Essays on Development Finance

by

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ABSTRACT

This thesis consists of three essays that examine investment choices in less developed countries.

Chapter 1 examines how the structure of existing microfinance contracts may discourage risky but high-expected return investments. I develop a theory that unifies models of investment choice, informal insurance, and formal financial contracts and test the predictions using a series of experiments with Indian microfinance clients. The experiments confirm that borrowers free-ride on their partners, making risky investments without compensating partners for this risk, and that the addition of peer-monitoring overcompensates, leading to sharp reductions in risk-taking and profitability. However, the theoretical prediction that group lending will crowd out informal insurance is not borne out by experimental evidence. While observed levels of informal insurance fall well short of the constrained Pareto frontier under both individual and joint liability, joint liability increases observed insurance transfers. Equity-like financing overcomes both of these inefficiencies and merits further testing in the field.

Chapter 2 investigates the relationship between inflation uncertainty and the investment decisions of small, microfinance-funded firms in the Dominican Republic. Using loan-level panel data from microfinance borrowers in the Dominican Republic, I find that periods of increased inflation uncertainty were associated with substantially lower investments in fixed assets and reduced business growth. This finding is robust to specifications controlling for other forms of systemic risk and aggregate economic activity, suggesting inflation uncertainty creates potentially large distortions to the investment decisions of poor entrepreneurs.

Chapter 3, co-authored with my advisor, Esther Duflo, turns to investment behavior for public goods. This paper proposes and implements a test of local government efficiency by using a policy in India that set aside leadership positions in local governments to members of disadvantaged minority groups. If local governments are efficient, even if they discriminate against minority groups by supplying fewer public goods, they should still supply the public goods that minority groups value most. We find that when leadership positions are reserved for disadvantaged minorities, hamlets in which these minorities live receive a greater allocation of public goods. Moreover, we find suggestive evidence that this increase in public goods in minority hamlets is not proportional to the distribution of goods when the leadership position is unreserved, suggesting that in the

absence of reservation, local governments do not efficiently respond to the minority group's preferences.

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Contents

Chapter 1

Contract Structure, Risk Sharing, and Investment Choice

1.1 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). 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, 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). At the same time, joint liability encourages 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 insurance. Both of these risk pooling factors may increase borrowers' willingness to take risk.

To shed light on how microfinance contracts affect investment choices, this paper develops a theory that unifies models of investment choice, informal insurance with limited commitment, and formal financial contracts. It then implements a corresponding experiment with actual microfinance clients in India, with the ultimate aim of understanding how microfinance can most effectively stimulate entrepreneurship, encourage growth, and reduce poverty.

The theory builds on a simple model of informal risk-sharing in the spirit of Coate and Ravallion (1993) and Ligon, Thomas, and Worrall (2002). 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.[1] On this framework I then overlay formal financial contracts. I

[1]Following Stiglitz (1990), most theoretical work in microfinance has assumed that riskier investments

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

The theoretical analysis produces two key 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 reversion to autarky and makes 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.

The model also 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.

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 key elements of the theoretical models and the microfinance investment decisions they represent. Based on extensive piloting, I designed the games to be easily understood by typical microfinance

represent at best a mean-preserving spread of the safer choice and often generated a lower expected return. Examples include Morduch (1999), Ghatak and Guinnane (1999), and Armendáriz de Aghion and Gollier (2000).

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, which 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 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 full information, where all actions and outcomes were observable, and limited information, 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.[2]

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.[3] An

[2]As described in Charness and Genicot (2007), this payment structure prevents individuals from self-insuring income risk across rounds. The utility maximization problem of the experiment matches that of the theoretical model.

[3]Giné and Karlan (2007), 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

experiment overcomes each of these challenges. While the use of an experiment entails a tradeoff 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 experiment generated several interesting results. First, actual informal insurance fell well short of not only the full risk-sharing benchmark but also the constrained optimal insurance arrangement. Average net transfers were only 14% of the full risk-sharing amount and approximately 30% of transfers in the constrained optimal arrangement. This shortfall 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), and casts doubt on constrained Pareto optimality as the focal selection criteria for informal risk-sharing equilibria.

Second, joint liability induced greater *upside* risk-sharing than individual liability. That joint liability caused borrowers to assist their partners' loan repayments is not surprising; however, transfers as a percentage of the full risk-sharing amount *excluding transfers required for loan repayment* nearly doubled under joint liability. While theory predicts such a response for relatively risk-tolerant individuals making high-risk investments, the effect was broadly distributed and suggests a behavioral response.[4]

Third, despite these increased transfers, joint liability produced free-riding. Risk-tolerant individuals, as measured in a benchmarking risk experiment, took significantly greater risk under joint liability with limited information. Yet the transfers 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

client base under individual liability but are unable to evaluate investment behavior.

[4]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).

complete information, and when individuals were given explicit approval rights over their partners' investment choices, risk-taking fell below the autarky level. 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.

Fourth, 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.[5] Instead, my 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 1.2 places this paper in the context of related literature. Section 1.3 develops the model of informal risk-sharing with formal financial contracts and endogenous investment choice. Proofs are contained in Appendix B, unless otherwise noted. Section 1.4 describes the experimental design, and Section 1.5 presents the experimental results. Section 1.6 concludes.

[5]The theory of strategic default on microfinance contracts is explored in Besley and Coate (1995) and Armendáriz de Aghion (1999), while Armendáriz de Aghion 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.

1.2 Related Literature

This paper builds on a theoretical literature that characterizes optimal self-enforcing risk-sharing arrangements in a variety of settings. Among others in this vein are Coate and Ravallion (1993), Ligon, Thomas, and Worrall (2002), Kocherlakota (1996), and Genicot and Ray (2003). 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, Fafchamps and Lund 2003, Fernando 2006, Foster and Rosenzweig 2001). 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 (Charness and Genicot 2007, Barr and Genicot 2007, Robinson 2007) that uses the precise control possible in an experimental setting to understand how such mechanisms work in practice.

This paper also contributes to literature on peer monitoring and other elements of typical microfinance contracts. Since Stiglitz (1990), most of this literature has adopted the convention that riskier investments at best match the expected return of safer choices. Thus, great attention has been paid to mechanisms capable of reducing *ex ante* moral hazard over investment choice (Armendáriz de Aghion and Morduch 2005, Varian 1990, Conning 2005). In contrast, this paper considers investments where additional risk is compensated with increased expected returns, a natural assumption that has received little attention to date. In this setting, peer monitoring can discourage efficient risk-taking, a result which complements Banerjee, Besley, and Guinnane's (1994) prediction of excessive and socially inefficient monitoring in credit cooperatives.

This research also fits into the growing literature on the relative merits of group versus individual liability lending. 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 remains difficult to answer 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 (2007) overcome this limitation with a large, natural field experiment that randomized 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.

Because precise contract variation, control, and measurement are all limited in such "real-life" experiments, laboratory experiments constitute a valuable alternative. Abbink, Irlenbusch, and Renner (2006) study the effect of group size and social ties on loan repayment rates in an experimental setting, which allowed controlled variation that would have been impractical in a natural setting. Giné, Jakiela, Karlan, and Morduch (2007) pioneered the use of laboratory experiments to unpack the effects of various design features in microfinance contracts using a relevant subject pool. My paper explores in more detail a number of the issues they illuminated, with a number of key differences. Most importantly, I allow for informal insurance, an important risk management device for poor borrowers in poor countries, which may mitigate free-riding by enabling risk-taking individuals to compensate their partners for default insurance. My experiments also highlight the role of information by varying the information environment in all treatments and present subjects with an optimization problem equivalent to a discrete-time, infinite-horizon model. This allows for comparison between the experimental results and the underlying theory described in Section 1.3. Finally, I explore the effects of equity, a potential microfinance contract that may encourage investments with higher expected returns.

1.3 A Model of Investment Choice and Risk Sharing

1.3.1 Description of the Economic Environment

Consider a world where two individuals make periodic investments that are funded by their endowments and possibly 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.

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. If one of them earns more than the other, she may give something to her less fortunate partner. In this model, she does this not out of the goodness of her heart, but in expectation of reciprocity. In the future, she may be the one who needs help. Such transfers 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.

Terms of the outside financing are set by a third party. They specify repayment requirements and default penalties, typically the denial of all future credit, and may include income transfer rules ranging from joint liability to equity. The following subsection describes the model setup and timing.[6]

[6]Note that the model as described, in particular the structure of formal contracts, is more general than required for the discussion herein. I include it for consistency with ongoing work-in-progress that explores contract structures, information, and preference asymmetry in more detail.

