The survey includes data on 323 of our 493 participants.

[18] The General Social Survey (GSS) contains three questions on "trust," "fairness" and "helping" which purport to measure social capital. The exact wording is as follows: the trust question, "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people?", the fairness question, "Do you think most people would try to take advantage of you if they got a chance, or would they try to be fair?", and the

Since our experiment randomizes contract structure within the games, nonrandom selection will not affect the internal validity of our results. However, selection into our experimental laboratory may alter the external validity of this exercise. To check this, we ran between-effects regressions of individual risky project choice on the set of socioeconomic characteristics and found that, with the exception of the propensity to hold a savings account, the variables do not systematically predict risky play.[19] To further address selection on nonrandom characteristics, we also run all main specifications with individual-level fixed effects, sweeping out the roles of fixed demographic variables, and find that results are robust. The census data also allow us to interact joint-liability contract structure with demographic characteristics, and again we find little evidence that sample selection within pool of individuals working at Polvos Azules alters our results.

III. Results

In this section, we first examine the rate of risky project choice and repayment to the bank across experimental treatments. We then look at whether project choice is affected by individual characteristics, such as gender, age, etc. Next, we turn to the model predictions regarding joint-liability games, that players choice of projects will depend on their type and that of their partners. We then look at the ability to coordinate joint outcomes within liability groups, and at the impact of introducing the ability to punish the partner. Finally, we look at the determinants of partner choice.

Our main findings conform to the theoretical predictions discussed above, though there are several key points of divergence. Not surprisingly, rates of repayment are higher in treatments including dynamic incentives than analogous treatments without them. We also find that adding a joint-liability clause increases the rate of risky project choice, particularly in settings which also include a dynamic incentive clause. Consistent with the model, we find the highest rates of risky project choice in games including communication between borrowing partners; much of this results from changes in behavior by the most risk-averse borrowers, who are more likely to choose the risky project when matched with less risk-averse partners. We also find assortative matching when players are allowed to choose their borrowing partners. The main divergence from our theoretical predictions occurs in the joint-liability games with perfect monitoring, but without communication: though the model predicts rates of

helpful question, "Would you say that most of the time people try to be helpful, or that they are mostly just looking out for themselves?" In cross-country regressions, several studies find that these GSS questions correlate with outcomes of interest. Stephen Knack and Philip Keefer (1997) find correlations with growth; Bruce P. Kennedy, Ichiro Kawachi, Deborah Prothrow-Stith, Kimberly Lochner, and Vanita Gupta (1998) and Daniel Lederman, Norman Loayza, and Ana Maria Menéndez (2002) with crime; John Brehm and Wendy Rahn (1997) with civic involvement; and Raymond Fisman and Tarun Khanna (1999) with communication infrastructure. In experimental economics, Dean S. Karlan (2005) finds that positive answers to the GSS questions predict the repayment of loans one year after the survey, and that positive answers to the GSS questions predict trustworthy behavior in a Trust game (conducted shortly after the GSS questions). Throughout the analysis, the dummy variable "2 positive GSS answers" equals one if an individual answered positively to at least two of the three questions.

[19] Individuals with savings accounts are more likely to choose the risky project in the dynamic games, but, as noted in the text, fixed effects specifications should control for this effect (results not shown).

Table 4—Summary Statistics: Game Outcomes

	Without dynamic incentives	With dynamic incentives	
Conditional/unconditional?	Both	Conditional	Unconditional
Panel A. Rate of risky project choice			
(1) Individual liability games	0.61	0.34	0.24
	(0.01)	(0.01)	(0.01)
(2) Joint-liability (JL) games	0.63	0.49	0.44
	(0.01)	(0.01)	(0.01)
(3) JL + monitoring (M) games	0.61	0.47	0.42
	(0.01)	(0.01)	(0.01)
(4) JL + M + communication (C) games	0.68	0.58	0.50
	(0.01)	(0.01)	(0.01)
(5) JL + M + C + partner choice (PC) games	0.69	0.53	0.46
	(0.01)	(0.01)	(0.01)
Panel B. Repayment rate			
(7) Individual liability games	0.68	0.82	0.58
	(0.01)	(0.01)	(0.01)
(8) Joint-liability (JL) games	0.88	0.94	0.84
	(0.01)	(0.00)	(0.01)
(9) JL + monitoring (M) games	0.90	0.95	0.85
	(0.01)	(0.00)	(0.01)
(10) JL + M + communication (C) games	0.87	0.91	0.78
	(0.01)	(0.01)	(0.01)
(11) JL + M + C + partner choice (PC) games	0.89	0.94	0.82
	(0.01)	(0.01)	(0.01)

Notes: Standard errors in parentheses. The first column reports the mean rate of risky project choice and repayment in the games without dynamic incentives. The second reports average outcomes among currently active borrowers in games with dynamic incentives, while the third column reports the mean outcome rates among all participants. Data are drawn from the first six rounds within each game.

risky project choice which converge to those observe in communication treatments, observed rates more closely track those in game with imperfect information.

A. *Project Choices and Repayment Rates*

We begin by comparing the proportion of borrowers investing in the risky project across the experimental treatments. Summary statistics on rates of risky project choice and loan repayment in the first six rounds of each game are reported in Table 4. As predicted, adding dynamic incentives reduces investment in the risky project in the individual liability treatments (from 61 percent of choices to 34 percent). As discussed in Section I, rates of risky project choice in the individual liability games characterize the proportions of different risk-aversion types in the population.[20]

[20] The estimated value of λ_1, the proportion of borrowers who choose the safe project even in the absence of dynamic incentives, is 0.39 (i.e., 1 minus 0.61); the estimated value of λ_2, the proportion if borrowers induced to choose the safe project by the dynamic incentive clause, is 0.27 (i.e., 0.61 minus 0.34). Our model predicts that each borrower should choose the same project in all rounds of either individual liability treatment. In practice, individual choices are quite noisy: the median subjects invests in the risky project in 60 percent of rounds in the individual liability treatment without dynamic incentives, and 40 percent of the time when dynamic incentives are imposed. For simplicity, we use the overall frequency with which the risky project is chosen in the absence of dynamic incentives to estimate λ_1.

Repayment rates in the individual-liability treatments are also consistent with the theoretical predictions. The repayment rate under dynamic incentives (0.82) is significantly higher than the repayment rate without dynamic incentives (0.68, p-value < 0.001). Thus, the simple dynamic incentive has considerable power, dramatically increasing the proportion of loans recouped by the bank.

