Contract Structure, Risk Sharing, and Investment Choice

Greg Fischer*
London School of Economics

November 2012

Abstract

Few microfinance-funded businesses grow beyond subsistence entrepreneurship. This paper considers one possible explanation: that the structure of existing microfinance contracts may discourage risky but high-expected return investments. To explore this possibility, I develop a theory that unifies models of investment choice, informal risk sharing, and formal financial contracts. I then test the predictions of this theory using a series of experiments with clients of a large microfinance institution in India. The experiments confirm the theoretical predictions that joint liability creates two potential inefficiencies. First, borrowers free-ride on their partners, making risky investments without compensating partners for this risk. Second, the addition of peer-monitoring overcompensates, leading to sharp reductions in risk-taking and profitability. Equity-like financing, in which partners share both the benefits and risks of more profitable projects, overcomes both of these inefficiencies and merits further testing in the field.

Keywords: investment choice, informal insurance, risk sharing, contract design, microfinance, experiment.

JEL Classification Codes: O12, D81, C91, C92, G21

*Contact information: g.fischer@lse.ac.uk. I would like to thank Esther Duflo, Abhijit Banerjee, and Antoinette Schoar for advice and encouragement throughout this research. I am indebted to Shamanthy Ganeshan who provided outstanding research assistance. Daron Acemoglu, Oriana Bandiera, Tim Besley, Gharad Bryan, Robin Burgess, David Cesarini, Sylvain Chassang, Raymond Guiteras, Gerard Padró i Miquel, Rob Townsend, Tom Wilkening, and various seminar participants generously contributed many useful comments and advice. I am also grateful to the editor and three anonymous referees for providing thoughtful comments. In Chennai, the Centre for Micro Finance and the management and employees of Mahasemam Trust deserve many thanks. I gratefully acknowledge the financial support of the Russell Sage Foundation, the George and Obie Shultz Fund, the National Science Foundation's Graduate Research Fellowship, and the Economic and Social Research Council's First Grants Scheme.

1 Introduction

In 2005, designated the "International Year of Microcredit" by the United Nations, microfinance institutions around the world issued approximately 110 million loans with an average size of $340. The following year, Muhammad Yunus and Grameen Bank received the Nobel Peace Prize for their efforts to eliminate poverty through microcredit. But while the provision of small, uncollateralized loans to poor borrowers in poor countries may help alleviate poverty, there is little evidence that microfinance-funded businesses grow beyond subsistence entrepreneurship. Few hire employees outside their immediate families, formalize, or generate sustained capital growth.

This paper considers one possible explanation for this phenomenon: the structure of existing microfinance contracts *themselves* may discourage risky but high-expected return investments. Typical microfinance contracts produce a tension between mechanisms that tend to reduce risk-taking, such as peer monitoring, and those that tend to encourage risk-taking, such as risk-pooling. Much of the theoretical literature has focused on joint liability, a common feature in most microfinance programs, as a means to induce peer monitoring and mitigate *ex ante* moral hazard over investment choice (e.g., Stiglitz 1990, Varian 1990, Armendariz and Morduch 2005, Conning 2005). Under joint liability, small groups of borrowers are responsible for one another's loans. If one member fails to repay, all members suffer the default consequences.

While this mechanism has been widely credited with making it possible, indeed profitable, to lend to poor borrowers in poor countries, a growing literature critically explores the relative merits of joint versus individual liability.[1] There have long been suspicions that peer monitoring may overcompensate and produce too little risk relative to the social optimum (Banerjee, Besley, and Guinnane 1994). In particular, joint liability compels an individual to bear the cost of her partner's project when it fails but does not mandate a compensating transfer upon success. This creates an

[1] When all decisions are taken cooperatively (Ghatak and Guinnane 1999) or when binding *ex ante* side contracts are feasible (Rai and Sjöström 2004) these mechanisms are identical; however, joint liability lending is most prevalent in settings where binding, complete contracts are not feasible. Madajewicz (2003, 2004) compares individual and group lending directly, focusing on monitoring costs and the relationship between available loan size and borrower wealth, but this basic comparison is difficult to make empirically. In practice, variation in loan types is likely the product of selection on unobserved characteristics by either the borrower or the lender. Giné and Karlan (2011) overcome this limitation with a large, natural field experiment that randomly assigned individuals into joint and individual liability loan contracts. They find no impact of joint liability on repayment rates and some evidence that individual liability centers generated fewer dropouts and more new clients.

incentive to discourage risk-taking by others and thus joint liability may blunt the entrepreneurial tendencies of borrowers.

At the same time, joint liability induces risk-pooling—not only does the threat of common default induce income transfers to members suffering negative shocks, but the repeated interactions of microfinance borrowers are a natural environment for the emergence of informal risk sharing. This risk-pooling may increase borrowers' willingness to take risk themselves. Moreover, the ability to share risk informally allows borrowers whose risky projects succeed to compensate their partners for the implicit insurance provided by joint liability. In doing so, it can mitigate the incentives to discourage risk-taking. It is therefore critical to evaluate formal contracts in an environment where informal risk sharing is possible.

To shed light on how microfinance contracts affect investment choices, this paper develops a theoretical framework that unifies models of investment choice, informal risk-sharing with limited commitment, and formal financial contracts in order to illustrate a range of theoretical effects and motivate a series of empirical tests. It then implements a corresponding experiment with actual microfinance clients in India.

The theoretical framework builds on a simple model of informal risk-sharing in the spirit of Coate and Ravallion (1993) and Ligon, Thomas, and Worrall (2002).[2] In this model, two risk-averse individuals receive a series of income draws subject to idiosyncratic shocks. In the absence of formal insurance and savings, they enter into an informal risk-sharing arrangement that is sustained by the expectation of future reciprocity. I enrich this model by endogenizing the income process, allowing agents to optimize their investment choices in response to the insurance environment. Contrary to much of the static investment choice literature in microfinance, in this model risky projects generate higher expected returns than safe projects, reflecting the natural assumption that individuals must be compensated for additional risk with additional returns.[3] On this framework I then overlay formal financial contracts. I

[2] An extensive empirical literature documents the importance of informal insurance arrangements as a risk management tool for those who lack access to formal insurance markets (e.g., Townsend 1994, Udry 1994, Foster and Rosenzweig 2001, Fafchamps and Lund 2003, Fernando 2006). Taken as a whole, the empirical evidence suggests that informal risk coping strategies do not achieve full risk pooling even though in some cases they perform remarkably well. This paper adds to an emerging experimental literature (Barr and Genicot 2008, Robinson 2008, Charness and Genicot 2009) that uses the precise control possible in an experimental setting to understand how such mechanisms work in practice.

[3] Following Stiglitz (1990), most theoretical work in microfinance has assumed that riskier investments represent at best a mean-preserving spread of the safer choice and often generated a lower

consider in turn individual liability, joint liability, and an equity-like contract in which all investment returns are shared equally.

The model illustrates two opposing influences of joint liability on investment choice. Mandatory transfers from one's partner encourage greater risk-taking by partially insuring against default. Risk-taking borrowers may compensate their partners for this insurance with increased transfers when risky projects succeed, or they may "free-ride," forcing their partners to insure against default without compensating transfers. The parallel need to *provide* this insurance counters the risk-encouragement effect of receiving it, and relatively risk-averse individuals may elect safer investments to avoid joint default should their partners' projects fail.

The theoretical analysis also produces two important supporting results. First, it demonstrates that joint liability contracts may crowd out informal insurance. By effectively mandating income transfers to assist loan repayment, joint liability eases the sting of punishment and can make cooperation harder to sustain. Second, informal insurance tends to increase risk-taking. Contrary to standard risk-sharing models, this has the surprising implication that we may find *more* informal insurance among risk-tolerant individuals whose willingness to take riskier investments expands their scope for cooperation.

While these models offer useful insights, in the context of repeated interactions they produce a multiplicity of equilibria, and theory alone can provide only partial guidance regarding the likely consequences of informal insurance and formal contracts for investment behavior. To shed further light on these questions, I conducted a series of experiments with actual microfinance clients in India. The experiments capture the key elements of the theoretical framework and the microfinance investment decisions it represents. Based on extensive piloting, I designed the games to be easily understood by typical microfinance clients—project choices and payoffs were presented visually, all randomizing devices used common items and familiar mechanisms (e.g., guessing which of an experimenter's hands held a colored stone), and game money was physical—and confirmed understanding at numerous points throughout the experiment. Individuals were matched in pairs that dissolved at the end of each round with a 25% probability in order to simulate a discrete-time, infinite-horizon model with discounting. In each round, subjects could use the proceeds of a "loan" to invest

expected return. Examples include Morduch (1999), Ghatak and Guinnane (1999), and de Aghion and Gollier (2000).

in one of several projects that varied according to risk and expected returns. Returns were determined through a simple randomizing device, after which individuals could engage in informal risk-sharing by transferring income to their partners. In order to play in future rounds, subjects needed to repay their loans according to the terms of a formal financial contract, which I varied across treatments.

I considered five contracts: autarky, individual liability, joint liability, joint liability with a project approval requirement, and an equity-like contract in which all income was shared equally. Much of the microfinance literature assumes a local information advantage; therefore, to test the role of information, I conducted each of the treatments under both perfect monitoring, where all actions and outcomes were observable, and imperfect public monitoring, where individuals observed only whether their partner earned sufficient income to repay her loan. At the end of the experiment, one period was randomly selected for cash payment.[4]

A laboratory-like experiment allows precise manipulation of contracts, information, and investment returns to a degree that would be impractical for a natural field experiment. Moreover, even in carefully constructed field experiments, low periodicity, long lags to outcome realization, fungibility of investment funds and measurement issues associated with micro-business data complicate the use of investment choice as an outcome variable.[5] An experiment overcomes each of these challenges. While the use of an experiment entails a trade-off between control and realism, I attempted to maximize external validity with meaningful payoffs of up to one week's reported income, subjects drawn from actual microfinance clients, and an experimental design that closely simulates the underlying theory. This approach builds on Giné, Jakiela, Karlan, and Morduch (2009), which pioneered the use of laboratory experiments with a relevant subject pool in order to unpack the effects of various design features in microfinance contracts.

The core experimental result is that joint liability produced significant free-riding. Risk-tolerant individuals, as measured in a benchmarking risk experiment, took significantly greater risk under joint liability with imperfect monitoring. Yet the transfers

[4]As described in Charness and Genicot (2009), this payment structure prevents individuals from self-insuring income risk across rounds. The utility maximization problem of the experiment corresponds to that of the theoretical model.

[5]Giné and Karlan (2011), for example, were able to randomize across joint and individual loan contracts with a partner bank in the Philippines. They find no difference in default rates and faster expansion of the client base under individual liability but are unable to evaluate investment behavior.

they made when successful did not increase with the riskiness of their investments or the expected default burden they placed on their partners. Increased risk-taking was not evident under joint liability with perfect monitoring, and when individuals were given explicit approval rights over their partners' investment choices, risk-taking fell below that observed in autarky. Together, these results indicate that increased risk-taking was not the product of cooperative insurance. They also suggest that peer monitoring mechanisms, as embodied in explicit project approval rights, not only prevent *ex ante* moral hazard but more generally discourage risky investments, irrespective of whether or not such risks are efficient. This may in part explain why we see little evidence that microfinance-funded businesses grow beyond subsistence entrepreneurship. It may also help us reconcile some of the anecdotal evidence on the limits of joint liability and the increasing willingness of microfinance institutions to consider contracts other than joint liability.[6]

The equity-like contract increased risk-taking and expected returns relative to other contracts while at the same time producing the lowest default rates. Increased risk was almost always hedged across borrowers, with the worst possible joint outcome still sufficient for loan repayment. These results are encouraging and suggest that equity-like contracts merit further exploration in the field.

It is worth emphasizing that both the theory and experiment abstract from effort, willful default, partner selection, and savings. This is not meant to imply that any of these factors is unimportant.[7] Instead, the purpose is to isolate the elements of risk-sharing, investment choice, and formal contracts and to explore their implications.

The rest of this paper is organized as follows. Section 2 develops the model of informal risk-sharing with formal financial contracts and endogenous investment

[6] In 2002, Grameen Bank in Bangladesh introduced the Grameen Generalized System, typically referred to as *Grameen II*, which, among other features, formally eliminates joint financial liability. BancoSol, a large and well-known Bolivian microfinance institution, has moved much of its portfolio to individual loans. For anecdotal evidence on the limits of joint liability see, for example, Woolcock (1999) and Montgomery (1996).

[7] The theory of strategic default on microfinance contracts is explored in Besley and Coate (1995) and Armendariz (1999), while Armendariz and Morduch (2005) and Laffont and Rey (2003) both treat moral hazard over effort in detail. To the best of my knowledge, neither area has seen careful empirical work in the context of microfinance. Similarly, the empirical implications of savings for informal risk sharing arrangements remain poorly understood. Bulow and Rogoff's (1989) model of sovereign debt implies that certain savings technologies can unravel relational contracts, including informal insurance. Ligon, Thomas, and Worrall (2000) consider a simple storage technology and find that the ability to self-insure can crowd out informal transfers, with ambiguous welfare implications.

choice. Proofs are contained in Appendix B, unless otherwise noted. Section 3 describes the experimental design, and Section 4 presents the experimental results. Section 5 concludes.

2 A Model of Investment Choice and Risk Sharing

The primary aim of this section is to illustrate important theoretical effects of formal financial contracts and informal risk-sharing arrangements on investment choices and to motivate a series of empirical tests. While the theoretical setting is distilled to just those elements necessary to frame the informal risk-sharing and investment choice problem, the economic environment remains quite complex. Multiple equilibria, issues of equilibrium selection, and the importance of assumptions about the structure of information and beliefs limit the ability to make general propositions. However, restrictions to the particular economic environment modeled in the experiment will allow some concrete empirical predictions derived from theory and numerical simulations and, where such predictions are not sharp, to frame the theoretical effects influencing behavior.

2.1 Overview of the Economic Environment

Consider a world where two individuals make periodic investments that are funded by outside financing. Each period, they each allocate their investment between a safe project that generates a small positive return with certainty or a risky investment that may fail but compensates for this risk by offering a higher expected return.

Formal financial contracts govern individuals' ability to borrow and hence their investment opportunities. These formal financial contracts specify the availability of borrowing as a function of past outcomes, repayment terms, and the feasible range of income transfers between agents. Their terms are set by a third party before the start of the game and are constant throughout the game.[8] The analysis considers four principle types of formal financial contracts: autarky, individual liability, joint liability and quasi-equity, which is equivalent to joint liability with third-party enforced equal sharing of all income. The individual and joint liability contracts capture

[8] This maps to the experimental setting where formal financial contracts are the key dimension of experimental variation and exogenously imposed for each game.

key elements of micro-lending contracts that exist in practice. The other two are counterfactual and provide benchmarks for risk-sharing arrangements, with practical implications discussed more fully in Section 4. All four are described in more detail below.

Individuals are risk averse, but they cannot save and lack access to formal insurance. In order to maximize utility they therefore enter into an informal risk-sharing arrangement that may extend beyond any sharing rules specified in the formal contract. This informal arrangement is not legally enforceable and must therefore be self-enforcing: an individual will transfer no more than the discounted value of what she expects to get out of the relationship in the future.

Throughout, I consider two monitoring environments: perfect monitoring, where all investment choices and income realizations are observable, and imperfect public monitoring, where each player observes only her own actions and income realizations as well as the transfers made by her partner.

2.2 The Economic Environment

I model the economic environment described above using a discrete-time, infinite-horizon economy with two agents indexed by $i \in \{A, B\}$ and preferences

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \delta^t u_i(c_{i,t})$$

at time $t = 0$, where $\mathbb{E}_0$ is the expectation at time $t = 0$, $\delta \in (0, 1)$ is the discount factor, $c_{i,t} \geq 0$ denotes the consumption of agent i at time t, and u_i represents agent i's per-period von Neumann-Morgenstern utility function, which is assumed to be nicely behaved: $u_i'(c) > 0, u_i''(c) < 0 \quad \forall c > 0$ and $\lim_{c \to 0} u_i'(c) = \infty$. In the notation that follows, I suppress the time and agent indicators where not required for clarity.

This remainder of this section describes the three components of the game structure: the stage game, the dynamic game, and formal financial contracts.

Stage Game. The stage game depends on a state variable, $\{D_A, D_B\}$, that indicates the amount of borrowing available to each agent and evolves according to a deterministic transition function that is set by the formal financial contract as described below. In every stage game, player i chooses an action $a_i = (\alpha_i, \tau_i)$, which specifies an investment allocation and transfer. These actions are played in steps 2 and 4 of the stage game, respectively. Each stage game proceeds as follows:

1. Players begin the stage game with a formal financial contract in place. Each individual has zero wealth and access to a loan D_i, where the amount of this loan is specified by the formal financial contract, described below. In describing the stage game, I will proceed by considering the case in which $D_i = D$ for both players.

2. From her total capital, D_i, each individual allocates a share $\alpha_i \in [0, 1]$ to a risky investment that with probability π returns R for each unit allocated and 0 otherwise. The remainder, $1 - \alpha_i$, she allocates to a safe investment that returns $S \in [1, R\pi)$ with certainty. Denote by $\theta_i \in \{h, l\}$ individual i's state realization. When the risky project succeeds ($\theta_i = h$), individual i's total income is $y_i^h(\alpha_i, D_i) = \{\alpha_i R + (1 - \alpha_i)S\}D_i$. When the risky project fails ($\theta_i = l$), her income is $y_i^l(\alpha_i, D_i) = \{(1 - \alpha_i)S\}D_i$. Note that π is fixed: the probability of success is identical and independent across players and periods.

3. The state of nature is realized and each individual receives her income, y_i. Denote by $\theta = (\theta_A, \theta_B)$ the state of nature, such that for any state θ, $(y_A, y_B) = (y_A^{\theta_A}, y_B^{\theta_B})$. For notational simplicity I write the four states of nature as $\Theta = \{hh,\ hl,\ lh,\ ll\}$.[9]

4. Each individual chooses to transfer an amount $\tau_i \in T_i^f \equiv [\underline{\tau}_i, \overline{\tau}_i]$ to her partner, where the feasible range is specified by the formal financial contract and any transfers above $\underline{\tau}_i$ are voluntary. Income after transfers is $\tilde{y}_i = y_i - (\tau_i - \tau_{-i})$.

5. Loan repayment is determined mechanically: $P_i = \min(D_i, \tilde{y}_i)$. There is no willful default.

6. Agents consume. Because agents cannot save, the specified loan repayment uniquely determines consumption for the period: $c_i = y_i - (\tau_i - \tau_{-i}) - P_i$.

Dynamics. Consider an infinite repetition of the stage game where preferences and discounting are as described above. Players' access to loans in step 1 of the stage game, $\{D_{A,t}, D_{B,t}\}$, is given by a deterministic transition function that is set

[9] These states occur with probability π^2, $\pi(1-\pi)$, $\pi(1-\pi)$, and $(1-\pi)^2$, respectively.

by the formal contract, detailed below. As with actual microfinance contracts, an individual's ability to borrow in the current period is a function of past borrowing and repayment.

Let $a_{i,t} = (\alpha_{i,t}, \tau_{i,t})$ denote the action played by player i and $\theta_t \in \Theta$ denote the state of nature realized in period t. In games of imperfect public monitoring, each player observes only her own actions and income realizations as well as the transfers made by her partner. Player i's private history up to period t is given by $h_i^t \equiv \{a_{i,t'}, \tau_{-i,t'}, \theta_{i,t'}\}_{t'=0}^{t-1}$; h_i^0 is the empty set. Agents have observed more when choosing their transfer in step 4 of the stage game than when choosing the preceding investment: player i' interim private history in period t, $\tilde{h}_i^t$, is the concatenation of h_i^t and $\{\alpha_{i,t}, \theta_{i,t}\}$. For each $t \geq 0$, H_i^t is the set of all h_i^t; define $\tilde{H}_i^t$ analogously. Based on the history of observed transfers, agents form beliefs, $\mu(\cdot)$, about the full history of investment choices and income realizations. In games of perfect monitoring, all investment choices and income realizations are observable, and a public history $h^t \equiv \{a_{i,t'}, a_{-i,t'}, \theta_{t'}\}_{t'=0}^{t-1}$ is a list of t action profiles identifying the actions played and the state of nature in periods 0 through $t-1$. The interim public history in period t, $\tilde{h}^t$, is the concatenation of h^t and $\{\alpha_{i,t}, \alpha_{-i,t}, \theta_t\}$. With h^0 equal to the empty set, for each $t \geq 0$, H^t is the set of all h^t; define $\tilde{H}^t$ analogously. Let $H_i = \bigcup_{t=0}^{\infty} H_i^t$ and define $\tilde{H}_i$, H, and $\tilde{H}$ analogously.