1.3.2 Model Setup and Timing

I model this setting using a discrete-time, infinite-horizon economy with two identical agents indexed by $i \in \{A, B\}$ and preferences

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t^i)$$

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

Individual are matched under a formal financial contract Γ_G that specifies the feasible range of transfers between parties, loan repayment terms, and the availability of future financing based on current outcomes. The following subsection describes these contracts in more detail. Then each stage of the game proceeds as follows:

1. Each individual has access to an endowment, I, and a loan $D_t^i \in \{0, D\}$ where $D_0^i = D$ and future borrowing is determined by the terms of the formal lending contract. From her total capital, $I + D_t^i$, she allocates a share $\alpha_t^i \in [0, 1]$ to a risky investment that with probability π returns R for each unit allocated and 0 otherwise. The remainder, $1 - \alpha_t^i$, she allocates to a safe investment that returns $S \in [1, R\pi)$ with certainty.

    (a) When the risky project succeeds, individual i's total income is $y_h^i(\alpha^i, D^i) = \{\alpha^i R + (1 - \alpha^i) S\}(I + D)$.

    (b) When the risky project fails, her income is $y_l^i(\alpha^i, D^i) = \{(1 - \alpha^i) S\}(I + D^i)$.[7]

[7]We could generalize the income process such that $y_t^i = y(\alpha, \theta)(1 + D_t^i)$, where $\theta \in \mathbb{R}^2$ is the state of nature and $y : [0, 1] \times \mathbb{R}^2 \to \mathbb{R}_+$. Define $\bar{y}(\alpha) = \int_\theta y(\alpha, \theta) f(\theta) d\theta$ and $\delta(\alpha) = \lim_{z \to 1^-} \int_{-\infty}^{y^{-1}(\alpha, z)} f(\theta) d\theta$, i.e.,

2. The state of nature is realized and each individual receives her income, y^i. Denote by $\theta \in \Theta = \{(j,k); j,k \in (l,h)\}$ the state of nature, such that for any state θ, $(y^A, y^B) = (y^A_j, y^B_k)$. For notational simplicity I write the four states of nature as hh, hl, lh, ll.

3. Because individuals are risk averse, they have an incentive to share risk and enter into an informal risk-sharing contract that may extend beyond any formal sharing rules.

   (a) This informal contract is not legally enforceable and thus must be self-sustaining. I assume that if either party reneges upon the contract, both individuals henceforth transfer only what is required by the formal contract ($\tau^i = \underline{\tau}^i$).

   (b) Each individual chooses to transfers an amount $\tau^i \in [\underline{\tau}^i, y^i]$ to her partner. Her income after transfers is $\tilde{y}^i = y^i - (\tau^i - \tau^{-i})$.

   (c) The financial contract, Γ^1_G, specifies the feasible range of transfers each individual can make. Formally, $\Gamma^1_G : (y^1, y^2) \to [\underline{\tau}^1, y^1] \times [\underline{\tau}^2, y^2]$.

4. The financial contract specifies the loan repayment (P^i_t) and the amount available in the next period (D^1_{t+1}). Formally, $\Gamma^2_G : (\tilde{y}^1_t, \tilde{y}^2_t, D^1_t, D^2_t) \to (P^1_t, P^2_t, D^1_{t+1}, D^2_{t+1})$.

   (a) Loan repayment (P^i_t) is determined mechanically. There is no willful default so if an individual has sufficient funds to repay her loan, she will. $P^i_t = \min(D^i_t, \tilde{y}^i_t)$.

   (b) The loan amount available in the following period evolves according to the fol-

the probability that $y(\alpha, \theta) < 1$. The returns assumptions translate to $\partial \bar{y}(\alpha)/\partial \alpha > 0$—expected returns are increasing in risk—and $\partial \delta(\alpha)/\partial \alpha > 0$—the probability of a loss is also increasing in α. This form allows for correlated returns through the distribution of θ and can eliminate the discontinuity created by the default threshold in the simplified, specific model.

lowing laws of motion for each formal contract (described immediately below):

$$\Gamma_I \;:\; D_{t+1}^i = \begin{cases} D \text{ if } P_t^i = D_t^i = D \\ 0 \text{ otherwise} \end{cases}$$

$$\Gamma_J, \Gamma_E \;:\; D_{t+1}^i = \begin{cases} D \text{ if } P_t^i = D_t^i = D \;\forall i \\ 0 \text{ otherwise.} \end{cases}$$

5. Because agents cannot save, the specified loan repayment uniquely determines consumption for the period: $c_t^i = y_t^i - (\tau_t^i - \tau_t^{-i}) - P_t^i$.

1.3.3 Formal Contracts

I consider three types of contracts: individual liability (Γ_I), joint liability (Γ_J) and quasi-equity (Γ_E), which is equivalent to joint liability with third-party enforced equal sharing of all income. The first two contracts capture key elements of micro-lending contracts that exist in practice. The third is counterfactual and provides a benchmark formal risk-sharing arrangement, with practical implications discussed more fully in Section 1.5.

For each contract I normalize the interest rate on loans to zero and constrain the amount of financing to $D^i \in \{0, D\}$. I also 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. The formal contracts have the following features.

Individual liability. Under individual liability, Γ_I, there are no mandatory transfers, $\underline{\tau}^i = 0$, and an individual can borrow in the subsequent period if she repays her own loan in the current one, $D_{t+1}^i = D$ if and only if $P_t^i = D_t^i = D$.

Joint liability. Under joint liability, Γ_J, if either individual has insufficient funds to repay her loan, her partner must help if she can: $\underline{\tau}^i = \max(\min(y^i - D^i, D^{-i} - y^{-i}), 0)$.[8] 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 $i \in \{A, B\}$.

Equity. Under the equity contract, Γ_E, individuals share their income equally such that $\underline{\tau}^i = \frac{1}{2} y^i$. 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: $D^i_{t+1} = D$ if and only if $P^i_t = D^i_t = D$ for $i \in \{A, B\}$.

1.3.4 Characterization of Informal Insurance Arrangements and Investment Choice

An informal insurance arrangement 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 assume individuals can enter into an informal risk-sharing contract supported by trigger strategy punishment. If either party reneges on the insurance arrangement, both members exit the informal insurance arrangement in perpetuity. Note that they are still subject to the transfer requirements, if any, of the formal financial contract. I will focus on the set of subgame perfect equilibria to this infinitely repeated game and restrict my attention to the constrained Pareto optimal arrangement. An equilibrium specifies a transfer arrangement $T(\alpha^A, \alpha^B) = (\tau_{hh}, \tau_{hl}, \tau_{lh}, \tau_{ll})$ for all investment choice pairs $(\alpha^A, \alpha^B) \in [0, 1]^2$ and an optimal investment allocation $(\alpha^{*A}, \alpha^{*B})$ conditional on this set of transfer arrangements.

[8] I assume that this transfer requirement is mandatory. Alternatively, one could endogenize the transfer choice such that an individual would only make transfers required for debt repayment if the amount of the required transfer was less than her default penalty. In practice, borrowers almost always make such transfers and modeling the choice formally seems an unnecessary complication.

Conditional on individuals' allocations to the risky asset, the vector $T = (\tau_{hh}, \tau_{hl}, \tau_{lh}, \tau_{ll})$ fully specifies the transfer arrangement. Incentive compatibility requires that in any state of the world the discounted future value of remaining in the insurance arrangement must be at least as large as the potential one-shot gain from deviation.

In the absence of any mandatory transfers, define individual A's expected autarkic utility as

$$\bar{V}^A = \pi u(y_{h\cdot}^A) + (1-\pi)u(y_{l\cdot}^A).$$

Under the transfer arrangement T, her expected per-period utility is

$$V^A(T) = \pi^2 u(y_{h\cdot}^A - \tau_{hh}) + \pi(1-\pi)u(y_{h\cdot}^A - \tau_{hl}) + \pi(1-\pi)u(y_{l\cdot}^A - \tau_{lh}) + (1-\pi)^2 u(y_{l\cdot}^A - \tau_{ll}).$$

Incentive compatibility requires

$$u(y_\theta^A - \tau_\theta^A) - u(y_\theta^A) + \frac{V^A(T) - \bar{V}^A}{r} \geq 0,\ \forall\theta,$$

where $r = (1-\beta)/\beta$. When formal contracts specify a minimum transfer $\underline{\tau}_\theta$ in state θ, we modify the constraint accordingly:

$$u(y_\theta^A - \tau_\theta^A) - u(y_\theta^A - \underline{\tau}_\theta) + \frac{V^A(T) - V^A(\underline{T})}{r} \geq 0,\ \forall\theta$$

where $\underline{T} = (\underline{\tau}_{hh}, \underline{\tau}_{hl}, \underline{\tau}_{lh}, \underline{\tau}_{ll})$.