Next, we consider the joint-liability treatments without dynamic incentives. Taking averages over the first six rounds, the mean rates of risky project choice in the joint-liability treatments without communication—the imperfect information and monitoring treatments—are 0.63 and 0.61, respectively (rows 2, 3). The model predicts that the rates of risky project choice in these games will be equal to the rate in the individual-liability game in the first round, but higher than in the individual-liability game in subsequent rounds. Our findings are consistent with this pattern, though not statistically significant. The rate of risky project choice in the first round of these two joint-liability games (0.60) is not statistically different from the rate in the individual-liability game (0.62, p-value $= 0.71$). The rate of risky project choice is higher in the two joint-liability games than in the individual-liability game in every round after the first one, though the difference is not significant (results not shown).

In games with communication, the model predicts a higher rate of risky project choice, since players learn their partners' types ex ante (row 4). This is precisely what we find. The rate of risky project choice in the communication treatment is 0.68, significantly higher than the rate in either the individual-liability treatment or the two joint-liability treatments without communication (p-values both < 0.001).

Lastly, consider the partner-choice games in which joint-liability groups form endogenously. Though the model predicts a rate of risky project choice equal to that observed in the individual-liability game, that is not what we find. Instead, the rate of risky project choice (0.69) is approximately equal to the rate observed in the communication treatment, and significantly higher than the rate in the individual-liability treatment (p-value < 0.001). The model also does an imperfect job of predicting repayment rates. The model predicts lower repayment in the monitoring and communication games than in other joint-liability treatments. In fact, rates are almost exactly equal across the four joint-liability treatments.

Next, we turn to the joint-liability treatments with dynamic incentives. The model predicts weakly lower rates of risky project choice under dynamic incentives, and that is exactly what we find when comparing the first column to the second. The proportion of borrower-rounds in which the risky project was selected is at least 10 percentage points lower in each dynamic incentive treatment than in the analogous treatment without dynamic incentives.

We now examine the predictions of the model in a regression framework. Following the focus on risk-taking and default in the literature on microfinance contracts, our main dependent variables are individual risky project choice and repayment in a round of play, conditional on being an active borrower.[21] Regressions are

[21] Philip Bond and Ashok S. Rai (2009) highlight the importance of the repayment rate as a summary measure of a microfinance lender's expected longevity which, in turn, impacts borrower incentives to repay future loans. In practice, most microfinance institutions regularly recruit new borrowers; our analysis considers repayment behavior

Table 5—OLS Regressions of Individual Risky Project Choice
Dependent variable: indicator for risky project choice

			Dynamic incentives? (Y/N)			
	All games		No		Yes	
Sample:	(1)	(2)	(3)	(4)	(5)	(6)
D	−0.263***	−0.215***	—	—	—	—
	(0.019)	(0.02)				
JL	0.02	0.015	0.02	0.022	0.151***	0.074***
	(0.017)	(0.015)	(0.017)	(0.015)	(0.017)	(0.018)
JL + M	−0.015	−0.021	−0.015	−0.023	−0.026	−0.008
	(0.019)	(0.016)	(0.019)	(0.016)	(0.02)	(0.018)
JL + M + C	0.073***	0.061***	0.073***	0.06***	0.113***	0.073***
	(0.019)	(0.017)	(0.019)	(0.017)	(0.021)	(0.02)
JL + M + C + PC	0.005	0.009	0.005	0.007	−0.055***	−0.033*
	(0.018)	(0.016)	(0.018)	(0.016)	(0.019)	(0.017)
D × JL	0.131***	0.07***	—	—	—	—
	(0.024)	(0.024)				
D × (JL + M)	−0.011	0.024	—	—	—	—
	(0.027)	(0.022)				
D × (JL + M + C)	0.04	0.002	—	—	—	—
	(0.028)	(0.023)				
D × (JL + M + C + PC)	−0.06**	−0.037*	—	—	—	—
	(0.025)	(0.022)				
Constant	0.606***	0.601***	0.606***	0.615***	0.343***	0.374***
	(0.017)	(0.012)	(0.017)	(0.013)	(0.016)	(0.017)
Individual FEs	No	Yes	No	Yes	No	Yes
Round FEs	No	Yes	No	Yes	No	Yes
Observations	24,840	24,840	13,541	13,541	11,299	11,299
Number of unique IDs	493	493	474	474	449	449
R^2	0.04	0.044	0.005	0.006	0.024	0.036

Notes: Robust standard errors, clustered at the player level, in parentheses. Data are drawn from the first six rounds within each game. C = Communication. D = Dynamic incentive. JL = Joint/liability. M = Monitoring. PC = Partner Choice.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

estimated using a linear probability model. Results with and without individual-level and round-level fixed effects are reported.[22] The fixed effects control for time-invariant participant characteristics and for learning. The sample includes only the first six rounds to limit possible survivor bias, and the qualitative results are robust to restricting estimation to shorter panels.

Results are consistent with the summary statistics reported above. The indicator for games including dynamic incentives is consistently significant, indicating that adding dynamic incentives to any loan mechanism reduces the rates of risky project choice by 21.5 percent (Table 5, column 2) and increases the repayment

within a cohort, and ignore interesting issues relating to the potential for contagion across cohorts. We also abstract from consideration of increasing loan sizes. As such, our results may not be directly comparable to average repayment rates at all microfinance institutions.

[22] Qualitative results are unchanged when an additional control for the number of previous days played is included.

Table 6—OLS Regressions of Loan Repayment
Dependent variable: indicator for loan repayment

	All games		Dynamic incentives? (Y/N): No		Dynamic incentives? (Y/N): Yes	
Sample:	(1)	(2)	(3)	(4)	(5)	(6)
D	0.139***	0.123***	—	—	—	—
	(0.012)	(0.012)				
JL	0.2***	0.202***	0.2***	0.201***	0.117***	0.144***
	(0.011)	(0.011)	(0.011)	(0.012)	(0.01)	(0.011)
JL + M	0.021**	0.023**	0.021**	0.019**	0.013**	0.006
	(0.009)	(0.009)	(0.009)	(0.009)	(0.006)	(0.007)
JL + M + C	−0.033***	−0.03***	−0.033***	−0.026**	−0.036***	−0.022**
	(0.011)	(0.011)	(0.011)	(0.012)	(0.008)	(0.01)
JL + M + C + PC	0.021**	0.02*	0.021**	0.021*	0.024***	0.016*
	(0.01)	(0.01)	(0.01)	(0.011)	(0.008)	(0.009)
D × JL	−0.083***	−0.067***	—	—	—	—
	(0.014)	(0.014)				
D × (JL + M)	−0.008	−0.019	—	—	—	—
	(0.011)	(0.012)				
D × (JL + M + C)	−0.003	0.012	—	—	—	—
	(0.014)	(0.016)				
D × (JL + M + C + PC)	0.003	−0.003	—	—	—	—
	(0.013)	(0.013)				
Constant	0.682***	0.678***	0.682***	0.668***	0.82***	0.809***
	(0.01)	(0.009)	(0.01)	(0.01)	(0.01)	(0.01)
Individual FEs	No	Yes	No	Yes	No	Yes
Round FEs	No	Yes	No	Yes	No	Yes
Observations	24,840	24,840	13,541	13,541	11,299	11,299
Number of unique IDs	493	493	474	474	449	449
R^2	0.057	0.058	0.055	0.052	0.029	0.041