Formal Financial Contracts. I consider the above game under four different formal financial contracts. Each game begins with a formal contract in place that specifies three rules, which are fixed throughout each game: (1) a deterministic transition function that determines the availability of borrowing ($D_{i,t}$) based on prior period repayment ($P_{i,t-1}$ and $P_{-i,t-1}$) and borrowing ($D_{i,t-1}$ and $D_{-i,t-1}$); (2) a feasible range of transfers, $T_i^f \equiv [\underline{\tau}_i, \overline{\tau}_i]$, from each individual as a function of each individual's income, y_i and y_{-i}; and (3) loan repayment (P_i) as a function of income after transfers, $\tilde{y}_i$. For all contracts, both individuals begin with access to a loan: $D_{A,0} = D_{B,0} = D$. I also normalize the interest rate on all loans to zero and exclude the possibility of willful default or *ex post* moral hazard—an individual will always repay if she has sufficient funds—in order to focus on investment choice and risk-sharing behavior: $P_i = \min(D_i, \tilde{y}_i)$.

Under autarky, an individual can borrow in the subsequent period if and only if she repays her own loan in the current one: $D_{i,t+1} = D$ if and only if $P_{i,t} = D_{i,t} = D$.

Individuals cannot make income transfers: $T_i^f = \{0\}$.

Under individual liability, an individual can borrow in the subsequent period if and only if she repays her own loan in the current one: $D_{i,t+1} = D$ if and only if $P_{i,t} = D_{i,t} = D$. Individuals can make voluntary income transfers: $T_i^f = [0, y_i]$.

Under joint liability, an individual can only borrow in the subsequent period if both she and her partner repaid their loans in the current period: $D_{i,t+1} = D$ if and only if $P_{i,t} = D_{i,t} = D$ for $i \in \{A, B\}$. If either individual has insufficient funds to repay her loan, her partner must help if she can. Additional voluntary transfers are possible: $T_i^f = [\max(\min(y_i - D_i, D_{-i}, y_{-i}), 0), y_i]$.

Under the equity contract, as with joint liability, an individual can only borrow in the subsequent period if both she and her partner repaid their loans in the current period. Individuals must share their income equally before any voluntary transfers: $T_i^f = [\frac{1}{2}y_i, y_i]$.

2.3 Strategies and Equilibria

Strategies and Restrictions. A pure strategy for player i, σ_i, is a mapping from all possible histories into the set of actions, A_i, with typical element a_i. There are two components to an action: an investment choice, α_i, and a transfer, τ_i. Strategies map from H^t into investment choices and from $\tilde{H}^t$ into transfers in games of perfect monitoring and from H_i^t and $\tilde{H}_i^t$ in games of imperfect public monitoring. $U_i(\sigma)$ is i's expected, discounted utility of strategy σ, where the expectation is taken over histories. In addition to the standard requirements for a perfect Bayesian equilibrium, I will consider equilibria whose strategies exhibit certain properties.

First, as is standard in the literature on informal insurance, the informal risk-sharing arrangement is supported by trigger strategy punishments. If either party reneges on the informal insurance arrangement, both members revert to the minimum transfer profile, i.e., they exit the informal insurance arrangement in perpetuity and make only those transfers required by the formal contract. Note that I assume no direct punishment; the only consequence for reneging on the informal risk-sharing arrangement is exclusion from further informal insurance possibilities. Second, immediately subsequent transfers are the only future actions conditioned on investment choices. This precludes, for example, both punishment based on prior investment choices and using investment choices to punish.[10]

Third, I restrict attention to strategies where, outside any punishment phase, transfers are only a function of current income realizations. Whenever the same income, (y_A, y_B), is realized, the same transfers are made.[11,12]

To summarize, for each player there is an equilibrium-path investment level, α^e, and a punishment-path investment level, α^p. Deviations from these investment levels have no implications for continuation play. For each player, there is also an equilibrium-path transfer rule that gives period-t transfers as a function of period-t realized incomes only—in particular, transfers are not a function of period-t investment levels—and a punishment-path transfer that prescribes the minimum transfer profile allowed by the financial contract in each period.

Informal Insurance Arrangements. An informal insurance arrangement, $T(\alpha_A, \alpha_B)$, specifies the net transfer from A to B for any state of nature θ given individuals' allocations to the risky asset (α_A, α_B). Since individuals are risk averse and $\pi R > S$, in autarky both individuals will allocate an amount $\alpha_i \in (0, 1]$ to the risky asset. Because $\alpha_i > 0$, there exist at least two states of the world where the autarkic ratios of marginal utilities differ, and individuals will have an incentive to share risk. I

[10] Based on pilot results, I choose to restrict attention to equilibria that do not condition on investment choices as this appears to more accurately reflect participants' behavior. Participants described their partners' behavior as untrustworthy, unfair, or non-cooperative when they failed to make certain transfers conditional on their outcome and not based on their investment choices. Those making risky investments were described as non-cooperative only if they failed to make significant transfers when their investments succeeded.

[11] Ligon, Thomas, and Worrall (2002) demonstrate that conditioning current transfers on the past history of transfers, what they call the dynamic limited commitment model, increases the scope for insurance. Adding a debt-like component to transfers, which they model as an evolution of the Pareto weight in favor of the transferring partner, can relax her incentive compatibility constraint. In any period, the debt repayment element from an individual who has received transfers in the past can more than offset the static risk-sharing (insurance) component. This could lead to misleading conclusions about the extent of informal insurance in any single period after the first; however, in expectation, the dynamic model simply expands the equilibrium set. The model in which transfers are only a function of current income realizations, what Ligon, Thomas and Worrall refer to as the static limited commitment model, therefore represents a conservative and analytically tractable framework in which to interpret experimental results where transfer behavior is averaged over all observations.

[12] In the empirical analysis, I restrict attention to transfers generating efficient payoff vectors in which the Pareto weight is equal to the ratio of marginal utilities in autarky. This restriction implies that if both individuals make the investment allocation that would be optimal in autarky, regardless of their risk preferences, transfers occur only when one project succeeds and one project fails (states hl and lh).

assume individuals can enter into an informal risk-sharing arrangement supported by the expectation of future reciprocity. Conditional on individuals' allocations to the risky asset, the vector $T_i = (\tau_i^{hh}, \tau_i^{hl}, \tau_i^{lh}, \tau_i^{ll})$ specifies the transfer from i to $-i$ in each state of the world, and the vector $T = T_A - T_B$ fully specifies the transfer arrangement. The *minimum transfer profile* describes the transfer vector in which individuals make only those transfers required by the formal financial contract. Note that although individuals may choose not to make any voluntary (informal) transfers, they are still subject to the transfer requirements, if any, of the formal financial contract.[13]

With the restrictions on strategies described above, incentive compatibility requires that in any state of the world the discounted future value of remaining in the informal insurance arrangement must be at least as large as the potential one-shot gain from deviation, i.e.,

$$u(y_i^\theta - \tau_i^\theta + \tau_{-i}^\theta) \geq u(y_i^\theta) - \delta\left(\frac{V_i(\alpha, T)}{1 - \delta \Pr[R_i|\, \alpha, T]} - \frac{V_i(\alpha^p, 0)}{1 - \delta \Pr[R_i|\, \alpha^p, 0]}\right), \qquad (1)$$

where $\Pr[R_i|\, \alpha, T]$ is the probability that individual i meets the repayment terms of her formal financial contract (as described above) conditional on investment choice α and transfer arrangement T; $V_A(\alpha^p, 0) = \pi u(y^h(\alpha^p, D)) + (1 - \pi)u(y^l(\alpha^p, D))$, A's expected per-period autarkic utility; $V_A(\alpha, T) = \pi^2 u(y^h(\alpha, D) - \tau^{hh}) + \pi(1 - \pi)u(y^h(\alpha, D) - \tau^{hl}) + \pi(1-\pi)u(y^l(\alpha, D) - \tau^{lh}) + (1-\pi)^2 u(y^l(\alpha, D) - \tau^{ll})$, A's expected per-period utility with investment choice α and transfer arrangement T; and B's utility is defined analogously.

When formal contracts specify a minimum transfer $\underline{\tau}^\theta$ in state θ, I modify the constraint accordingly:

$$u(y_i^\theta - \tau_i^\theta + \tau_{-i}^\theta) \geq u(y_i^\theta - \underline{\tau}_i^\theta + \underline{\tau}_{-i}^\theta) - \delta\left(\frac{V_i(\alpha, T)}{1 - \delta \Pr[R_i|\, \alpha, T]} - \frac{V_i(\alpha^p, \underline{T})}{1 - \delta \Pr[R_i|\, \alpha^p, \underline{T}]}\right), \qquad (2)$$

where $\underline{T} = (\underline{\tau}^{hh}, \underline{\tau}^{hl}, \underline{\tau}^{lh}, \underline{\tau}^{ll})$, the *minimum transfer profile.*

Definition 1 (Implementability) *For an investment allocation* (α_A, α_B)*, a transfer arrangement,* T*, is* implementable *if and only if it satisfies both agents' incentive*

[13] In the case of individual liability, the minimum transfer profile is analogous to reversion to autarky. I choose an alternative designation here to avoid confusion with the autarky contract and to highlight the fact that in the joint liability and equity contracts even agents who exit the informal insurance arrangement may still be required to make transfers in certain states.

compatibility constraints in all states, i.e., (2) holds for $i \in \{A, B\}$ and $\forall\theta$.

Equilibrium. I will concentrate on perfect Bayesian equilibria with the restrictions described above. In games of perfect monitoring, the set of *relevant histories* is the set of all $h \in H \cup \widetilde{H}$; in games of imperfect public monitoring, this is the set of all $h \in H_i \cup \widetilde{H_i}$. I define a *restricted perfect Bayesian equilibrium* (RPBE) as a strategy profile σ^* and beliefs $\mu(\cdot)$ such that for all players i, all relevant histories h, and all alternative strategies $\sigma_i^{'}$ (i) the incorporated transfer profiles are implementable, (ii) $U_i\left(\sigma_i^*|h, \mu(h)\right) \geq U_i\left(\sigma_i^{'}, \sigma_{-i}^*|h, \mu(h)\right)$, i.e., investment choices and transfer profiles are optimal conditional on beliefs, (iii) beliefs are updated according to Bayes' rule where applicable, and (iv) the immediately subsequent transfers are the only future actions conditioned on investment choices. As described above, this restricts attention to equilibria in which, outside any punishment phase, transfers are only a function of current income realizations.

In games of perfect monitoring, where investment choices and income are observable, these equilibria simplify to subgame perfect equilibria as is standard in the theoretical literature on informal insurance. Following previous literature, I will concentrate on payoff vectors that are Pareto efficient within the set of equilibrium payoffs.[14] That is, individuals' strategies and beliefs must constitute an RPBE and solve $\max_{\alpha,T} U_A(\sigma) + \lambda U_B(\sigma)$, where λ is the Pareto weight placed on B.

2.4 The Impact of Contracts and Monitoring on Informal Risk-Sharing

The following two sections develop predictions generated by the preceding model. This section explores the effects of monitoring and contracts on informal risk-sharing, and Section 2.5 concerns risk-taking decisions. They provide a framework for interpreting the experimental results presented in sections 4.1 and 4.2, respectively. This section divides the discussion of informal risk-sharing into two branches. First, I examine the role of monitoring. Much of the literature on microfinance discusses the importance of peer monitoring and local information,[15] and the experimental setting

[14] Of course, we could observe transfers inside the frontier. The empirical setting allows me to test the practical applicability of this convention, and Section 4.1 describes the results of these tests.

[15] Among the numerous examples are Banerjee, Besley, and Guinnane (1994), Stiglitz (1990), Wydick (1999), Chowdhury (2005), Conning (2005), Armendariz (1999), and Madajewicz (2004).

was designed to test their importance by evaluating each contract with and without perfect monitoring. Second, I examine the role of financial contracts themselves, focusing on the differences between individual and joint liability.

Monitoring. Standard models of informal insurance assume perfect monitoring; however, in practice, even when agents know one another well, this assumption is unlikely to hold. A full characterization of the equilibria that are Pareto efficient under imperfect monitoring is sensitive to a number of assumptions. I will consider symmetric equilibria, in the sense that punishment takes the form of reversion to the minimum transfer profile, which punishes both parties. The result is inefficiency. Since mutual punishments are inefficient and this punishment occurs with positive probability, the set of sustainable transfer arrangements is bounded away from the perfect-monitoring frontier.[16]

With imperfect public monitoring, at the time of making her transfer an individual knows only her own private history. Her partner's income is never revealed. Under a cooperative transfer regime, she chooses a pure strategy $T_i^{'} = (\tau_i^h, \tau_i^l)$, where the superscript denotes her own outcome. Her partner does likewise. We can assess the effect of imperfect public monitoring by determining if the transfer profiles, $T_A^{'}$ and $T_B^{'}$, that would implement a constrained efficient equilibrium under perfect monitoring, T^*, are themselves implementable under imperfect public monitoring.[17] If $\tau^h > \tau^l$ is to be incentive compatible, an individual who transfers τ^l must be punished with some positive probability p. Because of imperfect monitoring, punishment cannot be conditioned on income realization. This leads to the following prediction, which section B.2 discusses in more detail:

Prediction 1 (monitoring and informal insurance) *Fix the Pareto weight, λ. Then the RPBE with perfect monitoring features transfers at least as large as the RPBE with imperfect monitoring. If the incentive compatibility constraint is binding in the RPBE with perfect monitoring, i.e., the transfer arrangement does not achieve*

[16] This intuition is consistent with the work of Green and Porter (1984). Radner, Myerson, and Maskin (1986) study a model of partnership games in which every equilibrium (symmetric and not) is inefficient, while Fudenberg, Levine, and Maskin (1994) identify conditions under which there exist approximately efficient equilibria.

[17] Note that only strategies $T = (\tau^{hh}, \tau^{hl}, \tau^{lh}, \tau^{ll})$ where $\tau^{hl} + \tau^{lh} = \tau^{hh} + \tau^{ll}$ are replicable under limited information.

full insurance, then transfers in the RPBE with perfect monitoring are strictly larger than those in the RPBE with imperfect monitoring.

Formal Financial Contracts. I now turn to the effect of joint liability on informal insurance. Joint liability will affect the set of informal insurance arrangements that are consistent with an RPBE through its effect on the implementability constraint in equation (2). When neither party takes default risk, joint liability does not require transfers in any state of nature and will not affect the set of implementable transfers. However, when both agents have the potential for default and the transfers required by joint liability improve both individuals' expected utility from the minimum transfer profile, $V(\alpha^p, \underline{T})$, the scope for punishment by exiting the informal insurance arrangement is reduced. In those states where transfers are not required by the contract, this will tighten the incentive compatibility constraint in (2) and reduce the maximum implementable transfers. The effect in states where transfers are required is more nuanced, with the reduced scope for punishment offset by a smaller gain from immediate deviation as well as the direct effect of the mandatory transfer itself. Similar offsetting effects occur when only one individual takes default risk. In this case, the risk-taking individual's utility increases relative to individual liability without voluntary transfers—she benefits from the mandatory insurance of joint liability—reducing her willingness to make informal transfers. The reverse holds for her partner, and the net effect is ambiguous. For games of perfect monitoring, these effects are summarized in the following prediction, which is discussed in more detail in Section B.2.

Prediction 2 (joint liability and informal insurance) *Fix the Pareto weight, λ, and consider a game of perfect monitoring and an RPBE under individual liability ($\underline{T}= 0$) in which the transfer profile, T, implements a constrained efficient RPBE. The addition of joint liability ($\underline{T}\neq 0$) exerts four opposing effects on the transfer profile, T', that implements a constrained efficient RPBE: (i) by mandating transfers from one's partner ($\exists \theta$ s.t. $\underline{\tau}_{-i} > 0$), joint liability increases an agent's utility from the non-cooperative (punishment) equilibrium. This reduces the scope for punishment and therefore reduces the agent's maximum incentive compatible transfers; (ii) by mandating transfers to one's partner ($\exists \theta$ s.t. $\underline{\tau}_i > 0$), joint liability reduces an agent's utility from the non-cooperative equilibrium and hence increases the maximum incentive compatible transfers; (iii) when transfers are required joint liability* *reduces the scope for immediate deviation (if $\underline{\tau}_i > 0$ then $u(y_i - \underline{\tau}_i + \underline{\tau}_{-i}) > u(y_i)$) and therefore increases the maximum incentive compatible transfers; (iv) in states of the world where transfers are required for debt repayment, joint liability can mechanically increase transfers. The net effect of these forces depends on the specific parameters and individual preferences.*

To motivate further the empirical tests, we can solve numerically for specific parameter values relevant to the empirical setting in order to describe the payoff vectors that are Pareto efficient in the set of equilibrium payoffs.[18] The incentive compatibility constraints in (1) and (2) describe a set of constrained-efficient risk transfers with each point determined by the relative weight assigned to each agent by the social planner. As a benchmark, I selected a single point on this frontier using a Pareto weight, λ, equal to the ratio of marginal utilities in state hh under autarky.[19] A clear pattern emerges from the numerical simulations. For the parameter values used in the experiment, joint liability generally crowds out informal insurance when at least one individual takes default risk. For example, consider two individuals with constant relative risk aversion, $u(c) = c^{(1-\rho)}/(1-\rho)$, and risk aversion parameters of 0.52 and 0.39 who allocate 0.375 and 0.625 to the risky asset, respectively.[20] Individual liability supports a transfer from the individual taking more risk of approximately 30%

[18] See Section 3 for a detailed description of the experimental setting. It maps closely to the environment with parameter values $S = 1$, $R = 3$, $D = 1$, $\delta = 0.75$, and $\pi = 0.5$; however, as explained therein, subjects were presented with eight discrete investment choices rather than the continuous allocation problem described here.

[19] I set $\lambda = \lambda^0 \equiv u'_A(\alpha_A(R-S)+S-D)/u'_B(\alpha_B(R-S)+S-D)$, where α_A and α_B are the actual investment choices made by each agent. If this weight did not admit a non-zero, individually-rational transfer arrangement irrespective of the incentive compatibility constraints, I set λ to the closest value of λ that would. Specifically, there exists a feasible set of Pareto weights, $[\underline{\lambda}, \overline{\lambda}]$, for which a non-zero, individually-rational, implementable transfer arrangement may exist. If $\lambda^0 > \overline{\lambda}$ then I set $\lambda = \overline{\lambda}$, and if $\lambda^0 < \underline{\lambda}$, I set $\lambda = \underline{\lambda}$. From this starting point of a transfer vector that achieves full insurance with a Pareto weight of λ, I numerically searched for the transfer vector that would implement a constrained efficient RPBE. See Section 4.1 for a discussion of the empirical implications of the choice of starting weights.

To determine the range of λ, I solve $\arg\max_T V_A(\alpha_A, T)$ s.t. $V_B(\alpha_B, T) \geq V_B(\alpha_B, \underline{T})$, that is, for agents' actual investment choices, the transfer arrangement that maximizes A's utility while satisfying B's participation constraint. The solution is a transfer arrangement that achieves full insurance with a constant ratio of marginal utilities in all states of nature θ: $u'_A(y^\theta_A - D - \tau^\theta)/u'_B(y^\theta_B - D + \tau^\theta) \equiv \underline{\lambda}$. Similarly, I define $\overline{\lambda}$ as the ratio of marginal utilities that obtains from the transfer arrangement that maximizes B's utility while satisfying A's participation constraint.