Conditional on the set of insurance arrangements, each individual selects

$$\alpha^{i*} = \arg\max_{\alpha^i} V^i(T(\alpha^i, \alpha^{-i})).^9$$

[9] Transfers are specified over incomes in all states Θ; however, the investment allocation pair (α^A, α^B) maps one-for-one to incomes in these states.

An equilibrium is a fixed point of this problem.

I now show that moving from autarky to an environment with incentive compatible informal insurance arrangements increases each individual's allocation to the risky asset.

Proposition 1 (informal insurance increases risk taking) *Let T be a non-zero, incentive compatible informal insurance arrangement with no mandatory minimum transfers and a Pareto weight equal to the ratio of individuals' marginal utilities in autarky. Then $\alpha^{i*}(T) > \alpha^{i*}(0)$.*[10]

Note that in contrast to informal insurance and consistent with standard portfolio theory (e.g., Gollier 2004), when insurance is *required* by joint liability, an individual's risk taking may 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 $S = 1$, $R = 3$, $D = 1$, $\beta = 0.9$, 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 risk mitigation effect of joint liability. In response to increased risk taking by their partners, individuals may reduce their own allocation to the risky asset relative to autarky.

Next I show that as an individual's allocation to the risky project increases, she is willing to sustain larger informal transfers

Proposition 2 (risk taking encourages insurance) *For any $\alpha' > \alpha$, the maximum sustainable transfer $\tau_\theta(\alpha', \cdot) \geq \tau_\theta(\alpha, \cdot)$ in any state θ where transfers are made.*

[10] Note that this proposition requires convex production technology. With production non-convexities such as increasing returns to the risky investment, greater cooperation may lead to specialization wherein one party reduces her risk-taking in order to provide insurance so that her partner can take advantage of increasing returns.

Taken together Propositions 1 and 2 imply a positive feedback between risk-taking and insurance. Improved insurance increases risk taking, which in turn makes it easier to support greater insurance.

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 individual *may* engage in greater risk sharing. Consider the following environment: $S = 1$, $R = 3$, $D = 1$, $\beta = 0.75$, and $\pi = 0.5$. 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 1.4, the optimal investment choice for two individuals with $\rho = 0.4$ generates a payoff (y_h, y_l) of $(160, 40)$ and supports a maximum transfer of 42, or 70% of the full insurance transfer. For two, more risk averse 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.

Proposition 3 (Mandatory Insurance and Informal Transfers) *Mandatory insurance reduces maximum sustainable informal transfers in states of nature when transfers are not required:* $\tau_{ij}^*(\underline{T} > 0) \leq \tau_{ij}^*(\underline{T} = 0)$ *if* $\underline{\tau}_{ij} = 0$. *In states where transfers are required* ($\underline{\tau}_{ij} > 0$)*, total transfers increase if and only if either* $\tau_{ij}^*(\underline{T} = 0) < \underline{\tau}$ *(i.e., the mandatory transfer rule is binding) or* $\frac{u'(y_j + \underline{\tau}_{ij})}{u'(y_i - \underline{\tau}_{ij})} < \frac{r + \pi_{ij}}{\pi_{ij}}$.

Figure 2 illustrates three effects of joint liability on static project choice: free-riding, risk mitigation, and debt distortion. The figure plots individual B's best response function for α^B with respect to α^A in the environment $S = 1$, $R = 3$, $D = 1$, $\beta = 0.75$, 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.

While information likely plays an important role in determining informal insurance arrangements and the interactions of microfinance borrowers, it is beyond the scope of this model. The preceding theory is all developed under the assumption of perfect information.[11] In order to shed some light on the role of information and as Section 1.4 discusses in detail, I conducted each of the experimental treatments under both full and limited information. In the limited information treatment, individuals observed only whether their partners earned sufficient income to repay their loans. All other information about actions and outcomes was voluntary and unverifiable. While not explicitly modeled, limited information likely reduces cooperation. See, for example, Chassang (2006), Green and Porter (1984), and Fudenberg and Maskin (1986) for discussions of how imperfect information can reduce cooperation and push equilibria away from the full-information Pareto frontier. Full information, on the other hand, increases the likelihood of unmodeled social elements such as privately costly, out-of-game punishments.

[11] The model under limited information is complex and deserves to be the subject of a separate paper. In ongoing work-in-progress, I explore the role of information and preference asymmetry in more detail.

1.3.5 Summary of Theoretical Predictions

The following subsection summarizes the key theoretical predictions.

1. Relative to autarky, informal insurance will increase risk taking by risk-averse individuals.

2. Joint liability (mandatory insurance when one party has a low outcome) has four types of effects, the net impact of which is ambiguous.

   (a) Static Project Choice: The existence of mandatory transfers directly affects project choice. This effect can be divided into two components:

      i. Free Riding: Mandatory transfers from one's partner encourage greater risk taking by partially insuring against default. In many situations, this will lead to "free-riding" where a borrower selects a risky project, saddles her partner with the need to insure against default, and does not compensate her for this insurance by transferring income when the risky project succeeds.

      ii. Risk Mitigation: Joint liability and mandatory transfers to one's partner may decrease risk taking as borrowers adjust their project choices to avoid joint default should their partners' projects fail.

   If the risk of default (or the cost of avoiding it) is sufficiently large, the standard distortion of debt with limited liability dominates and pushes individuals towards the riskiest choice.

   (b) Informal Insurance: Joint liability changes the threat point of informal insurance in two ways:

      i. Crowding Out: Mandatory insurance reduces the cost of reversion to autarky and thus makes cooperation harder to sustain. This reduces informal insurance and in turn should decrease risk taking.

ii. Limited Deviation Gain: In states where joint liability causes one party to assist the other's loan repayment, mandatory insurance reduces the potential momentary gain from defection—one cannot avoid making the required transfer. This will strengthen informal insurance and increase risk taking.

When both parties have sufficient income to repay their loans, only the crowding out effect is present and formal insurance weakens informal insurance. When borrowers are relatively risk tolerant and the maximum gains to defection are relatively small, joint liability may increase informal insurance in those states where one party is unable to repay her loan without assistance.

(c) Dynamic Project Choice: A borrower who is responsible for the loan repayment of another and insufficiently compensated for this insurance may discourage risk taking dynamically through subgame perfect punishment strategies. In response to defection, one could terminate informal insurance or switch to a risky investment that inflicts on the defector either default risk or the need to insure against it. In equilibrium, this effect should reduce risk taking, though its magnitude is likely small.

(d) Explicit Approval Rights: Joint liability contracts may confer explicit approval rights over a borrower's partners' projects. These approval rights may be exogenous and absolute (Stiglitz 1990) or enforceable through social sanctions. Explicit approval rights exert two influences:

i. Forced Project Punishment: Approval rights provide an additional punishment mechanism—those who don't cooperate can be forced into suboptimal projects. This encourages informal insurance and increases risk taking.

ii. *Ex Ante* Project Veto: Approval rights can directly curtail excessive risk taking *ex ante* as partners simply veto or threaten to veto projects they deem "too risky."

When the risk of default is low even in the absence of approval rights or when borrowers are likely to cooperate on investment choice, we expect the forced project punishment effect to dominate. Otherwise, the threat of *ex ante* project veto will reduce risk taking.

To summarize, joint liability potentially causes two inefficiencies. Borrowers, unable to credibly commit to sharing their gains when successful, may free-ride on the default insurance provided by their partners. On the other hand, in an effort to stop free-riding, individuals may use approval rights to reduce risk taking and profitability.

3. With full insurance, perhaps enforced through mandatory transfers or an equity-like financial contract, borrowers internalize the cost of coinsurance. This increases risk taking relative to autarky without the free-riding problems of joint liability. When borrowers have identical preferences, the constrained Pareto optimum is obtained.

4. Limited information should weaken cooperation, reducing informal insurance under all contracts. While not explicitly modeled, we expect such reduced cooperation would have the following implications:

   (a) Under individual liability, informal insurance and, as a consequence, risk taking should fall.

   (b) Because the cooperative equilibrium is less valuable and defection harder to detect, free-riding in joint liability will be more likely. The net effect on risk taking will be offset to the extent individuals engage in risk mitigation to prevent joint default.

   (c) Approval rights will more likely be used to prevent risk taking.

1.4 Experimental Design and Procedures

1.4.1 Basic Structure

This section describes a series of experiments designed to simulate the economic environment described in Section 1.3. 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.[12] 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

[12] 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 the 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 name 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.