Notes: Robust standard errors, clustered at the player level, are in parentheses. Data are drawn from the first six rounds within each game. C = Communication. D = Dynamic incentive. JL = Joint/liability. M = Monitoring. PC = Partner Choice.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

rate by 12.3 percent (Table 6, column 2). Among joint-liability treatments without dynamic incentives, only the indicator for communication games is statistically significant; the point estimate suggests that ex ante type revelation increases the rate of risky project choice by 6.1 percentage points (Table 6). Again, in contrast to the theoretical prediction, allowing borrowers to choose their partners does not lead to a reduction in risky project choice in the absence of dynamic incentives. However, joint liability does have a significant impact on the repayment rate, even in the absence of changes in rates of risky project choice. The coefficient estimate suggests that including a joint-liability clause increases loan repayment by 20.2 percent via the insurance effect (Table 5). There is also evidence that allowing borrowers to communicate decreases repayment rates, while allowing either partner choice or monitoring without communication increases the repayment rate. However, these effects are small in magnitude relative to the overall joint-liability effect.

Coefficient estimates on the interaction between the indicators for dynamic incentives and joint liability indicate that joint liability increases the rate of risky project choice relative to the individual-liability contract with dynamic incentives, since forcing borrowers to insure each other lowers the expected cost of an individual default (Table 6). The effectiveness of dynamic incentives, however, means that the combination of dynamic incentives and joint liability decreases risky project choice relative to the joint-liability contract without dynamic incentives. Turning to the repayment rate, repayments rise due to the insurance effect. Adding both joint liability and dynamic incentives generates levels of loan repayment that are significantly higher than those observed under either joint liability or dynamic incentives alone (Table 5). Among the joint-liability games with dynamic incentives, adding communication leads to a significant increase in risky project choice. More surprisingly, it leads to a significant decrease in the repayment rate, suggesting that borrowers are not using the opportunity to communicate as a way to coordinate the timing of risky project choices while insuring each other.

Overall, the findings are broadly consistent with the theoretical predictions. Joint liability increases risk-taking under dynamic incentives while simultaneously increasing the repayment rate. In the absence of dynamic incentives, joint liability increases loan repayment without changing individual behavior. Communication among borrowers increases the rate of risky project choice and default. Surprisingly, this is even true under dynamic incentives.[23]

Much is written on how credit contracts may or should differ for different demographic groups. Microfinance has tended to focus on females. Women are viewed as more reliable customers, and they do, in fact, tend to repay their loans more frequently than men do (Beatriz Armendáriz de Aghion and Jonathan Morduch 2005). By the same token, they tend to be less prone to moral hazard (Dean S. Karlan and Jonathan Zinman 2009b). We examine our primary set of results for different demographic groups in order to identify systematic differences in the responses to different mechanisms. Table 7 breaks down the analysis of Table 5 by demographic categories. Despite some variation in significance across the specifications, we find that the sign patterns are broadly consistent across the demographic subsets we consider. Strikingly, we find no gender differences, and only minor differences between the old and the young. The patterns are also similar among better educated individuals, more trusting individuals (as measured by the GSS social survey questions), and individuals who have a savings account in a commercial bank. Thus, the results suggest that individual play within the game is not driven predominantly by demographic characteristics.

[23] Regressions do not control for attrition in dynamic games, as risk-taking players are gradually eliminated from the pool of active borrowers. We focus on the conditional rates of repayment and risky project choice as these are the experimental analogs of the "low default rates" discussed in much of the literature on microfinance. Our qualitative results are robust including interactions between the set of round dummies and the indicators for game with dynamic incentives and joint-liability games with dynamic incentives.

Table 7—OLS Regressions of Risky Project Choice by Demographic Category
Dependent variable: Indicator for risky project choice

Sample:	All subjects (1)	Female (2)	Younger (3)	Older (4)	Secondary (5)	GSS answers (6)	Saves (7)
D	−0.215***	−0.22***	−0.329***	−0.179***	−0.233***	−0.243***	−0.269**
	(0.02)	(0.026)	(0.058)	(0.037)	(0.025)	(0.087)	(0.116)
JL	0.015	0.006	0.049	−0.004	0.005	0.069	−0.04
	(0.015)	(0.019)	(0.042)	(0.024)	(0.018)	(0.094)	(0.069)
JL + M	−0.021	−0.014	−0.028	−0.052*	−0.014	−0.103**	−0.063
	(0.016)	(0.02)	(0.034)	(0.027)	(0.02)	(0.051)	(0.054)
JL + M + C	0.061***	0.063***	0.028	0.093***	0.046***	0.067	0.059
	(0.017)	(0.024)	(0.028)	(0.025)	(0.018)	(0.062)	(0.055)
JL + M + C + PC	0.009	−0.005	0.038	0.026	0.024	−0.018	−0.111
	(0.016)	(0.022)	(0.024)	(0.025)	(0.017)	(0.046)	(0.08)
D × JL	0.07***	0.091***	0.088	0.081**	0.077***	0.052	0.108
	(0.024)	(0.029)	(0.063)	(0.038)	(0.027)	(0.087)	(0.119)
D × (JL + M)	0.024	0.012	0.053	0.031	0.033	0.127	0.053
	(0.022)	(0.027)	(0.037)	(0.035)	(0.025)	(0.085)	(0.077)
D × (JL + M + C)	0.002	−0.009	0.013	−0.018	0.014	−0.05	0.072
	(0.023)	(0.031)	(0.05)	(0.034)	(0.027)	(0.063)	(0.137)
D × (JL + M + C + PC)	−0.037*	−0.018	−0.083*	−0.049	−0.074***	0.036	−0.083
	(0.022)	(0.027)	(0.049)	(0.03)	(0.025)	(0.081)	(0.134)
Constant	0.601***	0.609***	0.719***	0.589***	0.637***	0.549***	0.7***
	(0.012)	(0.015)	(0.027)	(0.02)	(0.014)	(0.063)	(0.059)
Individual FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Round FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	24,840	14,245	4,020	10,269	17,407	1,779	835
Number of unique IDs	493	253	61	131	271	24	24
R^2	0.044	0.046	0.094	0.033	0.05	0.052	0.05