[20] This corresponds to benchmark risk allocations of D and E in the experiment and corresponding investment choices of C and E. The vector of maximum incentive compatible transfer based on Pareto weights as described in the text is $(-54.4, 22.0, -98.8, 0)$. No informal transfers are incentive compatible under joint liability.

of her income when both projects succeed and 55% when only her project does. In exchange, when her project fails she receives approximately 16% of her partner's income, which both generates positive consumption and prevents default. In contrast, under joint liability, no informal transfers are incentive compatible. The partner taking default risk can rely on mandatory transfers and thus has no need to make compensating transfers when her project succeeds. The chief exception to this pattern of crowding out occurs when one partner is particularly risk averse.[21] In this case, the utility cost of inducing sufficient transfers from her to prevent default under individual liability is very high. Intuitively, the risk-averse partner does not want to be exposed to additional risk through an informal insurance arrangement. Under joint liability, the mandatory transfer requirement binds and transfers are larger than under individual liability.

2.5 The Impact of Contracts and Monitoring on Risk-Taking

I now turn to the effect of formal and informal insurance on individuals' allocation to the risky asset. Intuitively, informal insurance exerts two effects on risk-taking decisions. First, transfers from individuals with successful projects to partners whose projects fail increase agents' allocation to the risky asset. Second, pooling of income moves each agent's optimal investment choice to a point between their autarkic choices; this effect increases the optimal allocation to the risky asset for the more risk-averse agent and reduces the allocation for the more risk tolerant. While, the general effect of informal insurance on risk-taking depends on parameter values, preferences and Pareto weights, these two factors lead to the following prediction.

Prediction 3 (informal insurance and risk taking) *Fix the Pareto weight, λ, and consider a transfer arrangement T that implements an RPBE. If transfers are made only when exactly one risky project succeeds ($T = (0, \tau^{hl}, \tau^{lh}, 0)$; $\tau^{hl}, \tau^{lh} > 0$) then both individuals' allocations to the risky asset are greater than under the RPBE without transfers, $T = (0, 0, 0, 0)$. If the transfer arrangement achieves full insurance ($u'(y_A^\theta - \tau^\theta)/u'(y_B^\theta + \tau^\theta) = \lambda$, a constant, for all θ), then the less risk-tolerant partner will unambiguously allocate more to the risky asset than she would in an equilibrium without informal transfers;however, the difference in the investment allocation by the more risk-tolerant partner is indeterminate.*

[21] This corresponds to benchmark risk choices A or B, equivalent to $\rho > 1$.

Section B.2 discusses this prediction in more detail. Note that the first part of the prediction leads to the corollary that in any equilibrium that includes a symmetric insurance arrangement, both parties will allocate more to the risky asset than they would in an equilibrium without transfers. This would include as a special case the equity contract when both parties make the same investment. For asymmetric arrangements, both of the aforementioned effects cause the more risk-averse partner to allocate more to the risky asset than in an equilibrium without transfers, while they exert opposing effects on the more risk-tolerant partner's decision. With full insurance, restricting the Pareto weight to be equal to the ratio of marginal utilities in autarky is sufficient to ensure that total risk-taking increases.[22] Note, however, that if the Pareto weight is sufficiently skewed towards the utility of the less risk-tolerant agent, total risk-taking by the pair can fall. For example, consider the following environment: $S = 1$, $R = 3$, $D = 1$, $\delta = 0.75$, and $\pi = 0.5$. When individuals A and B have CRRA risk aversion parameters of 0.2 and 2.5, their autarkic allocations to the risky asset are 0.91 and 0.10, respectively. With full insurance and equal Pareto weights, the optimal total allocation to the risky asset increases to 1.22. The allocation that maximizes B's utility subject to meeting A's participation constraint, that is, an allocation that puts all of the decision weight on the less risk-tolerant individual, sees only 0.78 allocated to the risky asset.

The interaction between informal insurance and investment choice can produce surprising results. In contrast to standard models of informal insurance with exogenous income processes, a model with endogenous investment choice has the interesting feature that more risk-tolerant individuals may engage in greater risk sharing. Consider the environment described above. The maximum sustainable insurance transfer is realized for individuals with $\rho = 0.55$ who select $\alpha^* = 0.42$. They transfer, 0.82 or 65% of the full risk-sharing amount in states lh and hl. More risk-tolerant individuals are too impatient to support additional transfers, while more risk-averse individuals allocate a lower share to the risky asset. In the experimental setting described in Section 3, the optimal investment choice for two individuals with $\rho = 0.4$ generates

[22] While there is intuitive appeal to extending the results to arrangements where full insurance is not achieved, the conclusion is not maintained without additional assumptions on the method of equilibrium selection. As discussed in the appendix, starting from autarkic investment allocations, transfers from the less risk-tolerant partner in state hh and from the more risk-tolerant partner in ll will increase total risk taking; however, the direction of transfers in these states depends itself on the investment choices made by both individuals.

a payoff (y^h, y^l) of $(160, 40)$ and supports a maximum transfer of 42, or 70% of the full insurance transfer. For individuals with $\rho = 0.6$, the optimal investment choice generates a payoff of $(140, 50)$ and supports a maximum transfer of 26 or 59% of full insurance. Table 2 details the maximum sustainable transfer for all symmetric choice pairs and a range of risk aversion indices, and Table 3 demonstrates the interaction between informal insurance and investment choice, with more cooperative informal insurance supporting increased risk-taking.

Turning to formal contracts, joint liability exerts three influences on project choice: free-riding, risk mitigation, and debt distortion. Figure 2 illustrates these effects, plotting individual B's best response function for α_B with respect to α_A in the environment $S = 1$, $R = 3$, $D = 1$, $\delta = 0.75$, and $\pi = 0.5$ where $\rho_B = 0.4$. The dashed line shows $\alpha_B^*(\alpha_A)$ under individual liability with no informal insurance. Because there is no strategic interaction in this setting, B's best response is constant. Under joint liability with no informal insurance, three distinct effects are evident. First, for low values of α_A, B takes greater risk, "free-riding" on the effective default insurance provided by A. As α_A rises, α_B returns to its level under individual liability; however, once $\alpha_A > 0.5$, B must make transfers to A to prevent default when A's project is unsuccessful. As a consequence, B reduces her own risk-taking. Once A's risk-taking is sufficiently large (here, $\alpha_A \approx 0.9$) the cost of providing default insurance is too great (B's payoff after transfers is states hl and, particularly, ll, is too low); the usual distortionary effects of debt with limited liability take over; and B's best response is to allocate all of her capital to the risky asset.

Taken together, these factors imply that when insurance is required by joint liability, an individual's risk-taking may increase or decrease relative to autarky. Consider the following numerical example. Two individuals with CRRA utility and risk aversion parameter $\rho = 0.5$ are in an environment with $S = 1$, $R = 3$, $D = 1$, $\delta = 0.9$, and $\pi = 0.5$. In autarky, each individual's optimal allocation to the risky asset, α^*, is 0.25. Now consider the situation in which they are paired under joint liability and no informal insurance. There are now three Nash equilibria to the stage game: $(0, 1)$, $(1, 0)$ and $(0.25, 0.25)$. The first two equilibria demonstrate the free riding and risk mitigation effects of joint liability. In response to increased risk-taking by their partners, individuals may reduce their own investment in the risky asset relative to autarky. This example also leads to the following prediction:

Prediction 4 (joint liability and risk taking) *Fix the Pareto weight, λ, and consider RPBE with no voluntary transfers under both individual ($T = 0$) and joint liability ($T = \underline{T}$). If neither partner would take default risk under individual liability, i.e., $(1 - \alpha_i)S \geq 1$ for $i \in \{A, B\}$, then the total allocation to the risky asset by both individuals ($\alpha_A + \alpha_B$) is weakly greater under joint liability than under individual liability. However, if either partner optimally takes default risk under individual liability, the difference in the total allocation to the risky asset is indeterminate.*

Intuitively, if neither partner would take default risk in autarky, the need for any risk mitigation is limited to the amount that one's partner increases her risk-taking and the total impact is unambiguously non-negative. When at least one individual would take default risk in autarky, the problem does not admit a clean analytical solution; however, numerical simulations allow us to characterize how risk-taking responds to joint liability in different regions of the parameter space. For most of the empirically relevant values, total risk-taking weakly increases. However, there are three regions where total risk-taking can fall when moving from individual liability to joint liability with only those transfers required for debt repayment. In all cases, at least one individual optimally chooses to take maximal risk in autarky. First, when there is a large difference in risk aversion, the desire to prevent joint default can push the more risk-averse party to reduce her allocation to the risky asset. Second, when δ is sufficiently large and S is less than 2, such that no single individual's allocation to the safe asset would be sufficient to repay both loans, a relatively risk-tolerant individual may reduce her own allocation to the risky asset because the possibility of transfers from her partner reduces her own utility cost to preventing default. Third, when the probability of success, π, and the relative return to the risky asset, R/S, are both sufficiently close to 1, i.e., the risky asset is not too risky, even relatively risk-averse individuals will allocate their entire investment to the risky asset under autarky for δ sufficiently low. For intermediate values of δ, the possibility to guarantee repayment and hence future borrowing by reducing risk-taking can lead both parties to reduce their allocation to the risky asset.

Finally, I discuss the effect of approval rights on risk-taking. Joint liability contracts may confer explicit approval rights over a partner's project choice. These approval rights may be exogenous and absolute (Stiglitz 1990) or enforceable through social sanctions. While explicitly modeling such approval rights is beyond the scope of this model, they are practically important and, as described in Section 3, can be carefully studied in the experimental setting. It is therefore useful to frame the theoretical forces influencing their potential effects on investment choices. On one hand, approval rights provide an additional punishment mechanism, which can extend the set of equilibrium payoffs. On the other hand, when insurance is imperfect, approval rights may be used directly to curtail a partner's risk-taking when it reduces one's own utility. Observed behavior will depend on which equilibria is expected in the risk-sharing game. We can make the following conjecture.

Prediction 5 (approval rights) *For transfer arrangements sufficiently close to the minimum transfer profile, own payoffs under joint liability are decreasing in one's partner's risk-taking and approval rights will likely reduce risk-taking.*

The reasoning behind this prediction is at the core of the free-riding problem: the risk-taking partner benefits from the mandatory transfers required by joint liability and does not compensate her partner for this insurance. Her partner may use approval rights to prevent risk-taking because she is jointly responsible for failure but does not share the gains from success.

3 Experimental Design and Procedures

3.1 Basic Structure

This section describes a series of experiments designed to simulate the economic environment described in Section 2. Subjects were recruited from the clients of Mahasemam, a large microfinance institution in urban Chennai, a city of seven million people in southeastern India. All were women, and their mean reported daily income was approximately Rs. 55 or $1.22 at then-current exchange rates. Participants earned an average of Rs. 81 per session, including a Rs. 30 show-up fee, and experimental winnings ranged from Rs. 0 to Rs. 250.

Mahasemam organizes its clients into groups of 35 to 50 women called *kendras*. These *kendras* meet weekly for approximately one hour with a bank field officer to conduct loan repayment activities. To recruit individuals for the experiment, I attended these meetings and introduced the experiment. Those interested in participating were given invitations for a specific experimental session occurring within the following week and told that they would receive Rs. 30 for showing up on time.

At the start of each session, individuals played an investment game to benchmark their risk preferences. Subjects were given a choice between eight lotteries, each of which yielded either a high or low payoff with probability 0.5. Panel A of Table 4 summarizes the eight choices.[23] Payoffs in the benchmarking game ranged from Rs. 40 with certainty for choice A to an equal probability of Rs. 120 or Rs. 0 for choice H.

The body of the session then consisted of two to five games, each comprising an uncertain number of rounds. Figure 1 summarizes timing for each round of the stage game. At the start of each game, individuals were publicly and randomly matched with one other participant ($t = 0$ in Figure 1) and endowed with a token worth Rs. 40 ($t = 1$), which was described as a loan that could be used to invest in a project but which needed to be repaid at the end of each round. Each subject then used the token to indicate her choice from a menu of eight investment lotteries ($t = 2$), after which we collected their tokens. Because many subjects were illiterate, I illustrated the choices graphically as shown in Figure A1. These lotteries were designed to elicit subjects' risk preferences and were ranked according to risk and return. Payoffs ranged from Rs. 80 with certainty for choice A to an equal probability of Rs. 280 or 0 for choice H; the other choices were distributed between these two.[24] Because expected profits increase monotonically with risk, they serve as a proxy for risk-taking in the discussion below.

We then determined returns for each individual's project and paid this income in physical game money ($t = 3$). Pilot studies suggested that participants understood the game more clearly and payoffs were more salient when the game money was physical and translated one-for-one to rupees. After individuals received their income, they could transfer to their partners any amount up to their total earnings for the

[23]To determine investment success, subjects played a game where a researcher randomly and secretly placed a black stone in one hand and a white stone in the other. Subjects then picked a hand and earned the amount shown in the color of the stone that they picked (figure A1). Nearly all subjects played a similar game as children in which one player hides a single object, usually a coin or stone, in one of her hands. If the other player guesses the correct hand, they win the object and are allowed to hide the object in her hands. In Tamil, the game is known as either *kandupidi vilayaattu*, which translates roughly as "the find-it game," or *kallu vilayaattu*, "the stone game." Subjects' experience with games similar to the experiment's randomizing device provides some confidence that the probabilities of the game are reasonably well understood.

[24]The granularity of choices entailed a trade-off between feasibility (both subjects' comprehension and experimental logistics) and mapping as closely as possible to the theoretical framework of continuous choices. Piloting suggested a practical maximum of eight choices.

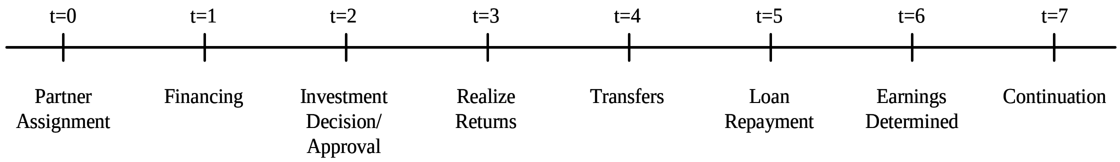


Figure 1: Timing of Events

period, subject to the rules of the financial contract treatment ($t = 4$). The next subsection describes these financial contract treatments in detail. After transfers were completed, we collected the loan repayment of Rs. 40 from each participant ($t = 5$). Willful default was not possible; if an individual had sufficient funds to repay, she had to repay.

After total earnings were calculated ($t = 6$), the game continued with a probability of 75% ($t = 7$). If the game continued, each individual played another round of the same game with the same partner beginning again at $t = 1$.[25] Those who had repaid their loans in the prior period, subject to the terms of the different contract treatments discussed below, received a new loan token and were able to invest again. Those who had been unable to repay in a previous round sat out and scored zero for each round until the game ended. This continuation method simulates the discrete-time, infinite-horizon game described in Section 2 with a discount rate of 33%. The game is also stationary; at the start of any round, the expected number of subsequent rounds in the game was four. When a game ended, loan tokens were returned to anyone who had defaulted and participants were randomly rematched with a different partner. Subjects were informed that once a game ended, they would not play again with the same partner.

In all treatments, individuals were allowed to communicate with their partners. Communication was an important step towards realism; however, the lack of anonymity raises concerns about the potential for out-of-game punishment and rewards. Although stakes were relatively high, the experiment took place within the context of a larger meta-game of social interactions. To mitigate these concerns, individuals from at least two geographically-separated *kendras* were invited to each session; approximately 75% of participants were matched with a partner from a different *kendra*.[26] I

[25] I determined if the current game would continue by drawing a colored ball from a bingo cage containing 15 white balls and 5 red. If a white ball was drawn, the game continued. If a red ball was drawn, the game ended.

[26] To further reduce the possibility of out-of-game interaction, we organized payment to all partic-

included within-*kendra* matches to test the effect of these linkages, and all results are reported for both outside- and within-*kendra* pairs.

At the start of each game, we verbally explained the rules to all subjects and confirmed understanding through a short quiz and a practice round. The Appendix provides an example of the verbal instructions, translated from the Tamil. At the end of each session, subjects completed a survey covering their occupations and borrowing and repayment experience. The survey also included three trust and fairness questions from the General Social Survey (GSS) and a version of the self-reported risk-taking questions from the German Socioeconomic Panel (SOEP).[27] I then paid each subject privately and confidentially for only one period drawn at random for each individual at the end of the session. This is a key design feature. If every round were included for payoff, individuals could partially self-insure income risk across rounds (Charness and Genicot 2009).

3.2 Financial Contract Treatments

Using the basic game structure described above, I considered five contract treatments: autarky, individual liability, joint liability, joint liability with approval rights, and equity. Each required loan repayment of Rs. 40 per borrower and included dynamic incentives—subjects failing to meet contractual repayment requirements were unable to borrow in future rounds and earned zero for each remaining round of the game. The

ipants according to *kendra* so members of each group could leave the lab at different times. While *kendras* were geographically separated, it was possible that individuals from different *kendras* could meet up outside the game, particularly at their local microfinance branches. However, discussions with participants and Mahasemam lending officers suggested that such occurrences would be rare. For two sessions, numbers 6 and 8 as described in Table 5, all participants were from a single *kendra*. Results are robust to excluding these sessions.

[27] The three GSS questions are the same as those used by Giné, Jakiela, Karlan, and Morduch (2009) and Cassar, Crowley, and Wydick (2007). Back-translated from the Tamil, they are: (1) "Generally speaking, would you say that people can be trusted or that you can't be too careful in dealing with people?"; (2) "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 (3) "Would you say that most of the time people try to be helpful, or that they are mostly just looking out for themselves?" Dohmen, Falk, Huffman, Schupp, Sunde, and Wagner (2006) demonstrates the effectiveness of self-reported questions about one's willingness to take risks in specific areas (e.g., financial matters or driving) at predicting risky behaviors in those areas. Based on this finding, I asked the following question: "How do you see yourself? As it relates to your business, are you a person who is fully prepared to take risks or do you try to avoid taking risks? Please tick a box on the scale where 0 means 'unwilling to take risks' and 10 means 'fully prepared to take risks.'" Subject were unaccustomed to abstract, self-evaluation questions and had difficulty answering.

Table 1: Summary of Financial Contract Treatments

	Communi-cation	Dynamic Incentives	Informal Risk Sharing	Joint Liability	Explicit Project Approval	Third-Party Enforced Transfers
Autarky (A)	●	●				
Individual Liability (IL)	●	●	●			
Joint Liability (JL)	●	●	●	●		
Joint Liability with Approval (JLA)	●	●	●	●	●	
Equity (E)	●	●	●	●		●

five experimental contract treatment described below embody the contracts described in Section 2.

Autarky (A). This treatment comprised individual liability lending without the possibility of income transfers. It captures the key features of dynamic loan repayment and provides a benchmark against which to measure the effect of other contracts and informal insurance on risk-taking behavior. Each subject was paired with another participant and could communicate freely as in all other treatments; however, no transfers are possible between individuals. Subjects were able to continue play if and only if they were able to repay Rs. 40 after their project return was realized.

Individual Liability (IL). This treatment embedded individual lending in an environment with informal risk-sharing. It followed the same formal contract structure of the autarky treatment but allowed subjects to make voluntary transfers to their partners after project returns were realized and before loan repayment.

Joint Liability (JL). This treatment captures the core feature of most microfinance contracts, joint liability. Members of a pair were jointly responsible for each others' loan repayments. A subject was able to continue play only if both she and her partner repaid Rs. 40. To isolate the effect of the formal contract and minimize framing concerns, instructions for this treatment differed from those for individual liability only in their description of repayment requirements.

Joint Liability with Approval Requirement (JLA). This treatment modifies basic joint liability to require partner approval of investment choices and reflects the assumption, proposed by Stiglitz (1990), that joint-liability borrowers have the ability to force safe project choices on their partners. It differed from the joint liability treatment only in that immediately after participants indicated their project choices, we asked their partner if they approved of the choice. A subject whose partner did not approve her choice was automatically assigned choice A, the riskless option. Note that under the imperfect monitoring treatment, approval rights also remove any uncertainty about one's partner's investment choice.

Equity (E). In this treatment I enforced an equal division of all income thereby eliminating the commitment problem and the implementability constraint it places on insurance transfers. Participants were able to make additional transfers, and the game was otherwise identical to the joint liability treatment.