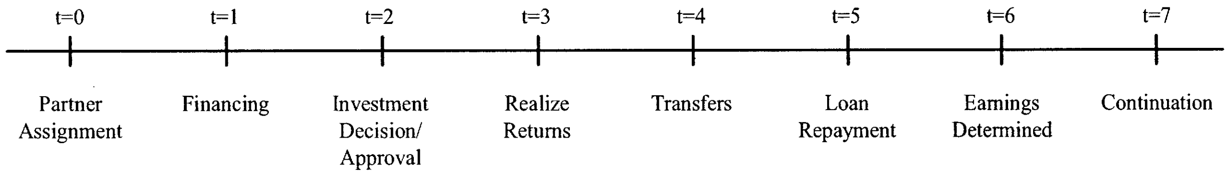

Figure 1: Timing of Events

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, which was described as a loan that could be used invest in a project but which needed to be repaid at the end of each round ($t = 1$). 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. Because expected profits increase monotonically with risk, I use them 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 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 earning 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 $t = 1$.[13] 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 1.3 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. Subject were informed that once a game ended, they would not play again with the same partner. Approximately 75% of participants were matched with a partner from a different *kendra* in order to limit the scope for out-of-game punishment. I included within-*kendra* matches to test the effect of these linkages. 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).[14] I then paid each subject

[13] 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.

[14] The three GSS questions are the same as those used by Giné, Jakiela, Karlan, and Morduch (2007) 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

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.[15]

1.4.2 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. In all treatments, individuals were allowed to communicate with their partner. While sacrificing a degree of control, I felt communication was an important step towards realism. The five experimental contract treatment described below embody the contracts described in Section 1.3.

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. 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

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.

[15] See appendix section B.1 for details.

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)	●	●	●	●		●

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.

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.

1.4.3 Information Treatments

All of the financial contract treatments except for autarky were played under two information regimes: full and limited information. Much of the literature on microfinance discusses the importance of peer monitoring and local information,[16] and these treatments were designed to see how information affects performance under different contracts. In all treatments, we seated members of a pair together and allowed them to communicate freely. Under **full information**, all actions and outcomes were observable. Under **limited information**, we separated partners with a physical divider that allowed communication but prevented them from seeing each other's investment choices and outcomes.[17] 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. Individuals could not see their partner make the transfer but saw the amount of the transfer once it was made.

1.5 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

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

[17] Unobservability was successfully enforced with the threat of financial punishment and dismissal from the experiment.

participants per session ranged from 8 and 24, depending on show-ups. The mean was 18.75. Participants were invited to attend multiple 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 1.5.1 describes the effect of contracts and information on informal risk-sharing. Section 1.5.2 concerns risk taking and project choice.

1.5.1 The Impact of Contracts and Information 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 full information. On average, transfers achieve only 14% of full risk-sharing and approximately 30% of the maximum implementable transfer.*

As discussed in Section 1.3, 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 autarky, i.e., no informal transfers. However there is a natural tendency to focus on the constrained Pareto optimal arrangement, 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 constrained Pareto optimal transfers using numerical simulations based on individuals' CRRA risk aversion parameters estimated from benchmark risk experiment, actual project choices for each subject pair, and a static transfer arrangement with equal Pareto weights. These experimental results find observed transfers well below those achieved by either full risk-sharing or at the constrained Pareto optimum.

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. 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 full information 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 full information, either individual made a transfer in only 50% of all rounds. Under limited information, the probability of any transfer fell to 30%. Furthermore, when transfers were made, they tended to remain well below the full risk-sharing benchmark, as shown in columns 3 and 4 of Table 7. Again, joint liability with full information 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 full information and 47% without—net transfers were smaller than those in other contracts.

This result highlights the importance of equilibrium selection. The preponderance of empirical research on informal insurance with limited commitment suggests that actual transfers fall short of full insurance.[18] 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 well below even the constrained Pareto optimal. One possible explanation, consistent with the results from Charness and Genicot (2007), is that the constrained Pareto optimal 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

[18]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.

correlated income processes; however, with heterogeneity, actual transfers were substantially below predicted levels and close to those I observed. This calls into question the use of constrained Pareto optimality as the focal selection criteria for informal sharing arrangements. 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 points to the importance of information.

RESULT 2. *Informal insurance is substantially larger under full information than when information is limited. On average, transfers under full information are 60% larger than those when information is limited.*

Theory predicts that cooperation will be harder to sustain when information is limited. While not explicitly modeled in Section 1.3, we expect that this weakening of cooperation will be reflected in smaller informal insurance transfers when information is limited. This result is evident in Figure 4 and the summary statistics presented in panel B of Table 6. Empirical support is provided by the simple cell-means regression

$$\tau_{it} = \alpha + \sum_j \beta_j T_j + \varepsilon_{it}, \tag{1.1}$$

where τ_{it} is the transfer made by individual i in round t, and T_j is a indicator for the contract and information treatment. Table 8 reports these results. In all contracts, full information generated substantially larger transfers than limited information. 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. F-tests reject the equivalence of treatment dummy coefficients between full and limited information for the individual liability contract at the 1%-level; however, large standard errors make it impossible to reject equivalence in the other contracts. Wilcoxon rank-sum tests reject equivalence at any conventional significance level ($p < 0.0001$) for all contracts.

These results are consistent with theoretical predictions that cooperation is harder to sustain when information is imperfect. The size of this information effect is large. Net transfers under joint liability increase from 12% of full risk-sharing when information is limited to 27% with full information.

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 full information and more than doubling under limited information.*

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 the impact of joint liability contracts on "upside" transfers, i.e., transfers *excluding* loan repayment assistance and thus representing pure insurance, is theoretically ambiguous. As shown in Proposition 3, joint liability can crowd out informal insurance and thus reduce maximum sustainable transfers; however, there is substantial overlap in the set of sustainable equilibrium transfers in all contract treatments. For example, autarky, no transfers beyond what is contractually required, is an equilibrium strategy under any formal contract. But while the current theory does not predict the behavior of *observed* transfers within the possible set of equilibria, there is intuitive appeal to the notion that comparative statics for observed transfers would move in the same direction as those for the Pareto frontier. This intuition proves incorrect as 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 limited and full information. 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 limited information 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 full information, which did not increase risk taking. With complete information, 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 information is limited, their transfers increase by 101% from 3.33 to 6.69, and this difference is significant at the 5%-level. With full information, the increase is smaller, 12%, and insignificant, but this from a relatively high base of 6.28 under individual liability with full information.

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 information is limited, 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 1.3 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 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:

$$\tau_{it} = \alpha_i + \beta_1 y_{it} + \beta_2 y_{-it} + \delta \sum_{\theta=1}^{t-1} (\tau_{it} - \tau_{-it}) + \varepsilon_{it}, \tag{1.2}$$

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 $\delta < 0$.

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 limited information 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.[19]

1.5.2 The Impact of Contracts and Information on Risk Taking

I now turn to the effect of contracts and information 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 120 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 information treatments. The illustrated values are calculated from the simple cell-means regression

$$\tilde{y}_{it} = \alpha + \sum\nolimits_j \beta_j T_j + \varepsilon_{it}, \tag{1.3}$$

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

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

As shown in Proposition 1, informal insurance should induce members of a pair to take additional risk. Using the parameters of the experimental setting, I calculated individuals' optimal investment choices under autarky and with informal insurance that achieves the constrained Pareto optimum. 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%.

Comparing investment choices in the individual liability treatment to those under autarky provides an immediate test of this hypothesis; the individual liability treatment differed from

[19] This interpretation is also supported by participants' qualitative responses. For example, after pairing were dissolved and partners rematched, one participant asked explicitly, "I loaned my partner Rs. 20 to repay her debt in the last round. How can I get it back now?"

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 (1.3) 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 limited and full information 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 available of informal insurance may also have made risk more salient and thus discouraged risk taking. While communication was allowed in all treatments, participants in the 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.

RESULT 6. *The effect of joint liability on risk taking depends on the information environment. Under full information, joint liability marginally reduces risk taking relative to individual liability. With limited information, joint liability increases aggregate risk taking as more risk-tolerant individuals take significantly greater risk, relying on their partners to insure against default.*

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 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 full information, we would expect greater risk-taking under joint liability. Under joint liability with limited information, 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 1.3 would dominate.

In the experiment under full information, 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 limited information, the effect is reversed. Joint liability increases risk taking by 3.7% (1.87; $p = 0.012$) 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 information on risk taking is pronounced. Limited information increases risk taking by 4.3% (2.17; $p = 0.009$) 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 information structure, while more risk-tolerant individuals take significantly greater risk when information is limited.

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 information is complete, joint liability does not appear to affect the investment choices of risk-tolerant individuals. In fact, as shown in column 4 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 (2007) finding that participants who tend to take risks reduce their risk-taking when their partners make safer choices.

When information is limited, risk-tolerant individuals increase their risk taking under the simple joint liability contract. As can be seen in column 2 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 ($p < 0.0001$).[20] 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 full and limited information, while increased risk taking is only evident when information is limited. Second, as shown in Figure 5, there is no discernible differences 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.

Consistent with theoretical predictions, cooperation appears easier to sustain when infor-

[20]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.

mation is complete. 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 discourage risk taking.