Notes: Robust standard errors, clustered at the player level, in parentheses. Data are drawn from the first six rounds within each game. Younger subjects are aged 22 or below, Older subjects 35 years old or above. Secondary indicates that a subject has completed secondary school. GSS answers equal one if a subject game positive responses to at least two of the three GSS questions described in footnote 14. Saves indicates subjects who have a savings account in a bank. C = Communication. D = Dynamic incentive. JL = Joint/Liability. M = Monitoring. PC = Partner Choice.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

B. *Heterogeneous Effects*

Though the lender is primarily concerned with average rates of repayment, our model predicts that the effects of the joint-liability treatment on risky choice depend on both individual risk attitudes and partner characteristics. One consequence of joint liability is that relatively safe players matched with relatively risky partners should unambiguously move toward the risky project in the joint-liability settings, particularly in the absence of dynamic incentives. In Table 8, we test our predictions about the impact of joint-liability contract structure on different types of players, exploiting the fact that we observe the same individuals making choices under different contracts. Our model predicts that θ_1-borrowers, the most risk averse, will change their behavior when matched with a riskier partner under joint liability. Following the model, we characterize θ_1-borrowers as those most likely to choose the safe project in the

Table 8—OLS Regressions of Risky Project Choice by Risk Aversion Level
Dependent variable: Indicator for risky project choice

	All players			Risk-aversion type: θ_1	Risk-aversion type: θ_2	Risk-aversion type: θ_3
Sample:	(1)	(2)	(3)	(4)	(5)	(6)
D	−0.143***	−0.14***	−0.143***	−0.135***	−0.156***	−0.065
	(0.017)	(0.017)	(0.017)	(0.045)	(0.022)	(0.041)
JL + M	−0.022	−0.017	−0.023	−0.049	−0.021	−0.004
	(0.016)	(0.017)	(0.017)	(0.041)	(0.022)	(0.044)
JL + M + C	0.06***	0.06***	0.059***	0.19***	0.037*	0.063**
	(0.016)	(0.017)	(0.017)	(0.044)	(0.022)	(0.031)
JL + M + C + PC	0.007	0.013	0.009	−0.099**	0.049**	−0.033
	(0.016)	(0.016)	(0.016)	(0.045)	(0.02)	(0.031)
D × (JL + M)	0.023	0.033	0.054***	0.038	0.029	0.043
	(0.022)	(0.024)	(0.021)	(0.064)	(0.03)	(0.052)
D × (JL + M + C)	0.003	−0.01	−0.026	−0.076	0.015	−0.073
	(0.023)	(0.024)	(0.021)	(0.056)	(0.03)	(0.05)
D × (JL + M + C + PC)	−0.04*	−0.052**	−0.044*	0.077	−0.098***	−0.027
	(0.022)	(0.023)	(0.022)	(0.055)	(0.03)	(0.035)
Safer player w/riskier partner #1	—	0.049*	—	—	—	—
		(0.026)				
Riskier player w/safer partner #1	—	0.005	—	—	—	—
		(0.013)				
Safer player w/riskier partner #2	—	—	0.051***	—	—	—
			(0.019)			
Riskier player w/safer partner #2	—	—	0.0002	—	—	—
			(0.01)			
Constant	0.621***	0.616***	0.609***	0.432***	0.667***	0.712***
	(0.013)	(0.014)	(0.014)	(0.035)	(0.015)	(0.035)
Individual FEs	Yes	Yes	Yes	Yes	Yes	Yes
Round FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,550	17,754	21,039	3,464	9,843	3,682
Number of unique IDs	491	424	472	99	126	89
R^2	0.036	0.037	0.035	0.039	0.048	0.018

Notes: Robust standard errors, clustered at the player level, in parentheses. Data are drawn from the first six rounds within each game. Risk Aversion Type based on choices in individual-liability games. Subjects are classified as θ_1-borrowers if their rate of risky project choice in individual games without dynamic incentives is at or below the twenty-fifth percentile; subjects are classified as θ_3-borrowers if their rate of risky project choice in individual games with dynamic incentives is at or above the seventy-fifth percentile. C = Communication. D = Dynamic incentive. JL = Joint/Liability. M = Monitoring. PC = Partner Choice.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

individual-liability setting without dynamic incentives. Specifically, we classify an individual as a θ_1-borrower if her rate of risky project choice in the individual games without dynamic incentives is below the 25th percentile (0.40). We define the variable "Safer Player w/ Riskier Partner #1" as an indicator for a θ_1-borrower matched with a partner of another risk aversion type; the variable "Riskier Player w/Safer Partner #1" is defined analogously. In column 2, we include these variables in a regression of individual risky project choice within the joint-liability games on the set of treatment dummies and fixed effects. θ_1-borrowers are significantly more likely to choose the risky project when matched with less risk averse partners. The coefficient estimates suggests that their rate of risky project choice increases by 4.9 percentage points. As predicted by the theory, riskier borrowers matched with safer partners do not change their behavior. In column 3, we consider an alternative definition of a "safer player" which is not explicitly motivated by our theoretical model—being below the twenty-fifth percentile in terms of risky project choice in either of the individual-liability games. The point estimate is similar, and the significance level increases.

Finally, in columns 4–6, we examine behavior in the joint-liability games, splitting the sample into those classified by our model as θ_1-, θ_2-, and θ_3-borrowers.[24] Dynamic incentives decrease the rate of risky project choice, but the effect is not significant among θ_3-borrowers. However, as predicted, communication has the largest impact on the most risk-averse participants, increasing the rate of risky project choice by an estimated 19 percentage points. Allowing partner choice significantly reduces the rate of risky project choice among θ_1-borrowers. Among θ_2-borrowers, partner choice increases the rate of risky project choice in the absence of dynamic incentives, and decreases it when dynamic incentives are imposed. Again, the results of our analysis fit the theory closely.

C. *Coordination*

Our theoretical model characterizes not only individual choices, but also equilibrium outcomes within joint-liability groups. Specifically, the model predicts that increasing information flows within games without dynamic incentives will lead to higher rates of coordination on the risky investment, while communication within the treatments including dynamic incentives may increase the likelihood that partners choose different projects.