3.3 Monitoring Treatments

All of the financial contract treatments except for autarky were played under two monitoring regimes: perfect and imperfect public monitoring. As described in Section 2.4, much of the literature on microfinance discusses the importance of peer monitoring and local information, and these treatments were designed to see how monitoring affects performance under different contracts. In all treatments, we seated members of a pair together and allowed them to communicate freely. Under **perfect monitoring**, all actions and outcomes were observable. Under **imperfect public monitoring**, we separated partners with a physical divider that allowed communication but prevented them from seeing each other's investment choices and outcomes. After investment outcomes were realized, we informed each participant if her partner had sufficient income to repay her own loan. Transfer amounts were observed only after the transfer was completed.[28]

4 Experimental Results

In total, I have 3,443 observations from 450 participant-sessions, representing 256 unique subjects. All sessions were run between March 2007 and May 2007 at a temporary experimental economic laboratory in Chennai, India. I conducted 24 sessions, averaging two hours each, excluding time spent paying subjects. As summarized in Table 5, the number of participants per session ranged from 8 and 24, depending on show-ups. The mean was 18.75. Participants were invited to attend multiple

[28] Using physical game money, each player placed her transfer in a bowl behind the physical divider. Experimental assistants then swapped the bowls simultaneously. Unobservability was successfully enforced with the threat of financial punishment and dismissal from the experiment.

sessions, and the number of sessions per participants ranged from 1 to 6, with a mean of 1.75. Summary statistics appear in Table 6.

In the subsections that follow, I separate the experimental results into two categories. Section 4.1 describes the effect of contracts and monitoring on informal risk-sharing. Section 4.2 concerns risk-taking and project choice.

4.1 The Impact of Contracts and Monitoring on Informal Risk-Sharing

RESULT 1. *Actual informal insurance transfers fall well short of full risk-sharing and the maximum implementable informal insurance arrangement with perfect monitoring. On average, transfers achieve only 14% of full risk-sharing and approximately 30% of the maximum implementable transfer.*

As discussed in Section 2, existing models of informal insurance with limited commitment, including this one, do not make unique predictions for observed transfers. The dynamic game setting admits a multiplicity of equilibria that always includes the minimum transfer profile, i.e., no voluntary transfers. However there is a natural tendency to focus on payoff vectors that are Pareto efficient in the set of equilibrium payoffs, which places an upper bound on the performance of informal insurance and may also represent the outcome of focal strategies (Coate and Ravallion 1993). I calculate the transfers that would implement the efficient payoff vector using numerical simulations based on individuals' CRRA risk-aversion parameters estimated from the benchmarking risk experiments, actual project choices for each subject pair, and a static transfer arrangement.[29] These experimental results find observed transfers well below those achieved by either full risk-sharing or those required for constrained efficiency.

[29] This describes a set of transfer vectors with each vector determined by the relative weight assigned to each agent by the social planner. As a benchmark, I selected a single transfer vector using a Pareto weight, λ, equal to the ratio of marginal utilities in state hh under autarky. If this weight did not admit a non-zero, individually-rational transfer arrangement (e.g., one agent preferred autarky to any transfer arrangement based on the starting weight), I searched numerically and selected the weight closest to this initial value for which a non-zero transfer arrangement was individually rational. In general, performance relative to the constrained-efficient transfer arrangement should be interpreted with caution. When incentive compatibility constraints are binding or agents have different preferences, expected transfers are not independent of the Pareto weight. However, in the current setting, where the probability of any state is symmetric and independent of the Pareto weight, the results are robust to calculating the benchmark transfer vector based on any weight satisfying both agents' participation constraints, provided such a weight exists.

Columns 1 and 2 of Table 7 summarize net transfers from the partner with higher income under individual liability, joint liability and joint liability with approval. Columns 3 and 4 report the same information conditional on exactly one project in the pair succeeding. This corresponds to states hl and lh, where the direction of transfers is independent from assumptions about Pareto weights. If risk-sharing were complete, these transfers would equal one-half of the difference between payoffs; however, in each case transfers are well below the full risk-sharing benchmark. Joint liability with perfect monitoring generates the highest net transfers, 5.3, but this is only 27% of the full risk-sharing amount of 19.6. These shortfalls arise along both the extensive and intensive margins. For individual and joint liability contracts with perfect monitoring, either individual made a transfer in only 50% of all rounds. Under imperfect public monitoring, the probability of any transfer fell to 30%. Furthermore, when transfers were made, they tended to remain well below the full risk-sharing benchmark. Again, joint liability with perfect monitoring produces the largest net transfers relative to full insurance, but conditional on any transfer being made they still average only 43% of the full insurance amount. While transfers occur more often under joint liability with approval—in 72% of all rounds with perfect monitoring and 47% without—net transfers were smaller than those in other contracts.

This result may explain why we see semi-formal risk-sharing mechanisms, such as the state-contingent loans used for risk smoothing in northern Nigeria (Udry 1994); highlights the importance of equilibrium selection; and casts doubt on constrained efficiency as the focal selection criteria for informal risk-sharing equilibria. The preponderance of empirical research on informal insurance with limited commitment suggests that actual transfers fall short of full insurance.[30] While this can in part be explained by implementability constraints imposed by limited commitment (Ligon, Thomas, and Worrall 2002), these experimental results suggest that actual informal insurance may settle on an equilibrium with payoffs well below what would be constrained efficient. One possible explanation, consistent with the results from Charness and Genicot (2009), is that efficiency may be easier to obtain when there is an obvious focal strategy. In their experiment, transfers were close to theoretically predicted amounts when subjects had identical and perfectly negatively correlated

[30] See, for example, Townsend's (1994) study of risk and insurance in the ICRISAT villages; Udry's (1994) work on informal credit markets as insurance in northern Nigeria; and Fafchamps and Lund's (2003) study of quasi-credit in the Philippines.

income processes; however, with heterogeneity, actual transfers were substantially below predicted levels and close to those I observed.[31] Exploring alternative selection criteria, such as risk-dominance in the sense of Harsanyi and Selten (1988), offers a promising avenue for future research.

Although informal insurance consistently fell short of the theoretical maximum, formal contracts and information greatly influence risk-sharing behavior. The next result highlights the importance of monitoring.

RESULT 2. *Informal insurance is substantially larger under perfect monitoring than when monitoring is imperfect. On average, transfers under perfect monitoring are 60% larger than those when monitoring is imperfect.*

As shown in Prediction 1, we expect cooperation will be harder to sustain when monitoring is imperfect. In practice, this effect is large and economically significant. Net transfers under both individual and joint liability with imperfect monitoring are roughly half what they are under perfect monitoring. This result is evident in Figure 4 and the summary statistics presented in Table 7. Table 8 reports the results from the cell-means regression

$$\tau_{it} = \alpha + \sum\nolimits_{j} \beta_j T_j + \varepsilon_{it}, \tag{3}$$

where τ_{it} is the transfer made by individual i in round t, and T_j is a indicator for the contract and monitoring treatment. In all contracts, perfect monitoring generated substantially larger transfers than imperfect monitoring. The percentage difference was largest under individual liability, where mean transfers increase from 2.42 to 5.83, or 140%, and is substantial in all contracts. As shown in columns 1 through 4 of Table 7, perfect monitoring more than doubles observed net transfers as a percentage of the benchmark constrained efficient transfer for both the individual and joint liability contracts. Wilcoxon rank-sum tests reject equivalence at any conventional significance level ($p < 0.0001$) for all contracts. Columns 5 through 12 of Table 7 detail transfer behavior for outside and within-*kendra* pairs. Surprisingly, while net transfers are higher when individuals are paired with someone from their same *kendra*,

[31] There is some suggestive evidence that transfers may be higher as a percentage of the constrained Pareto maximum under both individual and joint liability when both parties pick the same project; however, this evidence is not robust. Transfers as a percentage of full risk-sharing are approximately equivalent for both symmetric and non-symmetric investment choices (approximately 20% under individual liability and 30% under joint liability). There is no evidence that when both parties have the same baseline risk preferences transfers are larger as a share of the constrained-efficient transfer or full insurance.

the differences are not statistically significant, and transfers as a percentage of full insurance or those necessary to implement the efficient payoff vector are comparable in both groups.

I now turn to a specific form of cooperation: transfers made when both members of a pair have sufficient income to repay their loans. These "upside" transfers represent pure insurance.

RESULT 3. *Upside risk-sharing is greater under joint liability, increasing by 40% under perfect monitoring and more than doubling under imperfect monitoring.*

We would expect that joint liability and the threat of common punishment would induce loan repayment assistance when one party lacked sufficient funds to repay and the other was able to cover the shortfall. However, as shown in Prediction 2, the impact of joint liability contracts on "upside" transfers, i.e., transfers *excluding* loan repayment assistance and thus representing pure insurance, is theoretically ambiguous. There is substantial overlap in the set of sustainable equilibrium transfers in all contract treatments. For example, the minimum transfer profile, no transfers beyond what is contractually required, is an equilibrium strategy under any formal contract. In practice, joint liability substantially increases observed upside risk-sharing.

Table 9 shows the results from the cell-mean regression of upside transfers, i.e., transfers excluding loan repayment assistance, made by individuals in each contract setting when their investments are successful. Upside transfers under joint liability are 3.85 (120%) and 2.94 (40%) larger than transfers under individual liability with imperfect and perfect monitoring. These differences are significant at the 1%- and 5%-levels. Much of this difference is driven by risk-tolerant individuals, whose transfers increase by 6.32 (228%) and 6.03 (132%) under joint liability. That risk-tolerant individuals increase their total transfers when successful under joint liability with imperfect monitoring may be expected given that, as discussed in Result 6, they also take significantly greater risk. As a consequence, their total payoff when successful is larger and they have more to share. They also accrue a greater debt by requiring assistance when their projects fail. However, risk-tolerant individuals' transfers as a percentage of the full risk-sharing amount also increase from 9.7% under individual liability to 17.5% under joint liability. They also increase their upside transfers under perfect monitoring, which did not increase their risk-taking. With perfect monitoring, risk-tolerant individuals' net transfers as a percentage of full risk-sharing increase from 25.7% to 47.5%.

Joint liability also appears to increase upside transfers made by risk-averse individuals, although this effect is more modest. When monitoring is imperfect, their transfers increase by 101% from 3.33 to 6.69, and this difference is significant at the 5%-level. With perfect monitoring, the increase is smaller (12%) and insignificant, although this is from a relatively high base of 6.28 under individual liability with perfect monitoring. While theory predicts such a response for relatively risk-tolerant individuals making high-risk investments, the effect was broadly distributed and suggests the possibility of a behavioral response.[32]

It is tempting to interpret increased upside transfers by individuals taking greater risk as compensation for the default insurance their partners provide, but several other factors call this interpretation into question. Joint liability increases upside transfers even for those not taking additional risk. Moreover, when monitoring is imperfect, transfers do not appear to increase with the amount of risk imposed. Panel A of Figure 5 shows mean transfers made at each payoff level. Note that transfers at payoff levels of 180 and above, each of which resulted from investments with potential default costs, do not differ from those made at a payoff of 160, the result of a successful investment in project D, which has no default risk. Transfers are flat above 160, even though the potential cost of default increases with the potential gain.

RESULT 4. *Informal insurance transfers are treated like debt; cumulative net transfers received to date are a strong predictor of net transfers made in the current period.*

The model presented in Section 2 solved for mutual insurance arrangements with a restriction to stationary transfers, that is, whenever the same state occurs, the same net transfer is made independent of past histories. As Kocherlakota (1996) and Ligon, Thomas, and Worrall (2002) demonstrate, a dynamic limited commitment model may improve welfare relative to the stationary model by promising additional future payments to relax incentive compatibility constraints on transfers in the current period. In practice, such dynamic transfer schemes may be implemented through informal loans as described in Eswaran and Kotwal (1989), Udry (1994) and Fafchamps and

[32] The economics literature has largely focused on importance of social capital in supporting lending arrangements. See, for instance, Karlan (2007), Abbink, Irlenbusch, and Renner (2006), and Cassar, Crowley, and Wydick (2007). Two notable exceptions are Ahlin and Townsend's (2007) work in Thailand and Wydick's (1999) in Guatemala, both of which find that social ties can *lower* repayment rates. However, sociological and anthropological case studies explore the possibility that microfinance and group lending in particular may affect social cohesion (e.g., Lont and Hospes 2004, Fernando 2006, Montgomery 1996).

Lund (2003).

I test formally for this effect by regressing transfers in each round after the first on payoffs, cumulative net transfers, and the first period transfers of both individuals:

$$\tau_{it} = \alpha_i + \beta_1 y_{it} + \beta_2 y_{-it} + \gamma \sum_{t'=1}^{t-1} (\tau_{it'} - \tau_{-it'}) + \varepsilon_{it}, \tag{4}$$

where τ_{it} is the transfer made by individual i in round t, y_{it} is individual i's income in round t, and individual fixed effects, α_i, are included to capture subjects' predisposition towards making transfers. If transfers are treated as debt to be repaid, we expect $\gamma < 0$.

As shown in panel A of Table 10, the coefficient on cumulative net transfers made is consistently negative—ranging from -0.120 to -0.302—and significant at the 1%-level. These results imply, for example, that under joint liability with imperfect monitoring we would expect an individual who received the same payoff as her partner and had previously received Rs. 20 of net transfers to make a net transfer of Rs. 5.

4.2 The Impact of Contracts and Monitoring on Risk-Taking

I now turn to the effect of contracts and monitoring on risk-taking behavior. As described above, expected profits serve as a proxy for risk-taking and increase monotonically from 40 for the riskless choice, A, to 140 for the riskiest choice, H. Panel B of Table 4 describes each of the eight project choices.

Figure 3 summarizes risk-taking levels relative to autarky across the contract and monitoring treatments. The illustrated values are calculated from the simple cell-means regression

$$\tilde{y}_{it} = \alpha + \sum\nolimits_j \beta_j T_j + \varepsilon_{it}, \tag{5}$$

where $\tilde{y}_{it}$ is the expected profit of individual i's project choice in round t, and T_j is an indicator for the contract and monitoring treatment. Table 11 presents the full results from this estimation.

RESULT 5. *Informal insurance does not increase risk-taking.*

As shown in the discussion of Prediction 3, constrained-efficient informal insurance should increase total risk-taking.[33,34] However, observed insurance fell well short what would be required for constrained efficiency, and the effect on risk-taking remains an empirical question.

Comparing investment choices in the individual liability treatment to those under autarky provides an immediate test of this response; the individual liability treatment differed from autarky only in that subjects were able to engage in informal risk-sharing. As is evident from Figure 3, the availability of informal insurance had little effect on individuals' risk-taking behavior. Neither of the individual liability coefficients from the estimation of (5) are significant as shown in panel A of Table 11. We can reject at the 5%-level increases of 1.2% and 3.2% in the imperfect and perfect monitoring treatments.

Given the relatively low levels of informal risk-sharing actually observed, this outcome is perhaps not surprising. While the experiments were designed such that the maximum implementable informal risk-sharing arrangement would increase the optimal contract choice by at least one class (e.g., the optimal contract pair for two individuals with CRRA utility and ρ of 0.5 would move from the pair $\{B, B\}$, with individual payoffs of 100 or 70 in autarky, to $\{C, C\}$, with individual payoffs of 140 or 50 under individual liability with informal insurance), the realized levels of informal insurance support only a small increase in risk-taking.

The availability of informal insurance may also have made risk more salient and thus discouraged risk-taking. While communication was allowed in all treatments, participants in autarky treatment rarely spoke to one another. Under individual liability with informal insurance, participants often discussed their project choices and occasionally made contingent transfer plans. These discussions typically focused on what would happen in the event of a bad outcome and, by making this state more salient, may have discouraged risk-taking.

[33] As shown in section 2.5, this prediction does not necessarily hold if individuals differ substantially in their risk aversion and the Pareto weight is heavily skewed towards the more risk-averse agent. Based on preferences calculated from benchmark risk choices, such a reduction would only be possible in 1.4% of all observations. Observed transfers in these observations are not consistent with a Pareto weight that substantially favors the more risk-averse agent.

[34] Using the parameters of the experimental setting, I calculated individuals' optimal investment choices under autarky and with informal insurance that achieves a payoff vector that is Pareto efficient in the equilibrium set. The numerical results imply that constrained-efficient insurance should increase risk-taking, as measured by the expected profit of individuals' project choices, by between Rs. 5 and Rs. 10, or 10% to 20%.

RESULT 6. *With imperfect monitoring, joint liability increases aggregate risk-taking as more risk-tolerant individuals take significantly greater risk, relying on their partners to insure against default. Those taking additional risk do not compensate their partners for this insurance but instead free-ride on the mandatory transfer requirement. However, this behavior is sensitive to the monitoring environment. Under perfect monitoring, joint liability marginally reduces risk-taking relative to individual liability.*

As described in Prediction 4 theory does not make sharp predictions for the effect of joint liability on investment choice. On one hand, risk-pooling and mandatory transfers from one's partner encourage risk-taking. On the other hand, the threat of joint default may induce risk mitigation and reduce risk-taking. Which effect dominates in practice depends on the risk tolerance of both partners, other parameter values, and the selected equilibrium of the dynamic game. In light of the relatively larger amount of informal insurance observed in joint liability relative to individual liability, particularly under perfect monitoring, we would expect greater risk-taking under joint liability. Under joint liability with imperfect monitoring, we would expect a more modest increase in risk-taking if individuals are behaving cooperatively; however, if cooperation breaks down, the free-riding effect described in Section 2 would dominate.

In the experiment under perfect monitoring, joint liability marginally reduces risk-taking relative to individual liability. Expected profits fall by 2.8% (1.43). This result, shown in panel B of Table 11, is consistent with the finding that increased communication between partners tends to decrease risk-taking, but it is not statistically significant. Under imperfect monitoring, the effect is reversed. Joint liability increases risk-taking by 3.7% (1.88; $p = 0.012$) relative to individual liability. However in neither case is the Wilcoxon rank-sum test significant; $p = 0.204$ and $p = 0.121$.

Within the joint liability contract, the effect of monitoring on risk-taking is pronounced. Imperfect monitoring increases risk-taking by 4.3% (2.17; $p = 0.009$) relative to joint liability with perfect monitoring, and the Wilcoxon rank-sum test easily rejects equivalence ($p = 0.001$). Large differences in behavior across risk types drives this increase. Risk-averse individuals respond little to joint liability regardless of the monitoring structure, while more risk-tolerant individuals take significantly greater risk when monitoring is imperfect.

I divide subjects into risk categories based on their choices in the risk benchmarking games. Approximately 70% of subjects picked one of the safe choices, A through D, and are categorized as "risk averse." The remaining 30% picked choices E through H and are categorized as "risk tolerant." This division corresponds to a coefficient of risk aversion of 0.44 for individuals with CRRA utility and a wealth of zero.

When monitoring is perfect, joint liability does not appear to affect the investment choices of risk-averse individuals. In fact, as shown in column 5 of Table 12, they take less risk than in autarky and their project choices are statistically indistinguishable from those of risk-averse individuals. This is consistent with Giné, Jakiela, Karlan, and Morduch's (2009) finding that participants who tend to take risks reduce their risk-taking when their partners make safer choices.

When monitoring is imperfect, risk-tolerant individuals increase their risk-taking under the simple joint liability contract. As can be seen in column 1, panel C of Table 12, the mean expected return for risk-tolerant individuals increases by 26% (1.2σ) from 51.3 under individual liability to 64.7 under joint liability. A nonparametric Wilcoxon rank test show this difference is significant at any conventional level ($p < 0.0001$).[35] Evidence of compensatory transfers is mixed. As discussed above, risk-tolerant individuals *do* make larger transfers under joint liability, but two facts call into question the intent of these transfers. First, as can be seen in panel B of Table 9, this increase appears in both perfect and imperfect monitoring, while increased risk-taking is only evident when monitoring is imperfect. Second, as shown in Figure 5, there is no discernible difference in transfers by risky individuals who chose projects just below the potential threshold for default (projects C and D) and those who forced their partners to insure against default (projects E, F, G and H). One interpretation of this result is that risk-tolerant individuals increase transfers under joint liability to compensate their partners for the option value of default insurance *even* if their investment choices render this insurance moot. Further experimentation would be useful to test this hypothesis.