RESULT 7. *Explicit approval rights are used to curtail risk taking under joint liability with limited information but have a negligible effect under full information.*

As described in Section 1.3, explicit approval rights could be used either as a threat to provide additional punishment support for cooperation or actively to prevent risk taking *ex ante*. As shown in panel C of Table 11, the risk-discouragement effect dominates, particularly when information is limited. When information is limited, 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 limited information, 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.*

Third-party enforcement of equal income distribution overcomes much of the commitment problem associated with informal risk-sharing arrangements. As such, 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 (1.3). 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 full information and 10% under limited information.

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.[21] 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.

[21] Low levels of reported default suggests that willful default is not prevalent.

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 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.

1.6 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? And how do formal financial contracts affect these behaviors? 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.

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 Pareto optimality 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, in contrast to theoretical predictions, joint liability did not crowd out 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 the constrained Pareto optimum. 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 the social effects, coordination devices, and other explanations.

Third, despite the apparent value attached to joint liability, when information was imperfect, such contracts still produced significant free-riding. Risk-tolerant individuals took substantially greater risk without compensating their partners for the added insurance burden. Granting approval rights eliminated free-riding but also reduced risk-taking below autarky levels. 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. Combined with the result that informal insurance had a negative, though statistically insignificant, effect on risk taking, this result suggests research into social determinants of investment choice would be fruitful and may explain 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.

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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

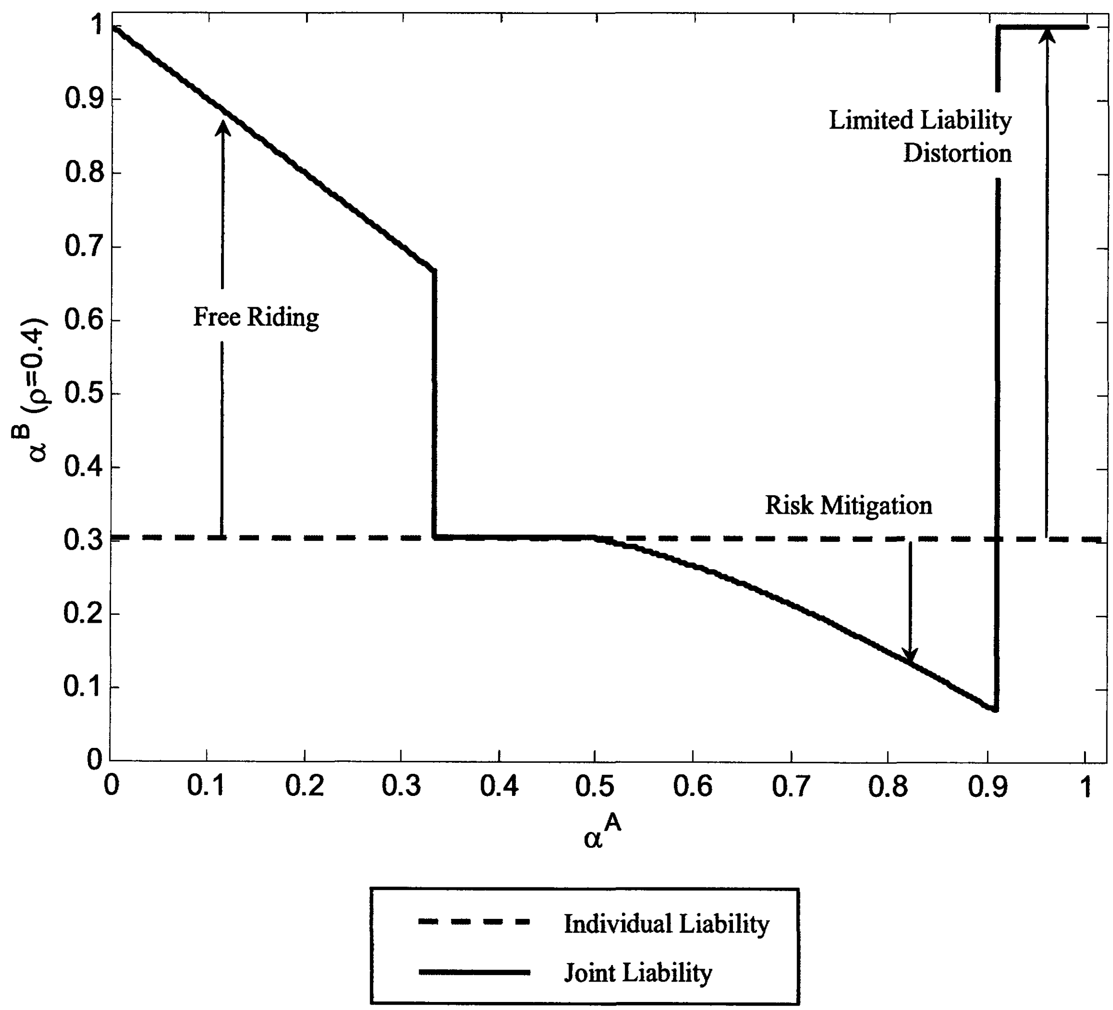
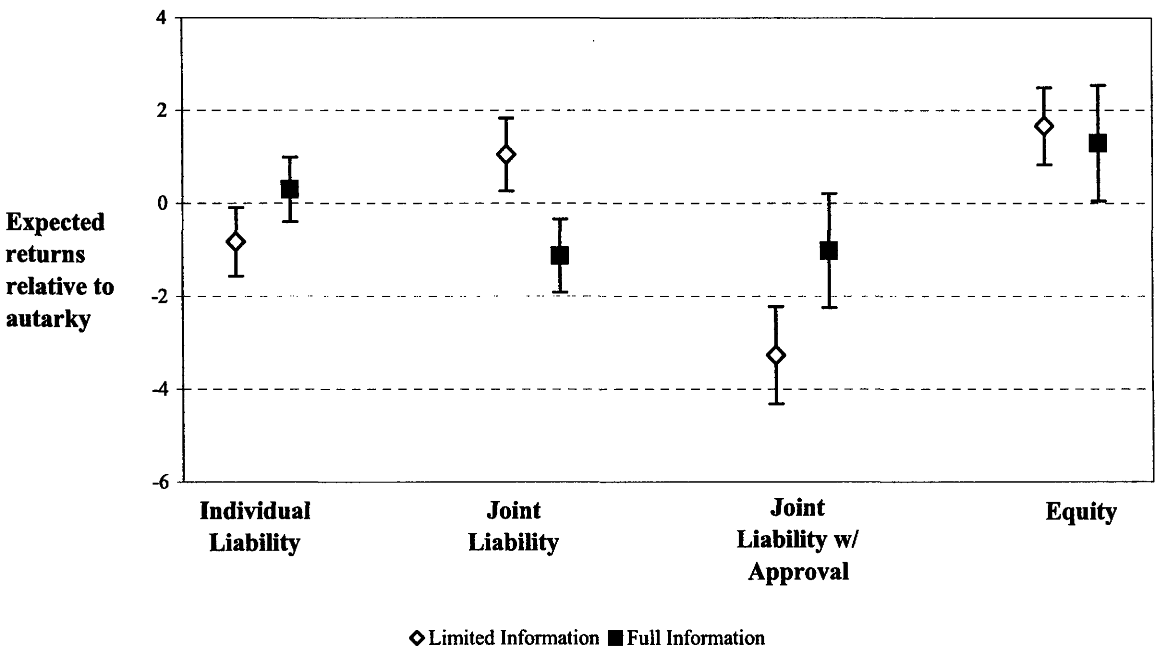