We examine joint outcomes using a multinomial logit specification with three possible values for the dependent variable: both played risky, played opposite, and both played safe (the omitted category). Allowing communication in games without dynamic incentives increases the probability of both playing risky, though the effect is only marginally significant (Table 9). Among games including dynamic incentives, adding communication leads to a substantial increase in the probability of the all-risky outcome and of discordant project choice. Allowing endogenous partner choice sharply decreases the frequency of the all-risky outcome without any increase in the likelihood of choosing opposite projects—indicating a strong increase in coordination on safe project choice.

Next, we disaggregate the analysis into "safer pairs" of two θ_1-borrowers, "mixed pairs" including only one θ_1-borrower, and "riskier pairs" which do not include a θ_1-borrower (columns 3 through 8). Consistent with our theoretical model, many of the main effects are driven by project choices in mixed pairs: communication within mixed pairs substantially increases the probability of the all-risky outcome,

[24] Following the strategy used to define θ_1-borrowers, we define θ_3-borrowers as those whose rates of risky project choice in the individual-liability game are above the seventy-fifth percentile. θ_2-borrowers are those who do not fall into either of the other two categories. Given our process for assigning individual types, it is theoretically possible that a single borrower could be classified as both a θ_1-borrower and a θ_3-borrower. We do not observe any such borrowers.

Table 9—Multinomial Logit Regressions of Joint Outcomes
Omitted outcome: Both chose safe project

Sample:	All pairs		Safer pairs		Mixed pairs		Riskier pairs	
Games w/ dynamic incentives?	No (1)	Yes (2)	No (3)	Yes (4)	No (5)	Yes (6)	No (7)	Yes (8)
Outcome #1: Both chose risky project								
M	−0.034	−0.197	0.099	0.287	−0.253	−0.539	0.023	0.107
	(0.175)	(0.188)	(0.936)	(1.188)	(0.314)	(0.382)	(0.234)	(0.24)
M + C	0.334*	0.872***	0.283	0.626	0.632*	1.507***	0.174	0.394
	(0.194)	(0.208)	(1.331)	(1.190)	(0.331)	(0.414)	(0.276)	(0.26)
M + C + PC	0.129	−0.477**	−0.235	−0.605	−0.143	−0.301	0.439	−0.51*
	(0.202)	(0.223)	(1.251)	(1.213)	(0.345)	(0.462)	(0.287)	(0.266)
Constant	0.639***	−0.852***	−1.640*	−4.628***	0.424	−1.314***	1.235***	−0.536***
	(0.157)	(0.156)	(0.942)	(1.014)	(0.291)	(0.317)	(0.215)	(0.202)
Outcome #2: Alternation/opposite projects								
M	0.046	0.026	−0.599	0.532	−0.12	−0.224	0.228	0.313*
	(0.156)	(0.136)	(0.594)	(0.796)	(0.259)	(0.236)	(0.207)	(0.179)
M + C	0.024	0.502***	0.549	0.968	−0.444	0.743**	−0.004	0.16
	(0.181)	(0.169)	(0.924)	(0.837)	(0.297)	(0.31)	(0.259)	(0.216)
M + C + PC	0.136	−0.194	0.693	−0.758	0.382	−0.126	0.227	−0.189
	(0.194)	(0.201)	(0.907)	(0.832)	(0.328)	(0.379)	(0.282)	(0.254)
Constant	0.802***	0.397***	−0.565	−1.115*	1.116***	0.521***	1.015***	0.47***
	(0.153)	(0.114)	(0.613)	(0.657)	(0.272)	(0.196)	(0.211)	(0.152)
Observations	10,554	8,416	364	357	2,720	2,269	5,920	4,848

Notes: Robust standard errors, clustered at the level of the joint liability pair, in parentheses. Data are drawn from the first six rounds within each game. Safer Pairs are those comprising two θ_1-borrowers. Mixed Pairs include exactly one θ_1-borrower. Riskier Pairs do not include a θ_1-borrower. C = Communication. M = Monitoring. PC = Partner Choice.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

particularly in games including dynamic incentives. In games with dynamic incentives, communication also increases substantially the probability of partners choosing different projects in mixed pairs. Among riskier pairs of borrowers, monitoring increases the probability of choosing opposite projects, providing the first evidence that borrowers coordinate to avoid default under dynamic incentives. We find no evidence that adding partner choice improves the ability to coordinate on either the all-safe or the alternating equilibrium.

D. *Partner Choice*

As discussed above, allowing borrowing groups to form endogenously has a strong, negative effect on risk-taking under dynamic incentives. We also find that the proportion of pairs comprising two θ_1-borrowers is significantly higher in partner choice games than in other joint-liability treatments (5.6 percent of pairs versus 3.6 percent, p-value = 0.007). This is all consistent with assortative matching on risk preferences. We now examine more formally the determinants of matching among players using data from the market census and the social networks survey conducted at the end of each experimental session. For each communication game, we create all possible dyads, or pairs, of players; for example, if a game has 20 players, there are 190 possible combinations of two players. However, only ten of those pairs are matches, either randomly assigned by the computer in the communication treatments or elected by the players themselves in the partner-choice treatments[25]. The goal is to determine which variables were used by players in choosing their partners. We use information on where players were sitting during the games, whether they had attended any games as the guest of another player, and the census and social networks surveys.[26]

We report results for the pooled sample of partner-choice games, and also disaggregated into games with and without dynamic incentives (Table 10). For comparison purposes, we also report the results of similar regressions which use the randomly-assigned matches from the other communication treatments (without endogenous partner choice) as the dependent variable. In contrast, the coefficient on sitting in adjacent seats is positive and weakly significant in the partner choice games. Variables measuring the social links between players are jointly significant in all specifications, including—surprisingly—the communication games without endogenous partner choice. Sharing the same religion is also positively associated with the probability of matching in the partner choice games.

Measures of risk aversion drawn from the hypothetical lottery choice questions in the census survey have limited predictive power; specifically, we find no evidence of assortative matching among those deemed the "most risk averse" by the hypothetical question. However, we find strong evidence of assortative matching in games including dynamic incentives when we use estimates of individual risk-aversion type based on behavior in the individual-liability treatments. Those classified as θ_1-borrowers are more likely to form liability groups with similarly risk averse individuals, though the effect is only significant in games including dynamic incentives. Thus, our data are consistent with Ghatak's (1999) hypothesis that joint liability will lead to assortative matching.[27]

IV. Conclusion

Microfinance is transforming thinking about banking in low-income communities. The techniques that are employed to ensure loan repayment contain numerous overlapping mechanisms, and we have taken them apart in order to examine how important components function in isolation and how they interact with one another. The results draw from a series of experimental "microfinance games"

[25] Because all possible pairs appear in the regression, the errors will be correlated across all pairs that involve a given player. As a result, OLS methods will not be valid. Instead, we use the quadratic assignment procedure (QAP) method (David Krackhardt 1988), which involves generating datasets of the same size that preserve the dependence of the independent variables while scrambling the dependent variable. These permuted datasets correspond to the null hypothesis. As with the bootstrap method, one can check significance of a particular coefficient by checking where it falls in the empirical distribution.