The results in columns 3 and 7 of Table 12 demonstrate a stark difference in the behavior of pairs from the same *kendra*. While joint liability with imperfect monitoring still induces risk-tolerant types to increase their allocation to the risky asset, this increase is substantially less than when matched with a partner from a different

[35] This result is robust to moving the definition of "risk tolerant" up or down one risk class. A fully non-parametric specification for the effect of benchmarked investment choice on risk-taking under joint liability with limited information shows noticeable break between those who elected a "safe" choice in the benchmarking rounds and those who did not.

kendra (6.26 vs. 16.20). This effectively eliminates the free-riding phenomenon witnessed in outside-*kendra* pairs. Under perfect monitoring, risk-tolerant types actually reduce their allocation to the risky asset. While there are a number of factors that could be driving this behavior, it is consistent with the fact that for within-*kendra* pairs informal insurance under joint liability with perfect monitoring generates transfers closer to those required for constrained efficiency and the observation, discussed in Prediction 3, that income pooling pushes each agent's optimal choice to a point between their autarkic choices.[36]

When cooperation breaks down, we expect individuals to take action to discourage free-riding. The next result shows that explicit approval rights are used *ex ante* to reduce risk-taking.

RESULT 7. *Explicit approval rights are used to curtail risk-taking under joint liability.*

Consistent with Prediction 5, panel C of Table 11 confirms that approval rights are used to prevent risk-taking ex ante, particularly when monitoring is imperfect. When monitoring is imperfect, risk-taking in the JLA contract is 6.3% lower than in autarky and 8.3% lower than under joint liability without explicit approval. Both differences are significant at greater than the 1%-level. This effect is concentrated among risk-tolerant individuals, for whom expected profits fall 22% from 63.8 to 49.9. Risk-averse individuals also reduce their risk relative to individual or joint liability, but the effect is more modest and only borderline significant.

As expected, joint liability creates two potential inefficiencies: free-riding when the enforcement mechanisms necessary to sustain cooperation are weak *and* excessive caution when these mechanisms are strong. The next result turns to one possible solution: equity-like contracts under which full risk-sharing is enforced by a third-party.

RESULT 8. *Equity increases expected returns relative to other contracts while producing the lowest default rates. Under imperfect monitoring, expected profits are 5% larger than under individual liability and 10% larger than under joint liability with approval rights. While expected profits are only slightly larger than under joint liability, the increased willingness to take risk is distributed across individuals and not the result of risk-tolerant individuals free-riding on their partners.*

[36] Statistical tests of whether changes in risk allocation depend on the risk preferences of one's partner require a very thin parsing of the data and are inconclusive.

Third-party enforcement of equal income distribution overcomes much of the commitment problem associated with informal risk-sharing arrangements. When partners have identical preferences, it achieves full insurance. As such, and in line with Prediction 3, we would expect equity-like contracts to encourage greater risk-taking than under autarky or contracts where limited commitment reduces the sustainable amount of insurance.

This result can be seen in Figure 3 and the summary of expected profits by contract type in Table 11. Formal statistical evidence is provided by the regression described in (5). Tests for the equivalence of the equity treatment dummy coefficients against those for individual, joint liability, and joint liability with approval are each significant at better than the 5%-level. Wilcoxon tests reject equivalence at better than the 1%-level in each case. While statistically significant and practically meaningful, the differences in risk-taking between equity and individual liability or autarky are less than we would expect. Numerical simulations based on benchmarked risk-taking behavior predict expected profits under the equity contract should increase by 10% to 20% relative to autarky. Actual expected profits increase by 2% to 5%, approximately 0.10 to 0.25 standard deviations. Relative to joint liability with approval rights, the increase in expected profits from equity contracts is more than twice as large, 5% under perfect monitoring and 10% under imperfect public monitoring.

Panel C of Table 6 reports default rates for each contract, ranging from a high of 4.8% in autarky to 0% under equity. The low default rates are consistent with the reported rates of most microfinance institutions—Mahasemam itself reports client defaults of less than 1%—but since the terms of default were set by the experiment, I focus on relative performance across the contract treatments.[37] Default rates follow the pattern we would expect. Adding informal transfers (moving from autarky to the individual liability treatment) reduces default rates by two percentage points from 4.83% to 2.80%. Moving from individual to joint liability further reduces default rates to 1.35%, or 1.51% when approval rights are explicit. Finally, equity generated no defaults as increased risk was almost always hedged across borrowers, with the worst possible joint outcome still sufficient for loan repayment. Each of the differences in default rates is significant at the 5%-level.

While these experiments abstracted from key challenges for implementing equity contracts, including moral hazard over effort and costly state verification, the results

[37] Low levels of reported default suggest that willful default is not prevalent.

are encouraging. Innovative financial contracts may encourage substantial increases in the expected returns of microfinance-funded projects. However, further research is required to understand why observed risk-taking under the equity contract remained below what would be predicted based on individuals' benchmarked risk preferences. Based on the results of this experiment, exploration of how social factors influence decisions under uncertainty could provide important information on how to most effectively move from the lab to equity-like contracts in the field.

5 Conclusion

This paper has developed a theory of risk-taking and informal insurance in the presence of formal financial contracts designed to answer the questions: How do microfinance borrowers choose among risky projects? How do they share risk? How do formal financial contracts affect these behaviors? And can the structure of formal financial contracts themselves explain in part the limited growth observed in microfinance-funded businesses? To shed further light on these questions, it examined the results of a lab experiment that captured the key elements of the theory using actual microfinance clients in India as subjects. Theory-based experimentation allows us to test generalizable effects of financial contracts and to delineate mechanisms that would be challenging to identify in a full field setting.

The experiment uncovered a number of interesting results. First, informal insurance falls well short of not only the full risk-sharing benchmark but also the constrained optimal insurance arrangement predicted by theory. This calls into question the use of constrained efficiency as the focal equilibrium selection criteria for informal sharing arrangements. Exploring alternative selection criteria, such as risk-dominance in the sense of Harsanyi and Selten (1988) and Carlsson and van Damme (1993), offers a promising avenue for future research.

Second, joint liability encouraged informal insurance. Upside income transfers, those not required for loan repayment, were almost twice as large under joint liability as under individual lending. This result cannot be explained as compensation for default insurance—increased transfers are evident even among those who did not take additional risk. Joint liability may have increased the perceived social connection to one's partner, thus moving the equilibrium insurance arrangement towards constrained efficiency. Or joint liability may have provided a coordination device that facilitated implementation of cooperative transfer arrangements. A definitive explanation is beyond the scope of the available experimental evidence, and further research is necessary to distinguish social effects, coordination devices, and other explanations.

Third, the core result supports the motivating conjecture: the structure of existing microfinance contracts *themselves* may discourage risky but high-expected return investments. When monitoring was imperfect, joint liability produced significant free-riding. Risk-tolerant individuals took substantially greater risk without compensating their partners for the added insurance burden. Granting approval rights, some form of which likely exist in practice, eliminated free-riding but also reduced risk-taking below levels in autarky. The strength of this effect suggests that peer monitoring may not only reduce *ex ante* moral hazard but also discourage risk-taking more generally, regardless of efficiency. Taken together, these findings provide one explanation for the lack of demonstrable growth in microfinance-funded enterprises.

Finally, equity increased risk-taking and expected returns relative to other financial contracts, although these increases were less than half what theory would predict for optimal behavior. At the same time, equity also generated the lowest default rates. While there are significant hurdles to implementing such contracts in practice and further research is required to understand deviations from predicted risk-taking behavior, these results are encouraging and suggest that equity-like contracts merit further exploration in the field.

References

ABBINK, K., B. IRLENBUSCH, AND E. RENNER (2006): "Group Size and Social Ties in Microfinance Institutions," *Economic Inquiry*, 44(4), 614–628.

AHLIN, C., AND R. M. TOWNSEND (2007): "Using Repayment Data to Test across Models of Joint Liability Lending," *Economic Journal*, 117(517), F11–F51.

ARMENDARIZ, B. (1999): "On the Design of a Credit Agreement with Peer Monitoring," *Journal of Development Economics*, 60(1), 79–104.

ARMENDARIZ, B., AND J. MORDUCH (2005): *The Economics of Microfinance*. Cambridge, MA: MIT Press.

BANERJEE, A. V., T. BESLEY, AND T. W. GUINNANE (1994): "Thy Neighbor's Keeper: The Design of a Credit Cooperative with Theory and a Test," *Quarterly Journal of Economics*, 109(2), 491–515.

BARR, A., AND G. GENICOT (2008): "Risk Sharing, Commitment and Information: An Experimental Analysis," Discussion paper, The Centre for the Study of African Economies Working Paper Series Paper 278.

BESLEY, T., AND S. COATE (1995): "Group Lending, Repayment Incentives and Social Collateral," *Journal of Development Economics*, 46(1), 1–18.

BULOW, J., AND K. ROGOFF (1989): "Sovereign Debt: Is to Forgive to Forget?," *American Economic Review*, 79(1), 43–50.

CARLSSON, H., AND E. VAN DAMME (1993): "Global Games and Equilibrium Selection," *Econometrica*, 61(5), 989–1018.

CASSAR, A., L. CROWLEY, AND B. WYDICK (2007): "The Effect of Social Capital on Group Loan Repayment: Evidence from Field Experiments," *Economic Journal*, 117(517), F85–F106.

CHARNESS, G., AND G. GENICOT (2009): "Informal Risk Sharing in an Infinite-Horizon Experiment," *The Economic Journal*, 119(537), 796–825.

CHOWDHURY, P. R. (2005): "Group-Lending: Sequential Financing, Lender Monitoring and Joint Liability," *Journal of Development Economics*, 77(2), 415–439.

COATE, S., AND M. RAVALLION (1993): "Reciprococity Without Commitment: Characterization and Performance of Informal Insurance Arrangements," *Journal of Development Economics*, 40, 1–24.

Conning, J. (2005): "Monitoring by Peers or by Delegates? Joint Liability Loans and Moral Hazard," Hunter College Department of Economics Working Papers: 407.

de Aghion, B., and C. Gollier (2000): "Peer Group Formation in an Adverse Selection Model," *Economic Journal*, 110(465), 632–643.

Dohmen, T. J., A. Falk, D. Huffman, J. Schupp, U. Sunde, and G. G. Wagner (2006): "Individual Risk Attitudes: New Evidence from a Large, Representative, Experimentally-Validated Survey," Discussion paper, IZA.

Eswaran, M., and A. Kotwal (1989): "Credit as Insurance in Agrarian Economies," *Journal of Development Economics*, 31(1), 37–53.

Fafchamps, M., and S. Lund (2003): "Risk-sharing Networks in Rural Philippines," *Journal of Development Economics*, 71(2), 261–287.

Fernando, J. L. (ed.) (2006): *Microfinance: Perils and Prospects*. London, New York: Routledge.

Foster, A. D., and M. R. Rosenzweig (2001): "Imperfect Commitment, Altruism, and the Family: Evidence from Transfer Behavior in Low-Income Rural Areas," *Review of Economics and Statistics*, 83(3), 389–407.

Fudenberg, D., D. I. Levine, and E. Maskin (1994): "The Folk Theorem with Imperfect Public Information," *Econometrica*, 62(5), 997–1039.

Ghatak, M., and T. W. Guinnane (1999): "The Economics of Lending with Joint Liability: Theory and Practice," *Journal of Development Economics*, 60(1), 195–228.

Giné, X., P. Jakiela, D. S. Karlan, and J. Morduch (2009): "Microfinance Games," *American Economic Journal: Applied Economics*.

Giné, X., and D. S. Karlan (2011): "Group versus Individual Liability: Long Term Evidence from Philippine Microcredit Lending Groups," Discussion paper, Yale mimeo.

Green, E. J., and R. H. Porter (1984): "Noncooperative Collusion under Imperfect Price Information," *Econometrica*, 52(1), 87–100.

Harsanyi, J. C., and R. Selten (1988): *A General Theory of Equilibrium Selection in Games*. Cambridge, MA, London: MIT Press.

Karlan, D. S. (2007): "Social Connections and Group Banking," *Economic Journal*, 117(517), F52–84.

Kocherlakota, N. (1996): "Implications of Efficient Risk Sharing without Commitment," *Review of Economic Studies*, 63, 595–610.

Laffont, J.-J., and P. Rey (2003): "Moral Hazard, Collusion and Group Lending," IDEI Working Papers, Institut d'Economie Industrielle (IDEI), Toulouse.

Ligon, E., J. P. Thomas, and T. Worrall (2000): "Mutual Insurance, Individual Savings, and Limited Commitment," *Review of Economic Dynamics*, 3(2), 216–246.

——— (2002): "Informal Insurance Arrangements with Limited Commitment: Theory and Evidence from Village Economies," *Review of Economic Studies*, 69(1), 209–244.

Lont, H., and O. Hospes (eds.) (2004): *Livelihood and Microfinance: Anthropological and Sociological Perspectives on Savings and Debt*. Delft: Eburon.

Madajewicz, M. (2003): "Does the Credit Contract Matter? The Impact of Lending Programs on Poverty in Bangladesh," Columbia University working paper.

——— (2004): "Joint-Liability Contracts Versus Individual-Liability Contracts," Columbia University working paper.

Montgomery, R. (1996): "Disciplining or Protecting the Poor? Avoiding the Social Costs of Peer Pressure in Micro-credit Schemes," *Journal of International Development*, 8(2), 289–305.

Morduch, J. (1999): "The Microfinance Promise," *Journal of Economic Literature*, 37(4), 1569–1614.

Radner, R., R. Myerson, and E. Maskin (1986): "An Example of a Repeated Partnership Game with Discounting and with Uniformly Inefficient Equilibria," *Review of Economic Studies*, 53(1), 59–69.

Rai, A. S., and T. Sjöström (2004): "Is Grameen Lending Efficient? Repayment Incentives and Insurance in Village Economies," *Review of Economic Studies*, 71(1), 217–234.

Robinson, J. (2008): "Limited Insurance Within the Household: Evidence from a Field Experiment in Western Kenya," University of California Santa Cruz mimeo.

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

Townsend, R. (1994): "Risk and Insurance in Village India," *Econometrica*, 62(4), 539–591.

Udry, C. (1994): "Risk and Insurance in a Rural Credit Market: An Empirical Investigation in Northern Nigeria," *Review of Economic Studies*, 61(3), 495–526.

Varian, H. R. (1990): "Monitoring Agents with Other Agents," *Journal of Institutional and Theoretical Economics*, 146(1), 153–174.

Woolcock, M. J. V. (1999): "Learning from Failures in Microfinance: What Unsuccessful Cases Tell Us About How Group-based Programs Work," *American Journal of Economics and Sociology*, 58(1), 17–42.

Wydick, B. (1999): "Can Social Cohesion Be Harnessed to Repair Market Failures? Evidence from Group Lending in Guatemala," *Economic Journal*, 109(457), 463–475.

Figure 2: Illustration of Joint Liability Static Investment Choice Effects

Best Response Function for Individual B: S=1, R=3, D=1, β=0.75, π=0.5

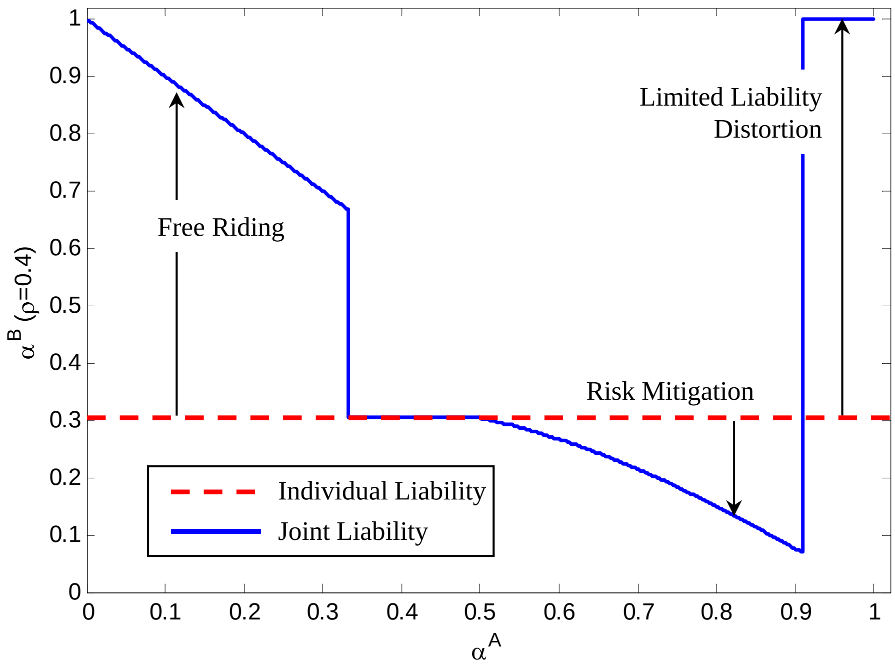
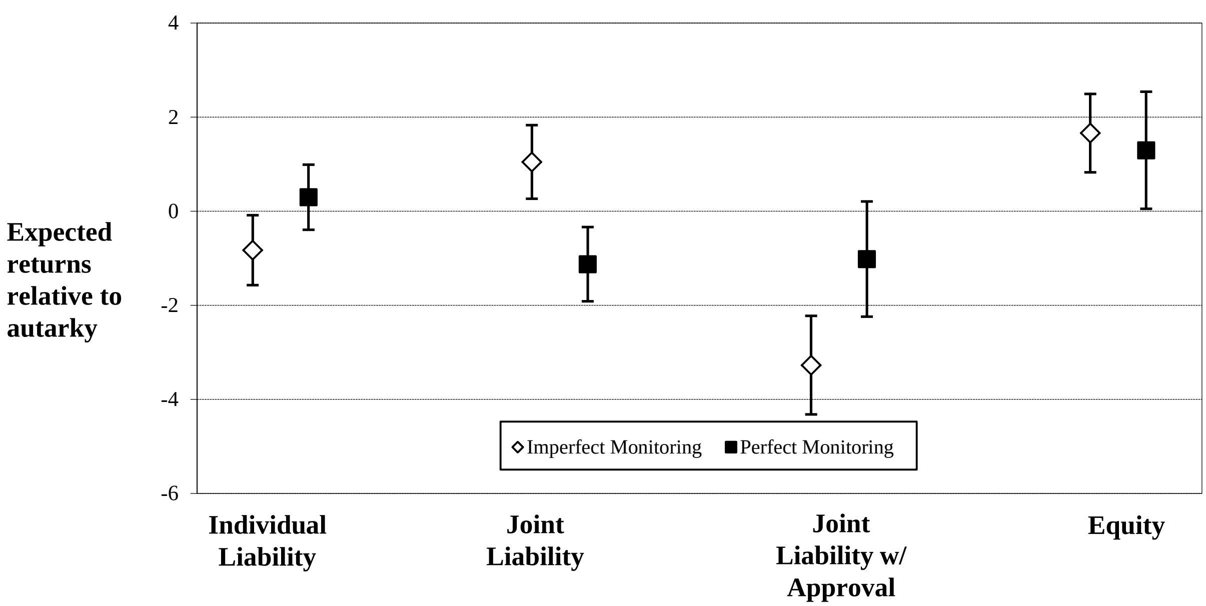
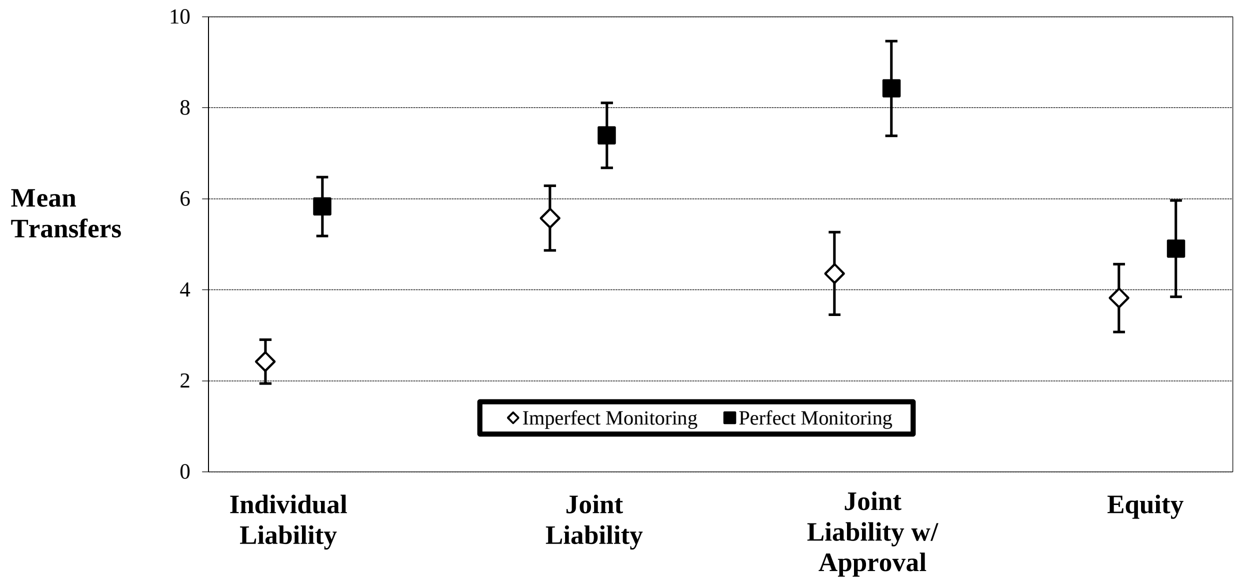


Figure 3: Risk Taking by Treatment



(1) Relative expected returns proxy for risk-taking behavior as expected returns increase monotonically in a project's riskiness. Plot points represent coefficients on treatment dummies in the regression $\text{ProjProfit}_i = \alpha + \sum_j \beta_j T_j + \varepsilon_i$.
(2) Mean expected returns in autarky equal Rs. 51.2.
(3) Error bars represent one standard deviation.