Figure 3: Risk Taking by Treatment



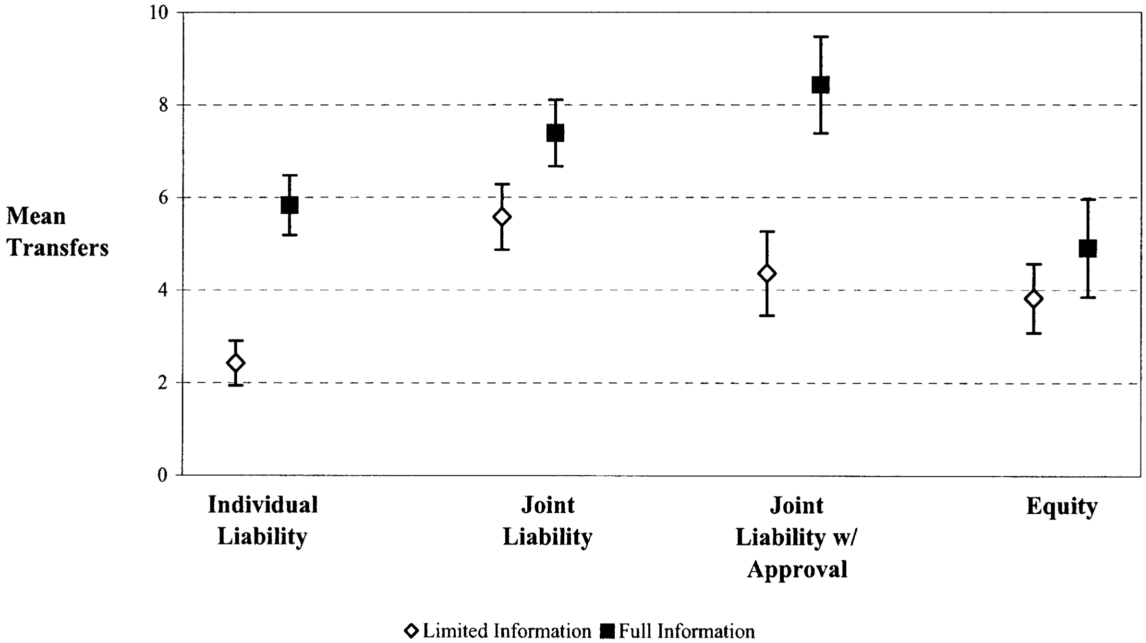
Notes:

(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:

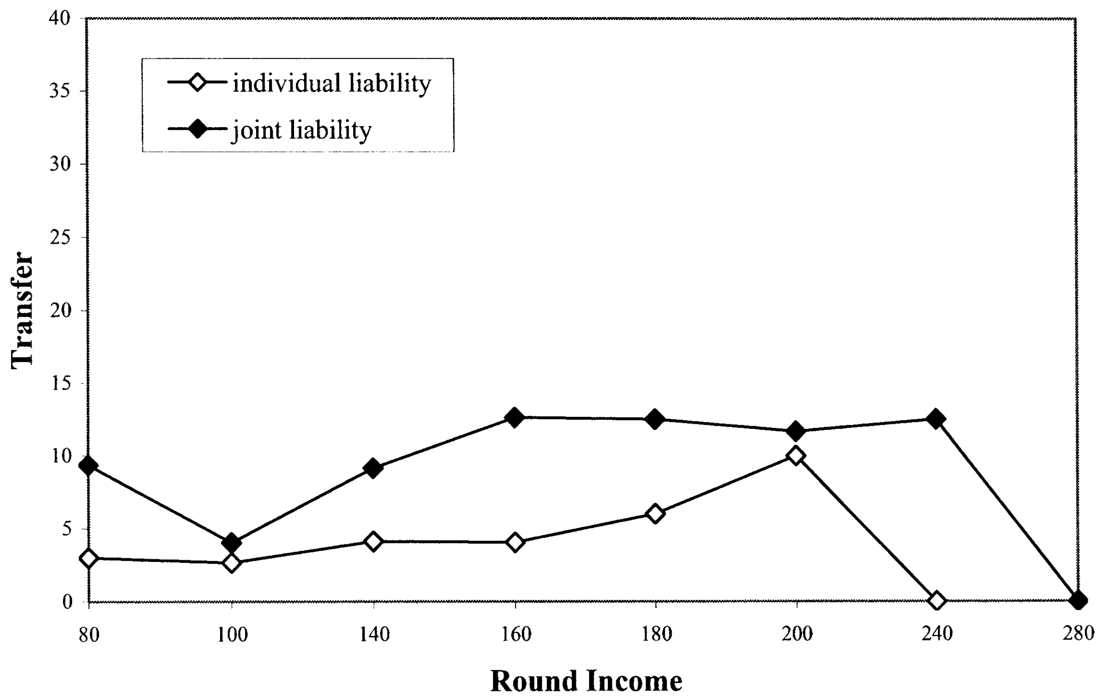
(1) Plot points represent coefficients on treatment dummies in the regression $\text{transfer}_i = \sum_j \beta_j T_j + \varepsilon_i$

(2) Error bars represent one standard deviation.

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

Figure 5: Transfers by Round Income

A. Limited Information



B. Full Information

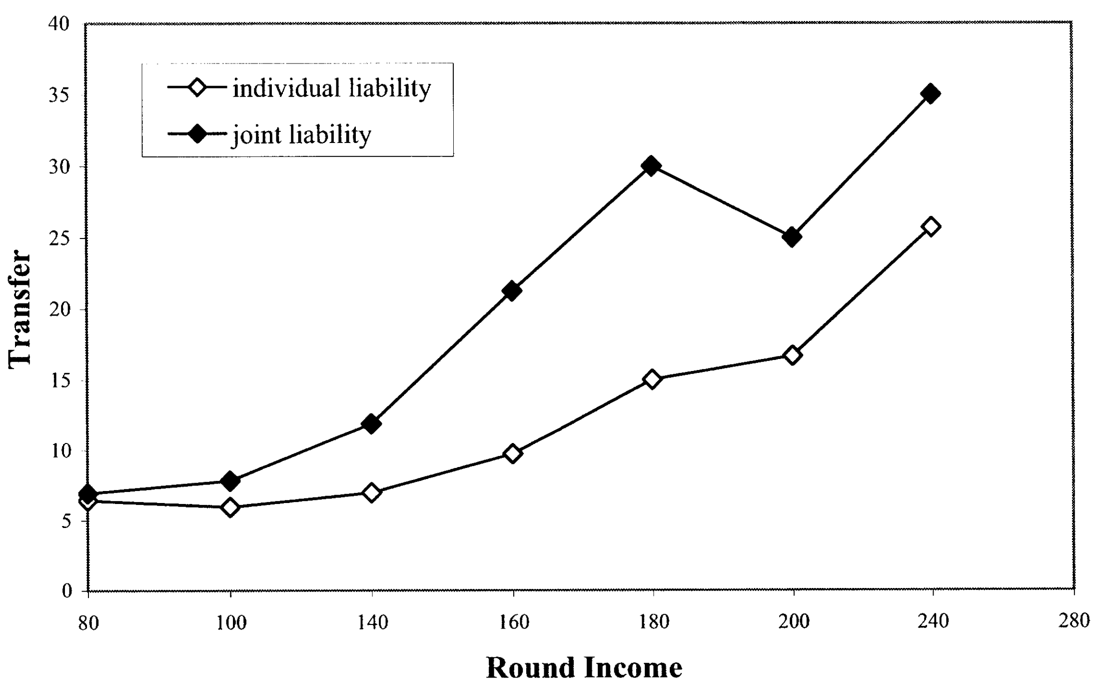


Table 2: Maximium Sustainable Transfers
Transfer when outcome is {h,l}

A. DYNAMIC INCENTIVES (future borrowing conditional on current repayment)

Choice Pair	Full Insurance	CRRA risk aversion index (ρ) 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

B. NO DYNAMIC INCENTIVES (borrowing available every period)

Choice Pair	Full Insurance	CRRA risk aversion index (ρ) 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	0	0	28	65	75	75	75	75
{F,F}	90	0	0	0	64	90	90	90	90
{G,G}	115	0	0	0	67	115	115	115	115
{H,H}	140	0	0	0	0	140	140	140	140

Table 3: Average Per Period Utility

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.

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
1	4/09/2007	5	24
2	4/10/2007	9	23
3	4/11/2007	12	16
4	4/13/2007	7	20
5	4/18/2007	6	14
6	4/23/2007	11	8
7	4/24/2007	9	22
8	4/25/2007	12	10
9	4/26/2007	7	21
10	4/27/2007	9	21
11	4/30/2007	7	20
12	5/01/2007	10	18
13	5/03/2007	12	15
14	5/04/2007	11	20
15	5/07/2007	10	20
16	5/08/2007	15	20
17	5/09/2007	11	17
18	5/10/2007	14	17
19	5/14/2007	11	23
20	5/15/2007	10	24
21	5/16/2007	11	17
22	5/17/2007	9	20
23	5/18/2007	10	20
24	5/21/2007	13	20

B. OBSERVATION COUNTS BY GAME

	Information		
Game	Full	Limited	Total
Benchmarking	--	--	341
Debt in autarky	--	--	768
Individual liability	420	520	940
Joint Liability	352	336	688
Joint liabilty with partner approval	172	110	282
Equity	318	106	424

Table 6: Summary Statistics

	Information(2) Limited	Full	Total
	(1)	(2)	(2)
A. RISK-TAKING (measured by expected profits)			
Autarky			51.64
			(12.42)
			[812]
Individual Liability	50.33	51.46	50.96
	(9.71)	(13.81)	(12.17)
	[396]	[498]	[894]
Joint Liability	52.20	50.03	51.13
	(11.85)	(11.56)	(11.75)
	[338]	[330]	[668]
Joint Liability w/ Partner Approval	47.88	50.14	48.81
	(8.37)	(9.63)	(8.96)
	[156]	[108]	[264]
Equity	52.82	52.45	52.72
	(14.09)	(10.70)	(13.25)
	[284]	[104]	[388]
B. TRANSFERS			
Individual Liability	2.42	5.83	4.32
	(6.24)	(10.94)	(9.31)
	[396]	[498]	[894]
Joint Liability	5.58	7.39	6.47
	(13.41)	(11.27)	(12.42)
	[338]	[330]	[668]
Joint Liability w/ Partner Approval	4.36	8.43	6.02
	(6.81)	(7.93)	(7.55)
	[156]	[108]	[264]
Equity(3)	4.21	4.90	4.43
	(6.77)	(5.95)	(6.52)
	[228]	[104]	[332]

Notes:

(1) Standard deviations in parentheses. Observation counts in brackets.