[26] As discussed above, we allowed participants to attend multiple experimental sessions and encouraged them to invite other micro-entrepreneurs from the market to attend the sessions as their guests.

[27] Ghatak (1999) assumes risk neutral borrowers that differ in the probability that the project will succeed. He finds that safe borrowers will pair with other safe borrowers. We assume that players differ in their risk aversion and choose among two different projects with a different (but fixed) probability of success. The finding confirms that risk averse, and hence safe, borrowers will pair with other risk-averse borrowers.

TABLE 10—OLS REGRESSIONS OF DETERMINANTS OF GROUP FORMATION IN PARTNER-CHOICE GAMES
Dependent variable: Dyad formed a liability group (Indicator)

Partner choice: *Dynamic incentives?* (*Y*/*N*/*B*)	No Both (1)	Yes Both (2)	Yes No (3)	Yes Yes (4)
Sitting next to each other	−0.070	0.028*	0.034*	0.016
	(1.00)	(0.068)	(0.08)	(0.306)
Bought or sold from partner's store	−0.014	0.006	0.003	0.004
	(0.872)	(0.332)	(0.468)	(0.454)
Partners are related	0.012	0.209***	0.208***	0.22***
	(0.36)	(0.00)	(0.002)	(0.00)
Partners meet socially	−0.014	0.037***	0.026*	0.042*
	(0.844)	(0.004)	(0.096)	(0.062)
Know store locations	0.032***	0.024*	0.026	0.027
	(0.004)	(0.054)	(0.104)	(0.128)
Have watched over stores	0.043***	0.074***	0.054***	0.106***
	(0.00)	(0.00)	(0.004)	(0.00)
Has been host, guest of partner	−0.044	0.395***	0.544***	0.226***
	(0.802)	(0.00)	(0.00)	(0.002)
Both are popular	−0.0007	−0.028	−0.027	−0.038
	(0.528)	(0.994)	(0.946)	(0.944)
Both are trusted	−0.005	−0.015	−0.022	0.004
	(0.69)	(0.898)	(0.94)	(0.436)
Both most risk averse (census)	−0.025	−0.012	−0.022	0.003
	(0.874)	(0.728)	(0.742)	(0.508)
Both most risk loving (census)	−0.004	0.05***	0.048***	0.052*
	(0.592)	(0.006)	(0.038)	(0.082)
Both most risk averse (IL games)	0.002	0.084***	0.044	0.15***
	(0.458)	(0.006)	(0.166)	(0.008)
Both least risk averse (IL games)	0.004	−0.0003	0.015	−0.024
	(0.468)	(0.524)	(0.390)	(0.648)
Same marital status	0.007	−0.007	0.001	−0.02
	(0.278)	(0.762)	(0.474)	(0.9)
Same religion	0.001	0.04***	0.039***	0.048***
	(0.486)	(0.004)	(0.024)	(0.03)
Wealth difference	0.018***	−0.01	−0.013	−0.008
	(0.006)	(0.89)	(0.882)	(0.778)
Both Polvos Azules founders	0.028*	0.04**	0.053*	0.037
	(0.066)	(0.022)	(0.030)	(0.136)
Both own stores	−0.022	−0.017	0.009	−0.056
	(0.866)	(0.798)	(0.404)	(0.956)
Individual FEs	Yes	Yes	Yes	Yes
Individual game FEs	Yes	Yes	Yes	Yes
Observations	2,690	2,473	1,377	1,096
R^2	0.059	0.164	0.204	0.182

Notes: QAP *p*-values in parentheses. Column 1 (columns 2–4) includes all joint-liability treatments with communication but without (with) partner choice.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

conducted over seven months in Lima, Peru. The experimental approach allows us to pose clear but narrow questions and generate precise hypotheses about several loan features at once. By locating the games in a market setting in a developing country, we were able to attract participants who are similar to typical microfinance customers, including some who were in fact customers of local microfinance institutions.

We find that cutting off defaulting borrowers from access to future loans powerfully reduces risky project choice, even when lenders use individual-liability contracts. These results on the power of dynamic incentives are consistent with recent shifts by micro-lenders from group-based mechanisms toward individual loans. The Grameen Bank of Bangladesh and Bolivia's BancoSol, for example, are the two best-known pioneers of group lending, but they have both shifted toward individual lending as their customers have matured and sought larger loans (Armendáriz de Aghion and Morduch 2005). Grameen has dropped joint liability entirely, and just one percent of BancoSol's loan portfolio remained under group contracts in 2005. In two experiments in the Philippines, Giné and Karlan (2006, 2009) found that group liability held no advantage over individual liability for either screening of clients or monitoring and enforcing contracts. Hence, joint liability does not always appear necessary to maintain high repayment rates. Given large enough incentives to avoid default, borrowers will choose safe projects and repay their loans.

The trade-off when relying on dynamic incentives alone is that borrowers may take too *little* risk, relative to what is socially optimal. In contrast to the outcomes under individual liability, we find that group-based mechanisms can support high repayment rates while facilitating risky (but profitable) project choice. Holding project choices constant, joint liability reduces default since group members must bail each other out when luck is bad.

The results clarify costs and benefits of group-based contracts. The implicit insurance against borrowers' investment losses helps risk-taking borrowers to maintain their good standing with lenders. Against that, the costs are borne by fellow borrowers and fall most heavily on the most risk-averse participants (who are the ones most likely to have to bail out their partners). We find that, as a consequence, when risk-averse borrowers have the chance to sort into groups of their own making, they seek other risk-averse borrowers. Moreover, when risk-averse borrowers are forced into groups with riskier investors, the risk-averse borrowers respond to the moral-hazard problem by making riskier choices than they would otherwise.

From a methodological vantage, the "framed" field experiments developed here act as a bridge from laboratory experiments to field experiments. Similar bridge work has been done with respect to auctions and charitable fundraising, but as Levitt and List (2007) discuss, much remains to be known about how the laboratory itself alters the behavior of individuals and thus the interpretation of results. By working with the same type of individuals that are of interest to those who study credit markets for the poor, we show how laboratory experimental tools can be used to begin crisper discussions of the relative merits of different lending mechanisms. With further links from these "framed" field experiments to "natural" field experiments, such approaches can be integrated in a research and development process that is helpful both to applied theorists interested in testing mechanisms and to practitioners interested in observing actual behavior under different incentive schemes.