Figure 4: Mean Transfers by Treatment



Notes:

(1) Plot points represent coefficients on treatment dummies in the regression $\text{transfer}_i = \sum_j \beta_j T_j + \varepsilon_i$

(2) Error bars represent one standard deviation.

(3) Equity transfers exclude mandatory, third-party-enforced transfers.

Figure 5: Transfers by Round Income

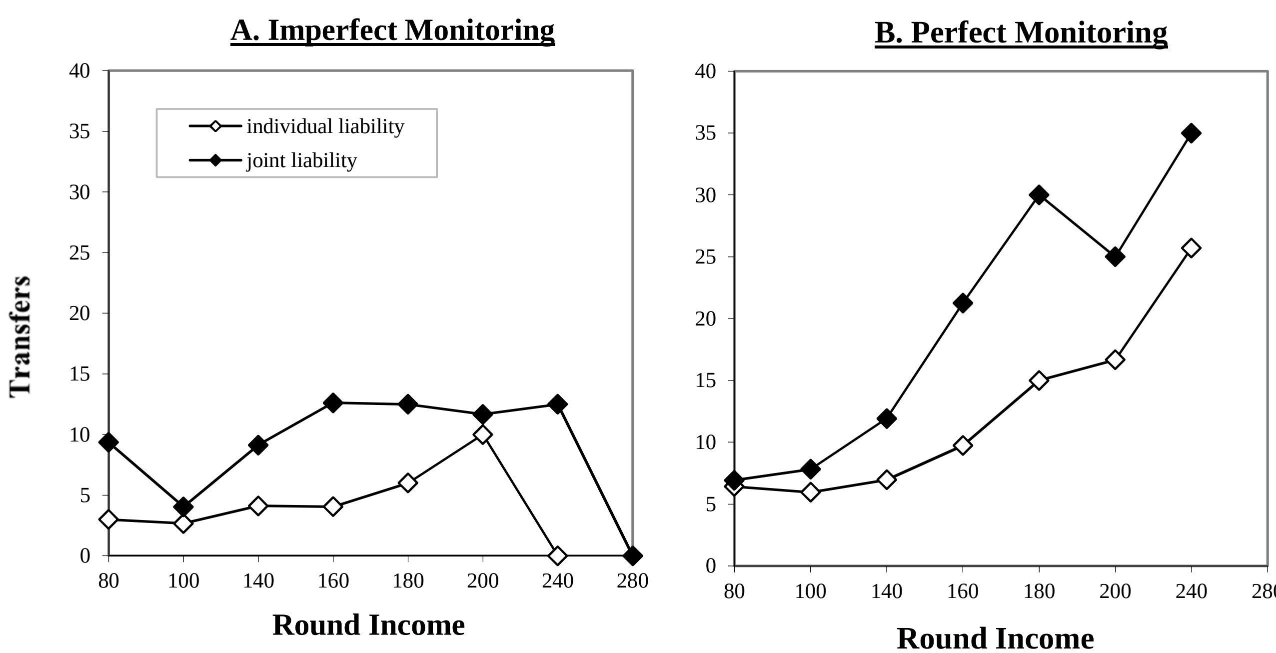


Table 2: Maximium Sustainable Transfers

Transfer when outcome is *hl*

	Full	CRRA risk aversion index (ρ)							
Choice Pair	Insurance	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
{A,A}	0	0	0	0	0	0	0	0	0
{B,B}	15	0	0	0	0	0	0	0	0
{C,C}	45	0	0	4	16	26	36	43	45
{D,D}	60	5	21	42	60	60	60	60	60
{E,E}	75	61	72	75	75	75	75	75	75
{F,F}	90	67	79	90	90	90	90	90	90
{G,G}	115	81	97	115	115	115	115	115	115
{H,H}	140	96	115	138	140	140	140	140	140

Note: Maximum incentive compatible transfer based on equal Pareto weights and homogeneous preferences. Reflects dynamic borrowing incentives with discount rate of 33%, individual liability debt contracts, and no additional formal financial contracts.

Table 3: Average Per Period Utility for Different Transfer Regimes

A. AUTARKY

	CRRA risk aversion index (ρ)							
Choice Pair	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
{A,A}	23.9	18.9	15.2	12.6	10.9	10.1	10.5	14.5
{B,B}	26.0	20.3	16.1	**13.2**	**11.3**	**10.3**	**10.6**	**14.6**
{C,C}	**28.8**	**21.5**	**16.5**	13.2	11.0	10.0	10.2	14.2
{D,D}	28.8	20.4	14.7	11.0	8.5	7.0	6.5	8.1
{E,E}	13.0	9.1	6.5	4.7	3.6	2.9	2.7	3.3
{F,F}	14.5	10.0	7.0	5.1	3.8	3.1	2.8	3.3
{G,G}	17.3	11.7	8.0	5.7	4.2	3.3	2.9	3.4
{H,H}	20.1	13.2	8.9	6.2	4.5	3.5	3.0	3.5

B. FULL INSURANCE

	CRRA risk aversion index (ρ)							
Choice Pair	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
{A,A}	23.9	18.9	15.2	12.6	10.9	10.1	10.5	14.5
{B,B}	26.2	20.4	16.2	13.3	11.4	10.4	10.7	14.6
{C,C}	29.8	22.6	**17.5**	**14.0**	**11.7**	**10.5**	**10.7**	**14.6**
{D,D}	**30.9**	**22.7**	17.1	13.2	10.7	9.2	8.9	11.6
{E,E}	19.4	14.1	10.4	8.0	6.4	5.4	5.2	6.7
{F,F}	21.0	15.1	11.1	8.4	6.6	5.6	5.3	6.7
{G,G}	24.9	17.5	12.6	9.3	7.2	5.9	5.5	6.9
{H,H}	28.5	19.7	13.9	10.1	7.7	6.3	5.7	7.0

C. MAXIMUM SUSTAINABLE TRANSFERS

	CRRA risk aversion index (ρ)							
Choice Pair	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
{A,A}	23.9	18.9	15.2	12.6	10.9	10.1	10.5	14.5
{B,B}	26.0	20.3	16.1	13.2	11.3	10.3	10.6	14.6
{C,C}	28.8	21.5	16.7	**13.7**	**11.6**	**10.5**	**10.7**	**14.6**
{D,D}	**29.5**	**22.1**	**17.0**	13.2	10.7	9.2	8.9	11.6
{E,E}	19.3	14.1	10.4	8.0	6.4	5.4	5.2	6.7
{F,F}	20.9	15.1	11.1	8.4	6.6	5.6	5.3	6.7
{G,G}	24.7	17.4	12.6	9.3	7.2	5.9	5.5	6.9
{H,H}	28.3	19.6	13.9	10.1	7.7	6.3	5.7	7.0

Note: Bold and boxed amount represents maximum per period utility along column. Maximum incentive compatible transfer based on equal Pareto weights and homogeneous preferences. Reflects dynamic borrowing incentives with discount rate of 33%, individual liability debt contracts, and no additional formal contracts. Full insurance reflects equal sharing of all income.

Table 4: Summary of Investment Choices

A. BENCHMARKING GAME

Choice	Payoffs: White (High)	Payoffs: Black (Low)	Expected Round Profit	Risk Aversion Coefficient
A	40	40	40.0	1.76 to ∞
B	60	30	45.0	0.81 to 1.76
C	70	25	47.5	0.57 to 0.81
D	80	20	50.0	0.44 to 0.57
E	90	15	52.5	0.34 to 0.44
F	100	10	55.0	0.26 to 0.34
G	110	5	57.5	0.17 to 0.26
H	120	0	60.0	−∞ to 0.17

B. CORE GAMES (all include debt repayment)

Choice	Payoffs: White (High)	Payoffs: Black (Low)	Expected Round Profit (1)	Implied Risk Aversion Coeff. in Autarky(2): Single Shot	Implied Risk Aversion Coeff. in Autarky(2): Dynamic(3)
A	80	80	40.0	6.2 to ∞	3.9 to ∞
B	100	70	45.0	0.59 to 6.20	1.0 to 3.9
C	140	50	55.0	-----	0.57 to 1.0
D	160	40	60.0	-----	−∞ to 0.57
E	180	30	70.0	-----	-----
F	200	20	80.0	-----	-----
G	240	10	100.0	-----	-----
H	280	0	120.0	−∞ to 0.59	-----

Notes:

(1) After debt repayment of Rs. 40.

(2) Assumes wealth level of zero.

(3) Continuation probability equals 75%. Default round income equals zero.

Table 5: Session Detail

A. SESSION SUMMARY

Session	Date	Rounds	Participants	Participants in larger kendra
1	11/30/2006	5	24	12
2	11/30/2006	9	23	12
3	11/30/2006	12	16	9
4	11/30/2006	7	20	11
5	11/30/2006	6	14	7
6	11/30/2006	11	8	8
7	11/30/2006	9	22	12
8	11/30/2006	12	10	10
9	11/30/2006	7	21	11
10	11/30/2006	9	21	11
11	11/30/2006	7	20	10
12	11/30/2006	10	18	10
13	11/30/2006	12	15	10
14	11/30/2006	11	20	10
15	11/30/2006	10	20	10
16	11/30/2006	15	20	11
17	11/30/2006	11	17	10
18	11/30/2006	14	17	10
19	11/30/2006	11	23	12
20	11/30/2006	10	24	12
21	11/30/2006	11	17	10
22	11/30/2006	9	20	10
23	11/30/2006	10	20	10
24	11/30/2006	13	20	10

B. OBSERVATION COUNTS BY GAME

	Monitoring		
Game	Perfect	Imperfect	Total
Benchmarking	--	--	341
Autarky	--	--	768
Individual liability	420	520	940
Joint Liability	352	336	688
Joint liability with partner approval	172	110	282
Equity	318	106	424

Table 6: Summary Statistics

	Monitoring(2) Perfect	Imperfect	Total	Diff Perf.-Imp.
	(1)	(2)	(3)	(4)
A. RISK-TAKING (measured by expected profits)				
Autarky			51.16	
			(10.99)	
			[717]	
Individual Liability	50.33	51.46	50.96	1.13
	(9.71)	(13.81)	(12.17)	{0.169}
	[396]	[498]	[894]	
Joint Liability	52.20	50.03	51.13	-2.17
	(11.85)	(11.56)	(11.75)	{0.017}
	[338]	[330]	[668]	
Joint Liability w/ Partner Approval	47.88	50.14	48.81	2.25
	(8.37)	(9.63)	(8.96)	{0.044}
	[156]	[108]	[264]	
Equity	52.82	52.45	52.72	-0.36
	(14.09)	(10.70)	(13.25)	{0.810}
	[284]	[104]	[388]	
B. TRANSFERS				
Individual Liability	2.42	5.83	4.32	3.41
	(6.24)	(10.94)	(9.31)	{0.000}
	[396]	[498]	[894]	
Joint Liability	5.58	7.39	6.47	1.82
	(13.41)	(11.27)	(12.42)	{0.059}
	[338]	[330]	[668]	
Joint Liability w/ Partner Approval	4.36	8.43	6.02	4.07
	(6.81)	(7.93)	(7.55)	{0.000}
	[156]	[108]	[264]	
Equity(3)	3.82	4.90	4.11	1.08
	(6.23)	(5.95)	(6.17)	{0.125}
	[284]	[104]	[388]	

Notes:

(1) Standard deviations in parentheses. Observation counts in brackets. Panels A-C exclude observations where the effective game differs from the randomly assigned treatment (e.g., after one partner defaults under individual liability, the surviving partner is effectively playing in autarky). p-value of difference in braces.

(2) In perfect monitoring treatment, all actions and payments are observable. In imperfect monitoring treatment, all partner's actions are unobservable. Players are informed only if partner earned enough to repay her debt, Rs. 40.

(3) Excludes mandatory, third-party enforced transfers.

Table 6: Summary Statistics (cont)

	Monitoring[2] Perfect	Imperfect	Total	Diff Perf.-Imp.
	(1)	(2)	(3)	(4)
C. DEFAULT RATES				
Autarky			4.74%	
			(0.21)	
			[717]	
Individual Liability	2.27%	3.21%	2.80%	0.94%
	(0.15)	(0.18)	(0.16)	{0.398}
	[396]	[498]	[894]	
Joint Liability	1.48%	1.21%	1.35%	-0.27%
	(0.12)	(0.11)	(0.12)	{0.762}
	[337]	[330]	[667]	
Joint Liability w/ Partner Approval	1.28%	1.83%	1.51%	0.55%
	(0.11)	(0.13)	(0.12)	{0.718}
	[156]	[109]	[265]	
Equity	0.00%	0.00%	0.00%	0.00%
	(0.00)	(0.00)	(0.00)	- -
	[284]	[104]	[388]	
D. AVERAGE NET INCOME PER ROUND				
Autarky			47.42	
			(40.92)	
			[768]	
Individual Liability	49.74	48.37	48.98	-1.37
	(37.82)	(37.92)	(37.86)	{0.586}
	[409]	[510]	[919]	
Joint Liability	52.39	49.03	50.75	-3.35
	(41.87)	(32.42)	(37.56)	{0.242}
	[352]	[336]	[688]	
Joint Liability w/ Partner Approval[3]	41.10	54.18	46.21	13.08
	(27.96)	(38.69)	(33.12)	{0.001}
	[172]	[110]	[282]	
Equity[3]	48.77	40.96	46.68	-7.81
	(31.29)	(29.54)	(30.99)	{0.028}
	[284]	[104]	[388]	

Notes:

(1) Standard deviations in parentheses. Observation counts in brackets. Panels A-C exclude observations where the effective game differs from the randomly assigned treatment (e.g., after one partner defaults under individual liability, the surviving partner is effectively playing in autarky). p-value of difference in braces.

(2) In perfect monitoring treatment, all actions and payments are observable. In imperfect monitoring treatment, all partner's actions are unobservable. Players are informed only if partner earned enough to repay her debt, Rs. 40.

(3) The project success rate for full risk sharing treatment in the perfect and imperfect monitoring settings was 37.1% and 46.9%. The project success rate for joint liability with partner approval was 57.9%. All equal 50% in expectation.

Table 7: Net Transfers as Percentage of Full Transfers[(1)]

	All Pairs				Same Kendra				Different Kendra			
	All Outcomes		Conditional on exactly one success[(2)]		All Outcomes		Conditional on exactly one success[(2)]		All Outcomes		Conditional on exactly one success[(2)]	
	Monitoring		Monitoring		Monitoring		Monitoring		Monitoring		Monitoring	
	Imperfect	Perfect[(3)]	Imperfect	Perfect[(3)]	Imperfect	Perfect[(3)]	Imperfect	Perfect[(3)]	Imperfect	Perfect[(3)]	Imperfect	Perfect[(3)]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Individual Liability												
Net transfers	1.3	3.6	2.8	6.8	2.1	3.6	3.5	6.1	1.1	3.5	2.5	7.0
Full risk-sharing transfer	19.1	20.3	30.6	36.5	18.6	20.2	27.4	36.3	19.3	20.4	32.0	36.6
Net as % of full sharing	6.9%	17.5%	9.2%	18.7%	11.3%	17.9%	12.8%	16.7%	5.5%	17.4%	7.8%	19.2%
Constrained-efficient transfer (CET)[(4)]	7.8	6.6	16.5	17.6	8.2	6.2	14.6	15.3	7.6	6.7	17.4	18.2
Net as % of CET	17.0%	53.8%	17.0%	38.8%	25.6%	57.9%	24.0%	39.5%	13.9%	52.9%	14.3%	38.7%
Joint Liability												
Net transfers	3.2	5.3	5.8	9.9	3.1	6.8	6.1	11.6	3.3	4.7	5.4	9.1
Full risk-sharing transfer	25.4	19.6	37.0	34.2	22.6	24.1	32.9	40.9	29.0	17.8	41.8	30.9
Net as % of full sharing	12.5%	27.2%	15.5%	29.0%	13.5%	28.2%	18.5%	28.3%	11.4%	26.7%	12.9%	29.4%
Constrained-efficient transfer (CET)[(4)]	10.7	7.3	20.5	17.2	9.9	10.7	20.8	20.6	11.8	6.0	20.1	15.5
Net as % of CET	29.5%	73.0%	28.1%	57.8%	30.8%	63.6%	29.3%	56.2%	28.0%	79.4%	26.7%	58.8%
Joint Liability with Approval												
Net transfers	-0.3	1.3	2.1	1.7	1.1	1.0	2.5	1.7	-1.4	1.4	1.7	1.7
Full risk-sharing transfer	14.9	19.0	27.4	32.2	15.6	19.0	24.7	31.7	14.3	19.0	30.0	32.5
Net as % of full sharing	-1.7%	6.8%	7.6%	5.2%	7.1%	5.3%	10.1%	5.3%	-10.0%	7.4%	5.6%	5.1%
Constrained-efficient transfer (CET)[(4)]	4.5	5.6	9.6	10.7	2.4	14.3	4.8	22.6	6.0	2.4	14.4	4.7
Net as % of CET	-5.7%	23.0%	21.7%	15.6%	46.7%	7.0%	52.6%	7.4%	-23.7%	59.3%	11.6%	35.1%

Notes:

(1) Net transfers equal transfers from partner with higher income minus transfers from partner with lower income. In the even of equal income, player with lower id number arbitrarily treated as having "higher" income.

(2) Corresponds to states *hl* and *lh*, as described in the text.

(3) In perfect monitoring treatment, all actions and payments are observable. In imperfect monitoring treatment, all partner's actions are unobservable. Players are informed only if partner earned enough to repay her debt, Rs. 40.

(4) Full risk sharing transfer equals (own payoff - partner's payoff)/2. Constrained-efficient transfer calculated via numerical simulation based on individuals' CRRA risk aversion parameter estimated from benchmark risk aversion experiment, actual project choices for each subject pair, and a static transfer arrangement with Pareto weight equal to the ratio of agents' marginal utilities in state *hh* under autarky. If no such transfer satisfies both agents' participation constraint, the Pareto weight nearest to the autarkic ratio and supporting individually rational participation is used.