(2) In full information treatment, all actions and payments are observable. In limited information 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)

	Information(2) Limited (1)	Information(2) Full (2)	Total (2)
C. DEFAULT RATES			
Autarky			4.80%
			(0.21)
			[812]
Individual Liability	2.27%	3.21%	2.80%
	(0.15)	(0.18)	(0.16)
	[396]	[498]	[894]
Joint Liability	1.48%	1.21%	1.35%
	(0.12)	(0.11)	(0.12)
	[337]	[330]	[667]
Joint Liability w/ Partner Approval	1.28%	1.83%	1.51%
	(0.11)	(0.13)	(0.12)
	[156]	[109]	[265]
Equity	0.00%	0.00%	0.00%
	(0.00)	(0.00)	(0.00)
	[284]	[104]	[388]
D. AVERAGE NET INCOME PER ROUND			
Autarky			47.79
			(42.44)
			[869]
Individual Liability	49.74	48.37	48.98
	(37.82)	(37.92)	(37.86)
	[409]	[510]	[919]
Joint Liability	52.39	49.03	50.75
	(41.87)	(32.42)	(37.56)
	[352]	[336]	[688]
Joint Liability w/ Partner Approval(3)	41.10	54.18	46.21
	(27.96)	(38.69)	(33.12)
	[172]	[110]	[282]
Equity(3)	48.77	40.96	46.68
	(31.29)	(29.54)	(30.99)
	[284]	[104]	[388]

Notes:

(1) Standard deviations in parentheses. Observation counts in brackets.

(2) In full information treatment, all actions and payments are observable. In limited information treatment, all partner's

(3) The project success rate for full risk sharing treatment in the full and limited information 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

Net transfers from partner with higher income

	All		Conditional on Any Transfer	
	Information		Information	
	Limited	Full	Limited	Full
	(1)	(2)	(3)	(4)
Individual Liability				
Net Transfers	1.3	3.6	7.0	7.7
Full Risk Sharing Transfer	19.1	20.3	23.5	22.5
Net as % of Full	6.9%	17.5%	29.8%	34.2%
Joint Liability				
Net Transfers	3.2	5.3	11.1	10.3
Full Risk Sharing Transfer	25.4	19.6	32.2	24.2
Net as % of Full	12.5%	27.2%	34.6%	42.7%
Joint Liability with Approval				
Net Transfers	-0.3	1.3	2.2	1.6
Full Risk Sharing Transfer	14.9	19.0	18.1	19.2
Net as % of Full	-1.7%	6.8%	12.1%	8.3%

Notes:

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

(2) Full risk sharing transfer equals (own payoff - partner's payoff)/2

Table 8: Effect of Contract Type & Information on Transfers

OLS Regression of Transfers on Treatment Dummies

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

	Limited Information[2] (1)	Full Information[2] (2)	Difference Lim - Full (3)
A. COEFFICIENT ESTIMATES			
Individual liability	- -[1]	3.41***	-3.41***
		(0.99)	
Joint liability	3.15***	4.97**	-1.82
	(0.88)	(1.95)	(2.08)
Joint liability w/ approval	1.93***	6.00**	-4.07
	(0.46)	(2.60)	(2.58)
Equity[3]	1.40*	2.48***	-1.08
	(0.78)	(0.83)	(0.69)
B. TREATMENT EFFECTS RELATIVE TO JOINT LIABILITY			
Individual	-3.15***	-1.56	
	(0.88)	(1.88)	
Joint liability w/ approval	-1.22	1.03	
	(0.80)	(3.21)	
Equity[3]	-1.76**	-2.49	
	(0.87)	(2.06)	
C. TREATMENT EFFECTS RELATIVE TO JOINT LIABILITY w/ APPROVAL			
Individual	-1.93***	-2.59	
	(0.46)	(2.47)	
Equity[3]	-0.54	-3.52	
	(0.70)	(2.68)	

Notes:

(1) Omitted Category: Individual Liability, Limited Information; Mean transfers: 2.42

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

(3) Excludes mandatory, third-party enforced transfers. Including these, total average transfers for the equity treatment under limted and full information are 13.10 and 14.31.

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

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

Transfers When Project Suceeds, Excluding Debt Repayment Assistance

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

	Limited Information (1)	Full Information (2)	Difference Lim - Full (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.

(2) In full information treatment, all actions and payments are observable. In limited information treatment, all partner's actions are unobservable. Players are informed only if partner earned enough to repay her debt of Rs.

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

(4) * Denotes significance at the 10%-level, ** at the 5%-level, and *** at the 1% level.

Table 10: Determinants of Transfer Behavior

	Individual Liability		Joint Liabilty		Joint Liabilty w/ App.	
	Limited	Full	Limited	Full	Limited	Full
	(1)	(2)	(3)	(4)	(5)	(6)
Transfers						
Own income (β_1)	0.033***	0.059***	0.048***	0.108***	0.040***	0.009
	(0.005)	(0.007)	(0.008)	(0.018)	(0.015)	(0.054)
Partner's income (β_2)	-0.009	-0.006	-0.025***	-0.028***	-0.013*	-0.024
	(0.009)	(0.014)	(0.009)	(0.006)	(0.007)	(0.052)
Cumulative net transfers (δ)	-0.120***	-0.186**	-0.247***	-0.189***	-0.302***	-0.162***
	(0.025)	(0.089)	(0.079)	(0.021)	(0.001)	(0.004)
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.

(2) In full information treatment, all actions and payments are observable. In limited information 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 & Information on Risk Taking

OLS Regression of Expected Profits on Treatment Dummies

Omitted Category: autkary; Mean expected profits: 51.2

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

	Limited Information (1)	Full Information (2)	Difference Lim - Full (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.

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

(3) * Denotes significance at the 10%-level, ** at the 5%-level, and *** at the 1% level.

Table 12: Contract Effect on Risk Taking by Risk Type

Risk Taking measured by expected profits

	Information(3)			
	Limited		Full	
	Risk Type(2)		Risk Type(2)	
	Low	High	Low	High
	(1)	(2)	(3)	(4)
Baseline				
Autarky	50.18	52.69	50.18	52.69
	(0.94)	(1.41)	(0.94)	(1.41)
Contract Effects Relative to Autarky Baseline				
Individual liability	0.07	-1.37	-0.04	0.47
	(0.99)	(1.68)	(1.41)	(2.28)
Joint liability	-0.54	12.10***	-0.81	-2.84*
	(0.91)	(4.07)	(1.09)	(1.60)
Joint liability with partner approval	-2.58**	-2.84*	-0.80	-0.41
	(1.29)	(1.57)	(0.94)	(5.03)
Equity	2.91*	0.15	1.32	4.81***
	(1.64)	(3.37)	(2.26)	(1.56)

Notes:

(1) Standard errors clustered at the session level in parentheses.

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

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

A Sample Instructions

The following instructions are for the joint liability game with limited information. 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 you 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 Experimental Design and Discounting

We are interested in the individual utility maximization of the form

$$\max_{c_t^i} \mathbb{E} \sum_{t=0}^{\infty} \beta^t u(c_t^i),$$

where $c_t^i = y_t^i - (\tau_t^i - \tau_t^{-i}) - P_t^i$ as described in Section 3. Because utility is additively separable and there is no scope for savings, this is solved by maximizing the expected utility in each round. As described in Charness and Genicot (2007), if every round counted towards an individual's payoff, she would seek to maximize the utility of the *sum* of income across *all* rounds,

$$\max_{c_t^i} \mathbb{E}u(\sum_{t=0}^{\infty} u(c_t^i)),$$

and could thereby partially self-insure income risk across rounds. When paid for only one round selected at random, an individual's expected utility is

$$\mathbb{E}u(c_{t*}^i),$$

where t^* is the round selected for payment. Thus, optimizing individuals seek to maximize expected utility in *each* round, as desired.