Appendix

I. Proof of Proposition 1

We begin by showing that a θ_2- or θ_3-borrower matched with a partner of a similar type will choose the risky project in all rounds in any subgame perfect equilibrium. First, note that Assumption 4 guarantees that $EU_i^{RR} > EU_i^{SS}$ for $i \in \{2,3\}$. To see this, observe that for $i = 1$, $EU_i^{SS} > EU_i^{RR}$, so it must be the case that

$$\alpha EU_i^{SR} + (1 - \alpha)EU_i^{SS} > EU_i^{RR} \tag{6}$$

for some $\alpha \in [0,1]$—specifically, α close enough to zero. Since $EU_i^{RS} > EU_i^{RR}$ for all i, if $EU_i^{SS} \geq EU_i^{RR}$ for $i \in \{2,3\}$, then the following would hold for all $\alpha \in [0,1]$:

$$\alpha EU_i^{RS} + (1 - \alpha)EU_i^{SS} > EU_i^{RR}. \tag{7}$$

Thus, Assumption 4 can only hold if $EU_i^{SS} < EU_i^{RR}$ for $i \in \{2,3\}$. Because this is true, a pair of θ_2- or θ_3-borrowers would never coordinate on the safe project in any round of a subgame perfect equilibrium, as it forces both below their minmax expected payout, EU_i^{RR} and both have a profitable deviation.

Next, we prove by contradiction that any alternating sequence—in which Borrower i chooses the risky project in periods $\tau \in Z_R$ and the safe project in all other periods while Borrower i's partner, Borrower j, chooses the safe project in periods $\tau \in Z_R$ and the risky project in all other periods—cannot constitute a subgame perfect equilibrium between to θ_2- or θ_3-borrowers. consider any such sequence. Borrower i receives expected utility stream

$$\left[\alpha EU_i^{SR} + (1 - \alpha)EU_i^{SR}\right]\left(\frac{1}{1 - \delta}\right), \tag{8}$$

where

$$\alpha = \frac{\sum_{\tau \in Z_R} \delta^\tau}{\sum_{\tau=0}^{\infty} \delta^\tau};$$

Borrower j receives expected utility stream

$$\left[\alpha EU_j^{SR} + (1 - \alpha)EU_j^{RS}\right]\left(\frac{1}{1 - \delta}\right). \tag{9}$$

If there exists a set Z_R such that expected payoffs for both borrowers exceed the minmax level, then the following inequalities must hold:

$$\left[\alpha EU_i^{RS} + (1 - \alpha)EU_i^{SR}\right]\left(\frac{1}{1 - \delta}\right) \geq EU_i^{RR}\left(\frac{1}{1 - \delta}\right) \tag{10}$$

and

$$\left[\alpha EU_j^{SR} + (1 - \alpha)EU_j^{RS}\right]\left(\frac{1}{1 - \delta}\right) \geq EU_j^{RR}\left(\frac{1}{1 - \delta}\right). \tag{11}$$

Since $Y_R > 3L$ (by Assumption 3),

$$u_i(Y_R - 2L) > u_i(Y_R - L) - u_i(Y_R - 2L) \tag{12}$$

by the concavity of $u_i(\cdot)$. This implies

$$\begin{aligned}(1 - p)[u_i(Y_R - L) - u_i(Y_R - 2L)] + u_i(Y_S - L)\\ < pu_i(Y_R - L) + (1 - p)u_i(Y_R - 2L),\end{aligned} \tag{13}$$

since $EU_i^{SS} < EU_i^{RS}$.[28] Rearranging the above and multiplying by $p/2$ yields

$$\begin{aligned}\frac{1}{2}pu_i(Y_R - \mathrm{L}) + \frac{1}{2}pu_i(Y_S - L) < p^2u_i(Y_R - L)\\ + p(1 - p)u_i(Y_R - 2L).\end{aligned} \tag{14}$$

Consequently, for equation (10) to hold, α must be greater than one half.[29] However, by a similar argument, for equation (11), α must be less than one half. This creates a contradiction. Finally, by an argument directly parallel to the one above, Assumption 4 guarantees that a subgame perfect equilibrium cannot exist wherein a θ_1-borrower plays safe in all rounds while her partner, a θ_2 or θ_3, invests in the risky project in some but not all rounds.

II. Game Administration and Experimental Instructions

All games were administered by a team of three to five researchers. Players were randomly assigned to numbered seats at the beginning of each game session, and were identified using their seat numbers throughout the day. In each game, each player received a packet of ten game worksheets. Sample worksheets are included in the Appendix. In each round, participants would circle their desired projects before returning their game packets to the researchers. Choices were then entered

[28] Recall $EU_i^{SS} = u_i\,(Y_S - L)$ and $EU_i^{RS} = pu_i\,(Y_R - L)$.
[29] Since EU_i^{RR} and $p^2u_i(Y_R - L) + p(1 - p)\,u_i(Y_R - 2L)$ and $EU_i^{SR} = pu_i(Y_S - L)$.

into a computer which randomized outcomes for players investing in the risky project and then reported individual earnings for that round (after automatically deducting the loan repayment). A member of the research team then highlighted final outcomes on participant game sheets before returning them to players. After players examined their results for the round, the game either continued into the next round or ended.

Read at the Beginning of All Games.—Good morning everyone. We are a group of college students carrying out research about how micro-entrepreneurs from Polvos Azules make business decisions. We would like you to participate in our study. If you choose to participate, we will ask you to play several types of games with us. Just for showing up and staying for two hours, you will receive ten soles. You may earn up to ten soles. How much you earn will depend on how many points you accumulate during the course of the games. The more points you accumulate during the games, the more money you will receive at the end of the session.

Packets of Game Worksheets Are Passed out at This Point.—You are not allowed to talk to each other during the course of the games. In addition, you are not allowed to look at the worksheets of people sitting near you.

Each game consists of multiple rounds. At the beginning of each round, you will receive a bank loan for 100 points. You must invest this loan in one of two projects: "Project Square" or "Project Triangle." Project Square pays 200 points with certainty. If you choose Project Triangle, your project may be successful or it may fail. Each time you choose Project Triangle, it is like the computer flips an imaginary coin. If the coin lands on heads, you will receive 600 points. However, if the coin lands on tails, you won't receive anything.

Note that project outcomes are independent, so if two players chose Project Triangle in the same round, one can be successful while the other fails because the computer tosses a different imaginary coin for each player.

Before receiving the points from your project, you have to repay the loan from the bank. This is done automatically by the computer, so no one has the right to decide whether or not to repay the loan. You can only use the points you earned in each round to repay the bank. In any round, if you choose Project Triangle and your project is not successful, you cannot repay the bank.