Table 8: Effect of Contract Type & Kendra Type on Transfers

OLS Regression of Transfers on Treatment & Kendra Match Dummies

$$\text{Transfer}_i = \sum_j \beta_j T_j + \sum_j \gamma_j T_j \times (K_i = K_{-i}) + \varepsilon_i$$

	Imperfect Monitoring[1]				Perfect Monitoring[1]				Difference (Imperfect-Perfect Monitoring)			
	All	Different Kendra	Same Kendra	Same Kendra Effect	All	Different Kendra	Same Kendra	Same Kendra Effect	All	Different Kendra	Same Kendra	Same Kendra Effect
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A. TRANSFERS[2]												
Individual liability	2.42***	2.50***	2.21**	-0.29	5.83***	5.98***	5.21***	-0.76	-3.41***	-3.48***	-3.01**	0.47
	(0.44)	(0.40)	(0.90)	(0.86)	(0.59)	(0.68)	(1.02)	(1.20)	(0.75)	(0.81)	(1.37)	(1.47)
Joint liability	5.58***	8.68**	3.16***	-5.52	7.39***	7.33***	7.55***	0.22	-1.82	1.35	-4.40***	-5.75
	(1.79)	(3.63)	(0.65)	(3.54)	(0.88)	(1.13)	(1.24)	(1.67)	(1.99)	(3.79)	(1.40)	(3.91)
Joint liability w/ approval	4.36***	4.52***	4.17***	-0.36	8.43***	7.88***	9.83***	1.95	-4.07***	-3.36**	-5.67***	-2.31
	(0.64)	(0.98)	(0.79)	(1.25)	(1.01)	(1.37)	(0.84)	(1.61)	(1.14)	(1.59)	(1.15)	(1.99)
Equity[2]	3.82***	3.17***	4.40***	1.23	4.90***	2.90***	7.86***	4.95***	-1.08	0.27	-3.46***	-3.73**
	(0.65)	(0.64)	(0.90)	(0.90)	(0.78)	(0.95)	(0.77)	(1.22)	(0.89)	(1.12)	(1.20)	(1.71)
B. UPSIDE TRANSFERS[2]												
Individual liability	3.21***	3.72***	2.64***	-1.08	6.70***	8.09***	6.92***	-1.17	-3.49***	-4.37***	-4.28**	0.09
	(0.59)	(0.70)	(0.94)	(0.97)	(0.89)	(1.27)	(1.59)	(1.99)	(1.07)	(1.46)	(1.84)	(2.15)
Joint liability	7.06***	12.97**	4.50***	-8.47*	9.65***	10.28***	12.32***	2.04	-2.58	2.70	-7.81***	-10.51*
	(2.55)	(5.30)	(1.18)	(5.14)	(1.19)	(1.67)	(2.04)	(2.68)	(2.79)	(5.54)	(2.36)	(5.79)
Joint liability w/ approval	4.70***	6.36***	5.29***	-1.08	9.27***	9.86***	9.71***	-0.16	-4.57***	-3.50	-4.42***	-0.92
	(1.00)	(1.68)	(1.24)	(2.09)	(0.92)	(1.66)	(1.03)	(1.95)	(1.32)	(2.32)	(1.61)	(2.87)

Notes:

(1) In perfect monitoring treatment, all actions and payments are observable. In imperfect monitoring treatment, all partner's actions are unobservable. Players are informed only if partner earned enough to repay her debt, Rs. 40.

(2) Excludes mandatory, third-party enforced transfers. Upside transfers denote transfers from an individual when her project succeeds, excluding debt repayment assistance.

(3) Individual clustered standard errors in parenthses. * denotes significance at the 10%, ** at the 5%, and *** at the 1% level.

Table 9: Effect of Contract Type & Monitoring on Upside Sharing

Transfers When Project Suceeds, Excluding Debt Repayment Assistance

$$\text{UpsideTransfer}_i = \sum_j \beta_j T_j + \varepsilon_i$$

	Imperfect Monitoring	Perfect Monitoring	Difference Imp-Per
	(1)	(2)	(3)
A. ALL			
Individual liability	3.21	6.70	-3.49***
	(0.35)	(0.85)	(0.92)
Joint liability	7.06	9.65	-2.58
	(0.82)	(2.59)	(2.72)
Joint liability w/ approval	4.70	9.27	-4.57***
	(0.35)	(1.37)	(1.41)
Difference: Joint - Individual	3.85***	2.94	
	(0.90)	(2.53)	
B. RISK TOLERANT SUBJECTS			
Individual liability	2.77	4.59	-1.82
	(0.81)	(0.92)	(1.23)
Joint liability	9.09	10.63	-1.53
	(4.97)	(4.10)	(6.44)
Joint liability w/ approval	6.36	9.50	-3.14
	(2.06)	(0.29)	(2.08)
Difference: Joint - Individual	6.32	6.03	
	(4.84)	(4.18)	
C. RISK AVERSE SUBJECTS			
Individual liability	3.33	6.28	-2.95*
	(0.29)	(1.74)	(1.77)
Joint liability	6.69	7.05	-0.36
	(0.98)	(3.22)	(3.37)
Joint liability w/ approval	4.20	10.14	-5.94***
	(0.32)	(0.82)	(0.88)
Difference: Joint - Individual	3.36***	0.77	
	(1.07)	(3.45)	

Notes:

(1) Standard errors clustered at the session level in parentheses. * Denotes significance at the 10%-level, ** at the 5%-level, and *** at the 1% level.

(2) In perfect monitoring treatment, all actions and payments are observable. In imperfect monitoring treatment, all partner's actions are unobservable. Players are informed only if partner earned enough to repay her debt, Rs. 40.

(3) Risk tolerant and risk averse classifications based on benchmark risk experiments

Table 10: Determinants of Transfer Behavior

	Individual Liability		Joint Liabilty		Joint Liabilty w/ App.	
	Imperfect	Perfect	Imperfect	Perfect	Imperfect	Perfect
	(1)	(2)	(3)	(4)	(5)	(6)
Transfers						
Own income (β_1)	0.033***	0.059***	0.048***	0.108***	0.040**	0.009
	(0.006)	(0.008)	(0.009)	(0.021)	(0.017)	(0.066)
Partner's income (β_2)	-0.009	-0.006	-0.025**	-0.028***	-0.013	-0.024
	(0.011)	(0.015)	(0.010)	(0.008)	(0.009)	(0.063)
Cumulative net transfers (γ)	-0.120***	-0.186*	-0.247***	-0.189***	-0.302***	-0.162***
	(0.029)	(0.101)	(0.092)	(0.024)	(0.001)	(0.005)
Observations	396	498	338	330	156	108
R^2	0.41	0.59	0.75	0.65	0.64	0.64
Mean transfers	2.42	5.83	5.58	7.39	4.36	8.43

Notes:

(1) Standard errors clustered at the session level in parentheses. Includes individual fixed effects. * Denotes significance at the 10%-level, ** at the 5%-level, and *** at the 1% level.

(2) In perfect monitoring treatment, all actions and payments are observable. In imperfect monitoring treatment, all partner's actions are unobservable. Players are informed only if partner earned enough to repay her debt, Rs. 40.

Table 11: Effect of Contract Type & Monitoring on Risk Taking

OLS Regression of Expected Profits on Treatment Dummies

Omitted Category: autkary; Mean expected profits: 51.2

$$\text{ProjProfit}_i = \alpha + \sum_j \beta_j T_j + \varepsilon_i$$

	Imperfect Monitoring (1)	Perfect Monitoring (2)	Difference Imp-Per (3)
A. COEFFICIENT ESTIMATES			
Individual liability	-0.83	0.30	-1.13
	(0.94)	(1.18)	(1.22)
Joint liability	1.05	-1.13	2.17***
	(0.83)	(1.17)	(0.76)
Joint liability w/ approval	-3.27***	-1.02	-2.25*
	(1.03)	(1.55)	(1.39)
Equity	1.66	1.29	0.36
	(2.86)	(1.28)	(1.81)
B. TREATMENT EFFECTS RELATIVE TO JOINT LIABILITY			
Individual	-1.88***	1.43	
	(0.69)	(1.40)	
Joint liability w/ approval	-4.32***	0.11	
	(0.73)	(1.40)	
Equity	0.61	2.42***	
	(2.58)	(0.85)	
C. TREATMENT EFFECTS RELATIVE TO JOINT LIABILITY w/ APPROVAL			
Individual	2.44***	1.32	
	(0.46)	(1.93)	
Equity	4.93**	2.31	
	(2.40)	(1.52)	

Notes:

(1) Standard errors clustered at the session level in parentheses. * Denotes significance at the 10%-level, ** at the 5%-level, and *** at the 1% level.

(2) In perfect monitoring treatment, all actions and payments are observable. In imperfect monitoring treatment, all partner's actions are unobservable. Players are informed only if partner earned enough to repay her debt, Rs. 40.

Table 12: Effect of Contract Type & Kendra Type on Risk-taking

OLS Regression of Risk-taking on Treatment & Kendra Match Dummies, by Risk Type

Omitted Category: autkary; Mean expected profits: 51.2

$$\text{ProjProfit}_i = \alpha + \sum_j \beta_j T_j + \varepsilon_i$$

	Imperfect Monitoring[1]				Perfect Monitoring[1]				Difference (Imperfect-Perfect Monitoring)			
	All	Different Kendra	Same Kendra	Same Kendra Effect	All	Different Kendra	Same Kendra	Same Kendra Effect	All	Different Kendra	Same Kendra	Same Kendra Effect
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A. ALL RISK TYPES												
Individual liability	-0.83	-0.94	-0.52	0.42	0.30	0.30	0.28	-0.02	-1.13	-1.24	-0.80	0.44
	(0.90)	(0.99)	(1.46)	(1.56)	(0.83)	(0.88)	(1.95)	(2.07)	(1.12)	(1.23)	(2.40)	(2.59)
Joint liability	1.05	2.63	-0.18	-2.81	-1.13	-1.94**	0.92	2.86*	2.17	4.57*	-1.10	-5.67*
	(1.19)	(2.31)	(1.02)	(2.55)	(0.87)	(0.95)	(1.53)	(1.69)	(1.45)	(2.57)	(1.75)	(3.11)
Joint liability w/ approval	-3.27***	-2.76*	-3.87***	-1.10	-1.02	-0.97	-1.16	-0.19	-2.25	-1.80	-2.71**	-0.91
	(1.02)	(1.64)	(0.93)	(1.78)	(1.32)	(1.79)	(1.02)	(2.07)	(1.68)	(2.55)	(1.19)	(2.86)
Equity[2]	1.66	0.97	2.28	1.31	1.29	0.86	1.94	1.08	0.36	0.11	0.34	0.23
	(1.24)	(1.57)	(1.73)	(2.21)	(1.23)	(1.36)	(2.28)	(2.65)	(1.25)	(1.96)	(2.59)	(3.70)
B. RISK-AVERSE TYPES[4]												
Individual liability	0.07	0.14	-0.12	-0.27	-0.04	0.07	-0.93	-1.00	0.11	0.08	0.81	0.73
	(1.14)	(1.28)	(1.57)	(1.67)	(1.33)	(1.28)	(3.32)	(3.00)	(1.51)	(1.61)	(3.52)	(3.48)
Joint liability	-0.54	-1.04	-0.25	0.79	-0.81	-1.21	0.86	2.07	0.27	0.17	-1.11	-1.28
	(1.06)	(1.34)	(1.23)	(1.45)	(1.37)	(1.55)	(1.56)	(1.92)	(1.46)	(1.86)	(1.64)	(2.44)
Joint liability w/ approval	-2.58	-1.90	-5.51***	-3.61	-0.80	-1.33	0.02	1.35	-1.78	-0.56	-5.53***	-4.97
	(1.77)	(2.11)	(1.66)	(2.43)	(1.79)	(2.86)	(1.32)	(3.27)	(2.66)	(3.87)	(1.73)	(4.26)
Equity[2]	2.91*	2.57	3.32	0.75	1.32	2.32	-0.68	-3.00	1.59	0.25	4.00	3.75
	(1.74)	(2.23)	(2.41)	(3.08)	(1.92)	(2.36)	(2.78)	(3.47)	(1.73)	(3.14)	(3.43)	(5.75)
C. RISK-TOLERANT TYPES[4]												
Individual liability	-1.37	-2.04	1.60	3.64	0.47	1.41	-3.09	-4.50	-1.84	-3.45	4.69	8.14
	(2.22)	(2.13)	(4.97)	(4.69)	(1.95)	(1.98)	(3.46)	(3.50)	(2.45)	(2.52)	(5.51)	(5.83)
Joint liability	12.10***	16.20***	6.26***	-9.94**	-2.84	-2.10	-4.72**	-2.63	14.94***	18.30***	10.98***	-7.32
	(2.93)	(3.43)	(1.89)	(4.28)	(1.84)	(2.14)	(2.26)	(2.55)	(4.03)	(4.52)	(2.39)	(4.82)
Joint liability w/ approval	-2.84	-3.94*	-1.02	2.92	-0.41	0.55	-3.69**	-4.24	-2.43	-4.49	2.67	7.15
	(1.78)	(2.13)	(2.38)	(2.69)	(3.59)	(4.73)	(1.51)	(4.67)	(3.77)	(5.05)	(1.82)	(5.14)
Equity[2]	0.15	-3.19	6.81	10.00	4.81*	2.31	6.20**	3.89	-4.67	-5.50	0.61	6.11
	(4.66)	(3.14)	(8.39)	(7.37)	(2.49)	(3.63)	(2.43)	(3.44)	(3.79)	(3.57)	(7.83)	(10.23)

Notes:

(1) In perfect monitoring treatment, all actions and payments are observable. In imperfect monitoring treatment, all partner's actions are unobservable. Players are informed only if partner earned enough to repay her debt, Rs. 40.

(2) Excludes mandatory, third-party enforced transfers. Upside transfers denote transfers when project succeeds, excluding debt repayment assistance.

(3) Individual clustered standard errors in parenthses. * denotes significance at the 10%, ** at the 5%, and *** at the 1% level.

(4) Risk type based on investment choices in benchmarking rounds.

A Sample Instructions

The following instructions are for the joint liability game with imperfect monitoring. Detailed instructions for other treatments are available on request.

INSTRUCTIONS

Good afternoon everyone and thank you for agreeing to participate in our study. We are conducting a study of how microfinance clients make investments and share risk. Instead of asking you a lot of questions, what we'd like to do is have you play some games with us. The games are simple. You don't need any special skills. They're probably like games you played before. You don't need to know how to read. There are no "right" or "wrong" answers. We just want to understand how you make choices and what sorts of investment you prefer.

Here is how the game works. You will play games where the amount of money you win is based on picking a colored stone. *Display large 100/10 payoff sheet.* One of us will hold a stone in each hand. One stone is white. The other is black. *Show stones.* We will mix the stones up and you will pick a hand. No one will know which stone is in which hand, so the color you get is based on chance.

If you pick the white stone you will win the amount shown in white. If you pick the black stone you will win the amount shown in black.

Play practice round and administer oral test to confirm understanding. Distribute project choice sheets and tokens (carom coins).

We will give you choices about which game you want to play. Look at the sheet in front of you. It describes eight games. The color on the page tells you how much you win for each color stone. If you play game "B" how much do you win if you pick the white stone? How much for the black?

You can pick which game you want to play by placing a carom coin on your choice. For example, if you wanted to play the first game you would put your black carom coin over the "A". *Demonstrate.* And if you wanted to play [the fifth game], you put your coin over the "E".

The choice is yours. There are no right or wrong answers. It's only about which choice you prefer.

You can discuss your choices with the other person at your table, but do not speak with anyone else. Also, while you may talk with the person at your table, you may not look at her choices or score sheet. The first time you look at your partner's sheet, we will deduct Rs. 20 from your score. If you peek a second time, we will have to ask you to leave the study.

We will play several rounds today. At the end of the day we will put the number for each round you play in this blue bucket. Suppose you play three rounds. We will put the numbers 1, 2, and 3 in the bucket and you will pick a number from the bucket without looking. We will pay you in rupees for every point you scored in just that round. Remember, you will only be paid in rupees for one of the rounds that you play today. *Demonstrate example.* Remember, every round counts but you will only be paid in rupees for one of the rounds. At the end of the day, you will be paid individually and privately. No one will see exactly how much you earn.

Administer second test of understanding.

In this game you will play with a partner. You will use a white carom coin to mark your choices. When you make your choice, we will take your white coin. After you play the stone matching game, we will pay you in chips. The white chips are worth Rs. 5 and the red chips are worth Rs. 20. At the end of each round, you must repay your loan of Rs. 40. You and your partner are responsible for each other's loans. So to get your white coin back, you both must repay your loan. You may not look at your partner's score sheet or see how much she wins. However, after we play the stone matching game, we will tell you whether your partner made enough to pay her loan back.

After you play the stone matching game and receiving your chips, you can choose to give some of your earnings to your partner. You can discuss these transfers with your partner. You do not have to make any transfers. However, you are responsible for both your loan and your partner's loan and will be able to continue playing the game only if both of you can repay your loan of Rs.40.

If you wish to make any transfers, put any chips you wish to transfer to your partner in the bowl in front of you. Do not hand chips directly to her or place them in her bowl. Only place the chips you wish to transfer in the bowl in front of you. This is important because we need to keep track in order to pay you the correct amount at the end of the day. We will then collect your loan repayment.

Your earnings for the round will be equal to the total amount of chips that you have after any transfers you make to your partner and after you repay your loan. If either you or your partner are unable to repay your loan, you will both earn zero for the round and will not receive your white coin.

At the end of each round, we will pick a ball from this cage. There are 20 balls in the cage: 15 are white and 5 are red. If the ball is white, you will play another round of the same game with the same partner. If you do not have your white coin, you will have to sit out and will score zero for the round. If the ball is red, this game will stop and we will play a new game. Everyone will start with a new white coin and be matched with a new partner. After the red ball is pulled from the cage, you will not play with the same partner again for the remainder of the day. At any time, you can expect the game to last four more rounds but we will play until a red ball appears.

If you have any questions at any time, please raise your hand and one of us will come and assist you.

Administer final test of understanding.

Play practice round.

B Proofs and Derivations

B.1 Autarkic Investment Choice

In autarky (individual liability with no informal transfers), an individual's single-period investment choice problem solves

$$\max_{\alpha} U(\alpha, D) = \pi u[y^h(\alpha, D) - D] + (1-\pi)u[\max\{y^l(\alpha) - D, 0\}]. \tag{6}$$

Because of the discontinuity created by limited liability, this problem does not have a "nice" closed form solution for α^*, the optimal allocation to the risky investment. With the constant relative risk aversion utility function, $u(c) = c^{(1-\rho)}/(1-\rho)$, the first order condition for an interior maximum is:

$$\alpha^*_{INT} = \frac{(z-1)[S(1+D) - D]}{[(z-1)S + R](1+D)}, \tag{7}$$

where

$$z = \left[\frac{\pi(R-S)}{(1-\pi)S}\right]^{1/\rho}.$$

Accounting for the discontinuity created by limited liability, the optimal allocation is

$$\alpha^* = \begin{cases} \alpha^*_{INT}, \text{ if } EU(\alpha^*_{INT}) > EU(1) \\ 1, \text{otherwise} \end{cases}.$$ [38]

In the dynamic problem, individuals solve

$$\max_{\alpha} V(\alpha, D_t) = E\{U(\alpha) + \delta V(\alpha, D_t)\},$$

which is equivalent to the solution of

$$\max_{\alpha} \frac{U(\alpha, D_t)}{1 - \delta \Pr[R|\,\alpha]},$$

where $\Pr[R|\,\alpha]$ is the probability that the individual meets the repayment terms of the individual liability loan conditional on investment choice α.

B.2 Discussion of Predictions

As described in Section 2.3, note that λ represents the Pareto weight placed on agent B.

[38] In this formulation of the model with limited liability, it is never optimal for an individual to choose $\alpha \in \left(\frac{S(1+D)-D}{S(1+D)}, 1\right)$.

Definition 2 (relative marginal utility) *For any state of nature* $\theta \in \{hh, hl, lh, ll\}$ *and transfer arrangement* $T = \{\tau^{\theta}\}_S$*, let* $\kappa^{\theta}(T) = u^{'}(y_A^{\theta} - \tau^{\theta})/u^{'}(y_B^{\theta} + \tau^{\theta})$*.*

Where not required for clarity, I will drop the argument and refer to $\kappa^{\theta}(T)$ simply as κ^{θ}. Note that the first-best insurance arrangement involves full income pooling, $\kappa^{\theta} = \lambda$, a constant, $\forall\theta$. Under individual liability with no transfers ($T = 0$), the autarky treatment, the first-order conditions for optimal investment allocation require $\pi(R - S)u'(y_i^h) = (1 - \pi)Su'(y_i^l)$, which implies that $\kappa^{hh}(0) = \kappa^{ll}(0)$.