To begin the game everybody is assigned 500 points.

The only thing you have to do is circle one of the two projects for each round. After that you will hand us the game sheets and we will fill in the rest of the information after entering your choice into the computer. Do not forget to write your ID number in the upper right corner of each sheet.

We will be playing many rounds, but we are not sure how many. It will be as if we were rolling an imaginary dice, and with some probability the game stops and we will start another game.

There are going to be several types of games that we will explain as we play them. In some of them you will play alone, in others you will have a partner.

Read before Specific Game Specifications:

Individual Games without Dynamic Incentives: In this game, you will be playing alone, meaning you will be solely responsible for your loan from the bank. You will receive the loan from the bank and you will have to circle the project (Square or Triangle) that you want to invest in. In this game, you will always receive a new loan at the beginning of each round even when you were not able to repay your loan in the previous round. In this case, the bank will allow you to borrow again even if your project does not succeed and you do not repay the loan.

Individual Games with Dynamic Incentives: In this game, you will be playing alone, meaning you will be solely responsible for your loan from the bank. You will receive the loan from the bank and you will have to circle the project (Square or Triangle) that you want to invest in. In this game, the bank will not loan to you again if your project does not succeed and thus are unable to repay the loan. This will happen if you choose Project Triangle and your project fails. In that case you will have to remain in your seat and wait for the other participants to finish playing.

Joint-Liability Games with Dynamic Incentives: In this game, you will be borrowing jointly from the bank with a partner in the room. You will not know who the partner is, nor will you be shown what project the partner chooses. As before, you will choose a project by circling either Square or triangle. You and your partner are responsible for each other's loans. If your project succeeds and your partner's does not, you will have to repay your partner's loan. On the other hand, if your partner's project succeeds and yours does not, your partner will repay your loan. In this game, you will always receive a new loan at the beginning of each round even when neither of you are able to repay the loan in the previous round.

Joint-Liability Games without Dynamic Incentives: In this game, you will be borrowing jointly from the bank with a partner in the room. You will not know who the partner is, nor will you be shown what project the partner chooses. As before, you will choose a project by circling either Square or Triangle. You and your partner are responsible for each other's loans. If your project succeeds and your partner's does not, you will have to repay your partner's loan. On the other hand, if your partner's project succeeds and yours does not, your partner will repay your loan. In this game, the bank will not loan to you or your partner again if your projects do not succeed and you are unable to repay your loans. This will happen if both partners choose Triangle and both projects fail.

Monitoring Games without Dynamic Incentives: In this game, you will be borrowing jointly from the bank with a partner in the room. You will not know who the partner is. However, at the start of each round, we will show you what your partner chose (Square or Triangle) in the prior round. As before, you will choose a project by circling either Square or Triangle. You and your partner are responsible for each other's loans. If your project succeeds and your partner's does not, you will have to repay your partner's loan. On the other hand, if your partner's project succeeds and yours does not, your partner will repay your loan. In this game, you will always receive a new loan at the beginning of each round even when neither of you are able to repay the loan in the previous round.

Monitoring Games with Dynamic Incentives: In this game, you will be borrowing jointly from the bank with a partner in the room. You will not know who the partner is. However, at the start of each round, we will show you what your partner chose (Square or Triangle) in the prior round. As before, you will choose a project by circling either Square or Triangle. You and your partner are responsible for each other's loans. If your project succeeds and your partner's does not, you will have to repay your partner's loan. On the other hand, if your partner's project succeeds and yours does not, your partner will repay your loan. In this game, the bank will not loan to you or your partner again if your projects do not succeed and you are unable to repay your loans. This will happen if both partners choose Triangle and both projects fail.

Communication Games without Dynamic Incentives: In this game, you will be borrowing jointly from the bank with a partner in the room. Before the game begins, the computer will assign each of you a partner and we will ask you to move to a seat next to your partner. You and your partner will sit next to each other, and you will be allowed to talk to your partner throughout the game. In addition, in each round we will show you what your partner chose (Square or Triangle) in the prior round. As before, you will choose a project by circling either Square or Triangle. You and your partner are responsible for each other's loans. If your project succeeds and your partner's does not, you will have to repay your partner's loan. On the other hand, if your partner's project succeeds and yours does not, your partner will repay your loan. In this game, you will always receive a new loan at the beginning of each round even when neither of you are able to repay the loan in the previous round.

Communication Games with Dynamic Incentives: In this game, you will be borrowing jointly from the bank with a partner in the room. Before the game begins, the computer will assign each of you a partner and we will ask you to move to a seat next to your partner. You and your partner will sit next to each other, and you will be allowed to talk to your partner throughout the game. In addition, in each round we will show you what your partner chose (Square or Triangle) in the prior round. As before, you will choose a project by circling either Square or Triangle. You and your partner are responsible for each other's loans. If your project succeeds and your partner's does not, you will have to repay your partner's loan. On the other hand, if your partner's project succeeds and yours does not, your partner will repay your loan. In this game, the bank will not loan to you or your partner again if your projects do not succeed and you are unable to repay your loans. This will happen if both partners choose Triangle and both projects fail.

Partner-Choice Games without Dynamic Incentives: In this game, you will be borrowing jointly from the bank with a partner in the room. Before the game begins, we will ask you to stand up and find a partner that you would like to play with. You and your partner will sit next to each other, and you will be allowed to talk to your partner throughout the game. In addition, in each round we will show you what your partner chose (Square or Triangle) in the prior round. As before, you will choose a project by circling either Square or Triangle. You and your partner are responsible for each other's loans. If your project succeeds and your partner's does not, you will have to repay your partner's loan. On the other hand, if your partner's project succeeds and yours does not, your partner will repay your loan. In this game, you will always receive a new loan at the beginning of each round even when neither of you are able to repay the loan in the previous round.

Partner-Choice Games with Dynamic Incentives: In this game, you will be borrowing jointly from the bank with a partner in the room. Before the game begins, we will ask you to stand up and find a partner that you would like to play with. You and your partner will sit next to each other, and you will be allowed to talk to your partner throughout the game. In addition, in each round we will show you what your partner chose (Square or Triangle) in the prior round. As before, you will choose a project by circling either Square or Triangle. You and your partner are responsible for each other's loans. If your project succeeds and your partner's does not, you will have to repay your partner's loan. On the other hand, if your partner's project succeeds and yours does not, your partner will repay your loan. In this game, the bank will not loan to you or your partner again if your projects do not succeed and you are unable to repay your loans. This will happen if both partners choose Triangle and both projects fail.

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