Lemma 1 places some structure on the relative marginal utilities, κ^{θ}, generated by any transfer arrangement generating a payoff vector that is constrained efficient in the set of equilibrium payoffs.

Lemma 1 (properties of κ) *For any transfer arrangement,* $T = (\tau^{hh}, \tau^{hl}, \tau^{lh}, \tau^{ll})$*, generating a payoff vector that is constrained efficient in the set of equilibrium payoffs:*

1. $\kappa^{hl} \leq \kappa^{lh}$*;*

2. *If* $\kappa^{hl} = \lambda$*, then* $\kappa^{hh} = \lambda$*. Similarly, if* $\kappa^{lh} = \lambda$*, then* $\kappa^{ll} = \lambda$*;*

3. *If there exist* θ *and* θ' *such that* $\kappa^{\theta} > \kappa^{\theta'}$ *then* $\kappa^{hl} < \kappa^{lh}$*.*

Note that this implies that an individual is weakly better off when her project succeeds and her partner's fails than when her project fails and her partner's succeeds.

Proof. For the first part of the lemma, suppose $\kappa^{hl} > \kappa^{lh}$. This implies that $\frac{u_A'(y_A^{hl} - \tau^{hl})}{u_B'(y_B^{hl} + \tau^{hl})} > \frac{u_A'(y_A^{lh} - \tau^{lh})}{u_B'(y_B^{lh} + \tau^{lh})}$. But since $y_i^{hl} > y_i^{lh}$, there exists a $\hat{\tau} \in (\tau^{lh}, \tau^{hl})$ such that $T' = (\tau^{hh}, \hat{\tau}, -\hat{\tau}, \tau^{ll})$ satisfies the incentive compatibility constraints for both agents and $\frac{u_A'(y_A^{hl} - \hat{\tau})}{u_B'(y_B^{hl} + \hat{\tau})} = \frac{u_A'(y_A^{lh} + \hat{\tau})}{u_B'(y_B^{lh} - \hat{\tau})}$. This transfer arrangement increases expected utility for both agents, a violation of Pareto optimality. For the second part, suppose $\kappa^{hl} = \kappa > \kappa^{hh}$. This implies that A's incentive compatibility constraint does not bind in hh. Therefore, there exists $T'' = (\tau^{hh} + d\tau, \tau^{hl} - d\tau\frac{\pi u'(y_B^{hh} + \tau^{hh})}{(1-\pi)u'(y_B^{hl} + \tau^{hl})}, \tau^{lh}, \tau^{ll})$ that satisfies the incentive compatibility constraints and leaves B's expected utility unchanged. But $\kappa^{hl} > \kappa^{hh}$ implies that $V_A(\alpha, T'') > V_A(\alpha, T)$, a violation of Pareto optimality. A similar argument shows that $\kappa^{lh} = \lambda$ implies $\kappa^{ll} = \lambda$. The third part of the lemma follows immediately. ■

Lemma 2 (transfers when exactly one project succeeds) *For any non-zero transfer arrangement, transfers will be made in states where one risky project succeeds and the other fails,* $\theta \in \{hl, lh\}$*, and the agent whose project succeeds will make a transfer to the agent whose project fails. That is, if* $T \neq 0$*, then* $\tau^{hl} > 0 > \tau^{lh}$*.*

This lemma captures the intuition that if individuals make any transfers, they will do so in the states where the utility cost to make the transfer is the lowest and the benefit to receiving a transfer is the highest.

Proof. If $T \neq 0$, then $V_i(\alpha, T) > V_i(\alpha, 0)$ for both agents. If $\tau^{hl} \leq 0$ then $\exists\ \theta \neq hl$ such that $\tau^{\theta} > 0$. With lemma 1, monotonicity and concavity of u imply that $u_B(y_B^h + \tau^{hl}) \leq u_B(y_B^{\theta} + \tau^{\theta})$ and $u_B^{'}(y_B^h + \tau^{hl}) \geq u_B^{'}(y_B^{\theta} + \tau^{\theta})$. Similarly, $u_A(y_A^l - \tau^{hl}) > u_A(y_A^{\theta} - \tau^{\theta})$ and $u_A^{'}(y_A^h - \tau^{hl}) < u_A^{'}(y_A^{\theta} - \tau^{\theta})$. Therefore, $\exists\ \varepsilon, k > 0$ such that for T' with $\tau^{hl\prime} = \tau^{hl} + \varepsilon$ and $\tau^{\theta\prime} = \tau^{\theta} - k\varepsilon$ that is incentive compatible and increases expected utility for both agents, contradicting Pareto optimality. Therefore $\tau^{hl} > 0$. The same reasoning serves to prove $\tau^{lh} < 0$. ∎

Lemma 3 (symmetric optimal investment) *For any transfer arrangement generating a payoff vector that is constrained efficient in the set of equilibrium payoffs both individuals allocate the same share of their assets to the risky investment, i.e.,* $\alpha_A^* = \alpha_B^*$.

Proof. If full insurance transfers are implementable, then the individual maximizations with respect to investment allocation also maximize joint surplus. For any combined allocation to the risky asset, $\bar{\alpha} \equiv (\alpha_A + \alpha_B)/2$, we can solve for the individual allocation that maximizes total utility. The first order condition for this problem requires that both agents have the same marginal utility of income after transfers in states hl and lh, that is, $u_B'\left(\tilde{y}_B^{hl}\right) = u_B'\left(\tilde{y}_B^{lh}\right)$ and $u_A'\left(\alpha_A R + (2 - 2\bar{\alpha}) S - \tilde{y}_B^{hl}\right) = u_A'\left(\alpha_B R + (2 - 2\bar{\alpha}) S - \tilde{y}_B^{lh}\right)$. Both equations are satisfied if and only if $\alpha_A = \alpha_B$. ∎

Discussion of Prediction 1 (information and informal insurance).

Consider a transfer arrangement generating a payoff vector that is constrained efficient in the set of equilibrium payoffs under perfect monitoring, $T^* = (\tau^{hh}, \tau^{hl}, \tau^{lh}, \tau^{ll})$, where each element τ^{θ} denotes the transfer from A to B in state θ. A's incentive compatibility constraint in state hl can be written as

$$u(y^h - \tau^{hl}) \geq u(y^h) - \delta \left\{ \tilde{V}(\alpha^e, T) - \tilde{V}(\alpha^p, 0) \right\}, \tag{8}$$

where $\tilde{V}(\alpha^e, T)$ equals the expected continuation utility of investment choice α^e and transfer arrangement T, which equals $V_i(\alpha^e, T)/(1 - \delta \Pr[R_i|\, \alpha^e, T])$ with, as defined in Section 2.3, $\Pr[R_i|\, \alpha^e, T]$ the probability that individual i meets the repayment terms of her formal financial contract conditional on investment choice α^e and transfer arrangement T and $V_i(\alpha^e, T)$ agent i's expected per-period utility with investment choice α^e and transfer arrangement T.

With imperfect public monitoring, each player knows only her own outcome at the time of making her transfer and her partner's outcome is never revealed. We restrict individuals' transfers under imperfect public monitoring to pure strategies: each will choose a strategy $T_i^{'}$ where her transfers are conditioned only on her own income realization, $T_A^{'} = (\tau_A^h, \tau_A^h, \tau_A^l, \tau_A^l)$ and $T_B^{'} = (\tau_B^h, \tau_B^l, \tau_B^h, \tau_B^l)$, and the superscript denotes the agent's own outcome. Analogous to T, define $T^{'} = T_A^{'} - T_B^{'}$. Because transfers can no longer be conditioned on the other player's realization, a transfer arrangement T^* can be replicated if and only if $\tau^{hh} - \tau^{lh} = \tau^{hl} - \tau^{ll}$.[39] The proof proceeds by showing that for all potentially replicable transfer arrangements, the incentive compatibility constraint is more restrictive under imperfect public monitoring. First, note that for any $\tau^h > \tau^l$ to be feasible, an individual who transfers τ^l must be punished with some positive probability p. I assume that this punishment takes the same form as that of the perfect monitoring: reversion to the minimum transfer profile.

$\tilde{V}(\alpha^e, T')$ is the expected continuation value of the transfer profile T'. Thus the incentive compatibility constraint when individual A's investment is successful is

$$\pi u(y_A^h - \tau_A^h + \tau_B^h) + (1-\pi) u(y_A^h - \tau_A^h + \tau_B^l) + \delta \tilde{V}(\alpha^e, T') \geq u(y^h) + \delta \tilde{V}(\alpha^p, 0).$$

Without loss of generality, consider a transfer arrangement, T, under perfect monitoring, where $\tau^{hh} \geq 0$ and set τ_B^l to 0.[40] A's incentive compatibility constraint for $\tau_A^h = \tau^{hl}$ is

$$(1-\pi) u(y_A^h - \tau_A^h) \geq u(y^h) - \pi u(y_A^h - \tau_A^h + \tau_B^h) + \delta \left\{ \tilde{V}(\alpha^e, T) - \tilde{V}(\alpha^p, 0) \right\}.$$

By the non-negativity of τ^{hh}, this implies

$$u(y_A^h - \tau_A^h) \geq u(y^h) - \pi u(y_A^h - \tau_A^h + \tau_B^h) + \frac{\delta}{1-\pi} \left\{ \tilde{V}(\alpha^e, T) - \tilde{V}(\alpha^p, 0) \right\}$$

Therefore under imperfect public monitoring the maximum implementable transfer in state hl is greater than or equal to that under perfect monitoring only if

$$\begin{aligned} \frac{\delta}{1-\pi} \left\{ \tilde{V}(\alpha^e, T') - \tilde{V}(\alpha^p, 0) \right\} &\geq \delta \left\{ \tilde{V}(\alpha^e, T) - \tilde{V}(\alpha^p, 0) \right\} \\ \tilde{V}(\alpha^e, T') &\geq (1-\pi) \tilde{V}(\alpha^e, T) + \tilde{V}(\alpha^p, 0). \end{aligned} \tag{9}$$

In order to evaluate this inequality, we need to determine $\tilde{V}(\alpha^e, T')$, the continuation value of the imperfect public monitoring game:

$$\tilde{V}(\alpha^e, T') = \frac{U(\alpha^e, T') + \delta \hat{p} \tilde{V}(\alpha^p, 0)}{1 - \delta(1-\hat{p})}, \tag{10}$$

[39] For example, the symmetric transfer arrangement $T = (0, \tau, -\tau, 0)$ can be replicated under limited information by players adopting the strategies $T_A' = (\tau + k, \tau + k, k, k)$ and $T_B' = (\tau + k, k, \tau + k, k)$.

[40] Note that τ^{hh} must be non-negative for at least one of the agents.

where $\hat{p}$ is the probability that either player receives the low draw (and therefore makes the low transfer) and is punished, and $U(\alpha^e, T^{'})$ is the per-period expected utility of investment choice α^e and transfer arrangement T'. The probability that a given player has the low draw and is punished is $(1-\pi)p$, therefore the probability that both players avoid punishment is $(1-p+\pi p)^2$ and $\hat{p} = 1-(1-p+\pi p)^2$. Combining equations (9) and (10) provides the condition that the maximum sustainable transfer under imperfect public monitoring is greater than or equal to that under perfect monitoring only if

$$\begin{aligned}\frac{U(\alpha^e, T') + \delta\hat{p}\tilde{V}(\alpha^p, 0)}{1-\delta(1-\hat{p})} &\geq \frac{(1-\pi)U(\alpha^e, T')}{1-\delta} + \pi\tilde{V}(\alpha^p, 0) \\ (1-\delta)\tilde{V}(\alpha^p, 0) &\geq U(\alpha^e, T')\end{aligned} \tag{11}$$

However, note that for any positive transfer to be feasible, $U(\alpha^e, T') > (1-\delta)\tilde{V}(\alpha^p, 0)$, that is, in expectation the transfer arrangement must generate at least as much utility as the minimum transfer profile. Equation (11) implies an immediate contradiction, therefore transfers under the imperfect public monitoring are weakly less than those under perfect monitoring and strictly so if transfers are positive and the incentive compatibility constraint is binding under perfect monitoring. ■

Discussion of Prediction 2 (joint liability and informal insurance). This prediction describes the four effects of joint liability (mandatory transfers) on the maximum incentive compatible insurance arrangement. For illustration, first, consider the case where individual A does not take default risk but her partner does. Here, $\tilde{V}_A(\alpha, \underline{T})$ under joint liability is strictly less than $\tilde{V}_A(\alpha, 0)$ under individual liability. She must occasionally make but never receives such transfers. This relaxes her incentive compatibility constraint in (2) relative to (1). Furthermore, in states where transfers are contractually required (hl and ll), required transfers reduce the scope for deviation, $u(y_A^\theta - \underline{\tau}^\theta)$. For any T, her incentive compatibility constraints are relaxed and she will be willing to make weakly greater transfers in each state of the world. However, the situation is reversed for her partner. For her, $\tilde{V}_B(\alpha, \underline{T})$ under joint liability is greater than $\tilde{V}_B(\alpha, 0)$ under individual liability. Since $\underline{\tau}^\theta \geq 0$ for all θ and the incentive compatibility constraint in (2) unambiguously tightens. The net effect is ambiguous.

Now, suppose both individuals take default risk. For expositional simplicity, I restrict attention to investment allocations where total income is insufficient to repay both loans in states hl and lh, however, the results extend with minor modifications to cases where this does not hold. Here, $\tilde{V}_A(\alpha, \underline{T})$ under joint liability is greater than $\tilde{V}_A(\alpha, 0)$ under individual liability if $\frac{\pi u_A(y_A^h)+(1-\pi)u_A(y_A^h-\underline{\tau})}{1-\delta(2\pi-\pi^2)} > \frac{u_A(y_A^h)}{1-\delta\pi}$, which simplifies to $\frac{u_A(y_A^h-\underline{\tau})}{u_A(y_A^h)} > \frac{1-2\pi\delta}{1-\delta\pi}$. When the required transfers are relatively low, the probability of success is high, and the discount factor (and hence the value of being able to repay and reborrow) is high, the expected utility of making only those transfers required by joint liability exceeds that of autarky. If this condition holds for both individuals, joint liability reduces the maximum incentive compatible transfer in state hh. Turning to transfers in states hl and lh, we must account for the fact that the mandatory transfer limits the scope for deviation. Here, $\tilde{V}_A(\alpha, \underline{T})$ under joint liability is greater than $\tilde{V}_A(\alpha, 0)$ under individual liability if $\frac{u_A(y_A^h - \underline{\tau})}{u_A(y_A^h)} > \frac{1+d-4\delta\pi-3\delta^2\pi+\delta\pi^2+4\delta^2\pi^2}{(1-\delta\pi)(1+\delta(1-3\pi+\pi^2)}$. While the precise criteria offers little insight, the implications are similar to those above, but the parameter space over which the maximum implementable transfers are smaller under joint liability than under individual liability is further restricted. In all states, the net effect of joint liability on the set of implementable informal insurance transfers depends on the parameter values. ■

Discussion of Prediction 3 (informal insurance and risk taking).

For the first part of the prediction—if transfers are made only when exactly one risky project succeeds, then both individuals' allocations to the risky asset are greater than under an RPBE without transfers—note first that from lemma 2, $\tau^{hl} > 0 > \tau^{lh}$. Without loss of generality consider individual A's investment choice problem. In autarky, the optimal investment choice requires $\pi(R-S)u'(\alpha^*(R-S)+S) - (1-\pi)Su'((1-\alpha^*)S) = 0$. For any transfer arrangement, $T = (0, \tau^{hl}, \tau^{lh}, 0)$, the first order condition for optimality evaluated at $\alpha^*(0)$ is $\pi^2(R-S)u'(\alpha(R-S)+S-\tau^{hh}) + \pi(1-\pi)\{(R-S)u'(\alpha(R-S)+S-\tau^{hl}) - Su'((1-\alpha)S-\tau^{lh})\} - (1-\pi)^2 Su'((1-\alpha)S-\tau^{ll}) > 0$. Therefore $\alpha^*(T) > \alpha^*(0)$.

For the second part of the prediction, assume $\rho_A \leq \rho_B$, that is, B is weakly more risk averse than A. From lemma 3 we know that if T achieves full insurance, then $\alpha_A^*(T) = \alpha_B^*(T)$. Full insurance requires that $\kappa^\theta = \lambda\ \forall\theta$, therefore $\tau^{ll} > 0 > \tau^{hh}$. Intuitively, the more risk-tolerant party, A, is insuring her partner by making transfers in the jointly low state (ll) and receiving payment in the jointly high state (hh). As above, I evaluate each individual's first-order condition for optimal investment at the autarkic optimum. For individual B, the partial of each term evaluated at $\alpha_B(0)$ is positive, therefore B will unambiguously allocate more to the risky asset for an RPBE with $T \neq 0$ than for one with $T = 0$. For agent A, however, the effect of transfers in states hl and lh is positive, but the effect of τ^{hh} and τ^{ll} is negative, tending to reduce A's optimal allocation to the risky asset relative to autarky. The relative size of these effects depends on the parameters and the net impact is ambiguous.

Finally, I show that the combined effect of full insurance is to increase total risk-taking. Following lemma 3, if insurance is complete, then both agents allocate the same amount to the risky asset. If their combined allocation to the risky asset is unchanged, then $\alpha_i^*(T) = (\alpha_A^*(0) + \alpha_B^*(0))/2 \equiv \bar{\alpha}(0)$. This implies that total income in states hh and ll is the same as in autarky and total income is the same in states hl and lh. Full insurance requires $\kappa^\theta = \lambda\ \forall\theta$, which implies that (i) $\tilde{y}_i^{hh} \geq \tilde{y}_i^{hl} = \tilde{y}_i^{lh} \geq \tilde{y}_i^{ll}\ \forall i$ and (ii) $(R-S)\pi u_i'(\tilde{y}_i^{hh}) = S(1-\pi)u_i'(\tilde{y}_i^{ll})$, i.e., transfers in states hh and ll recover the autarkic distribution of income. Now we can evaluate the first-order condition for optimal investment at $\alpha_i^*(T) = \bar{\alpha}(0)$, which I rewrite as

$\phi_i(\alpha_i, T) \equiv \pi^2(R-S)u_i'(\tilde{y}_i^{hh})+\pi(1-\pi)\{(R-S)u_i'(\tilde{y}_i^{hl})-Su_i'(\tilde{y}_i^{lh})\}-(1-\pi)^2Su_i'(\tilde{y}_i^{ll}) = 0$. Next, I show that for all possible values of R, S and π, $\phi_i(\bar{\alpha}(0), T) > 0$. First, if $R \geq 2S$ and $\pi \geq \frac{1}{2}$, we substitute for $u'(\tilde{y}_i^{ll})$ from (ii) and use the fact that $\tilde{y}_i^{hl} = \tilde{y}_i^{lh}$ to rewrite $\phi_i(\alpha_i, T) = (2\pi-1)(R-S)\pi u_i'(\tilde{y}_i^{hh})+(R-2S)\pi(1-\pi)u_i'(\tilde{y}_i^{hl}) > 0$. Therefore, if $\alpha_i(T) = \bar{\alpha}(0)$ both individuals will allocate more to the risky asset and hence the total allocation to the risky asset will increase. If $\pi < \frac{1}{2}$, we use the fact that $\tilde{y}_i^{hh} \geq \tilde{y}_i^{hl}$, therefore $\phi_i(\alpha_i, T) \geq (2R+\pi R-3S)u_i'(\tilde{y}_i^{hh}) > 0$, and the total allocation to the risky asset will be larger than under autarky. Finally, if $\pi \geq \frac{1}{2}$ and $R < 2S$, we substitute for $u'(\tilde{y}_i^{hh})$ from (ii) and $\phi_i(\alpha_i, T) = (2\pi-1)(1-\pi)Su'(\tilde{y}_i^{ll})+(R-2S)\pi(1-\pi)u'(\tilde{y}_i^{hl}) > (2\pi-1)(1-\pi)Su'(\tilde{y}_i^{ll})+(R-2S)\pi(1-\pi)u'(\tilde{y}_i^{ll}) = (1-\pi)(\pi R-S)u'(\tilde{y}_i^{ll}) > 0$, and again the total allocation to the risky asset will be larger than without informal insurance.
■

Appendix

Figure A1: Presentation of Core Game Lotteries