B.2 Autarkic Investment Choice

In autarky, an individual's single-period investment choice problem solves

$$\max_{\alpha} U(\alpha, D) = \pi u[y_h(\alpha, D) - D] + (1-\pi)u[\max\{y_l(\alpha) - D, 0\}]. \tag{1.4}$$

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

$$\alpha_{INT}^* = \frac{(z-1)[S(1+D) - D]}{[(z-1)S + R](1+D)}, \tag{1.5}$$

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

$$\alpha^* = \begin{cases} \alpha_{INT}^*, \text{ if } EU(\alpha_{INT}^*) > EU(1) \\ 1, \text{otherwise} \end{cases}.$$ [22]

In the dynamic problem, individuals solve

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

which is equivalent to the solution of

$$\max_{\alpha} \frac{U(a, D_t)}{1 - \beta \Pr[Default|\, \alpha]}.$$

B.3 Informal Insurance and Allocation to the Risky Asset

Definition 1 (relative marginal utility) *For any state of nature $\theta \in \Theta = \{hh, hl, lh, ll\}$ and transfer arrangement $T = \{\tau_\theta\}_S$, let $\lambda_\theta = u^{'}(y_\theta^A - \tau_\theta)/u^{'}(y_\theta^B + \tau_\theta)$. Further, define the autarkic ratio of utilities, $\lambda_\theta^0 = u^{'}(y_\theta^A)/u^{'}(y_\theta^B)$.*

Note that the first-best insurance arrangement involves full income pooling, $\lambda_\theta = \lambda^0\ \forall\theta$, and for individuals with identical utility, $\lambda^0 = 1$. Under autarky ($T = 0$), the first-order conditions for optimal investment allocation require $\pi(R - S)u'(y_h^i) = (1 - \pi)Su'(y_l^i)$, which implies that $\lambda_{hh}^0 = \lambda_{ll}^0 \equiv \lambda^0$.

Lemma 1 (properties of λ) *For any constrained Pareto optimal transfer arrangement, $T = (\tau_{hh}, \tau_{hl}, \tau_{lh}, \tau_{ll})$:*

1. *$\lambda_{hl} \leq \lambda_{lh}$;*

2. *If $\lambda_{hl} = \lambda^0$, then $\lambda_{hh} = \lambda^0$. Similarly, if $\lambda_{lh} = \lambda^0$, then $\lambda_{ll} = \lambda^0$;*

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

Note that this implies that an individual is relatively 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 $\lambda_{hl} > \lambda_{lh}$. This implies that $\frac{u'(y_{hl}^A - \tau_{hl})}{u'(y_{hl}^B + \tau_{hl})} > \frac{u'(y_{lh}^A - \tau_{lh})}{u'(y_{lh}^B + \tau_{lh})}$. But since $y_{hl}^i > y_{lh}^i$, 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 $\frac{u'(y_{hl}^A - \hat{\tau})}{u'(y_{hl}^B + \hat{\tau})} = \frac{u'(y_{lh}^A + \hat{\tau})}{u'(y_{lh}^B - \hat{\tau})}$.

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

This transfer arrangement increases expected utility for both agents, a violation of Pareto optimality. For the second part, suppose $\lambda_{hl} = 1 > \lambda_{hh}$. 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 $\lambda_{hl} > \lambda_{hh}$ implies that $V^A(T'') > V^A(T)$, a violation of Pareto optimality. A similar argument shows that $\lambda_{lh} = \lambda^0$ implies $\lambda_{ll} = \lambda^0$. The third part of the lemma follows immediately. ■

Lemma 2 (symmetric optimal investment) *For any constrained Pareto optimal transfer arrangement with equal Pareto weights, $\alpha^{A*} = \alpha^{B*}$, i.e., both individuals allocate the same share of their assets to the risky investment.*

Proof. By contradiction, without loss of generality, assume that $\alpha^A > \alpha^B$. 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, $\bar{\alpha} = \alpha^A + \alpha^B$, we can solve for the individual allocation that maximizes total utility. The first order condition for this problem requires

$$u'\left(\frac{\alpha^A}{2}R + \left(1 - \frac{\bar{\alpha}}{2}\right)S\right) = u'\left(\frac{\alpha^B}{2}R + \left(1 - \frac{\bar{\alpha}}{2}\right)S\right),$$

which is satisfied at $\alpha^A = \alpha^B$.

If full insurance is not implementable, there must exist two states of the world, θ and θ', such that $\lambda_\theta > \lambda_{\theta'}$. From Lemma 1, $\lambda_{hl} < \lambda_{lh}$. If A's allocation, α^A, satisfies the first order conditions for optimality under the transfer arrangement T, then $\lambda_{hl} < \lambda_{lh}$ implies $\partial V^B/\partial\alpha^B > 0$, contradicting optimality. Similarly, if B's allocation, α^B, satisfies the first order conditions for optimality under the transfer arrangement T, then $\lambda_{hl} < \lambda_{lh}$ implies $\partial V^A/\partial\alpha^A < 0$. Thus, individual maximization requires $\alpha^{*A} = \alpha^{*B}$. ■

Proof of Proposition 1 (informal insurance increases risk taking). As shown above, in a symmetric transfer arrangement, both individuals allocate the same share of their assets to the risky investment, $\alpha^A = \alpha^B$, which implies that the constrained optimal transfer arrangement takes the form $T^* = (0, \tau, -\tau, 0)$. Note that for any transfer arrangement, T, the optimal investment allocation, α^*_T requires $\pi^2(R-S)u'(\alpha^*_T(R-S) + S - \tau_{hh}) + \pi(1-\pi)\{(R-S)u'(\alpha^*(R-S) + S - \tau_{hl}) - Su'((1-\alpha^*)S - \tau_{lh})\} - Su'((1-\alpha^*)S - \tau_{ll}) = 0$. Thus $\alpha^*_{T=T^*} > \alpha^*_{T=0}$. ■

Proof of Proposition 2 (risk taking encourages insurance). Consider a transfer arrangement T that does not achieve full insurance. Thus there exists a state θ where one of the agent's incentive compatibility constraints binds. Without loss of generality, assume that agent A's incentive compatibility constraint binds. From Lemma 1, we know that her incentive compatibility constraint must bind in state hl, therefore

$$u(y^A_{hl} - \tau_{hl}) - u(y^A_{hl}) + \frac{V^A(T) - \bar{V}^H}{r} = 0.$$

An increase in α relaxes this constraint. Therefore, using Lemma 1 and similar to the arguments made above, when α^A increases it must be possible for A to increase her transfer to B in state hl in exchange for an increased transfer from B in state lh that maintains B's expected utility while increasing A's. ■

B.4 Mandatory Insurance and Informal Transfers

To generalize the effect of joint liability or mandatory default insurance on informal risk sharing, I consider a slightly modified economic environment. Assume discrete-time, infinite-horizon economy with two agents indexed by $i \in \{A, B\}$ and preferences

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t^i)$$

at time $t = 0$, where $\mathbb{E}_0$ is the expectation at time $t = 0$, $\beta \in (0, 1)$ is the discount factor, $c_t^i \geq 0$ denotes the consumption of agent i at time t, and u is a common von Neumann-Morgenstern utility function, which is assumed to be nicely behaved: $u'(c) > 0, u''(c) < 0 \quad \forall c > 0$ and $\lim_{c \to 0} u'(c) = \infty$.

In every period, each individual receives income y^i drawn from the set $\{y_1, ..., y_n\}$ ranked in ascending order $y_1 < ... < y_n$. Let $\pi_{jk} = \Pr\{(y^A, y^B) = (y_j, y_k)\}$ and confine our attention to the set of symmetric distributions such that $\pi_{jk} = \pi_{kj}$ for all j and k. Denote by T a set of transfer rules $\{\tau_{jk}\}$ where the choice variable τ_{jk} is the net transfer from A to B when $(y^A, y^B) = (y_j, y_k)$. I depart from the standard framework by assuming the presence of a mandatory transfer arrangement $\underline{T} = \{\underline{\tau}_{jk}\}$ that defines a minimum transfer in each state. For any realization of income (y_j, y_k) where $y_j > y_k$, $\tau_{jk} \in [\underline{\tau}_{jk}, y_j]$.

Let $\bar{v}(\underline{T})$ denote each individual's per period expected utility in the absence of informal insurance. Thus

$$\bar{v}(\underline{T}) = \sum_{j=1}^{n} \sum_{k=1}^{n} \pi_{jk} u(y_j - \underline{\tau}_{jk}) = \sum_{j=1}^{n} \sum_{k=1}^{n} \pi_{jk} u(y_k + \underline{\tau}_{jk}).$$

Under a set of transfer rules T, A's per period expected utility will be

$$v^A(T) = \sum_{j=1}^{n} \sum_{k=1}^{n} \pi_{jk} u(y_j - \tau_{jk}).$$

B's utility is defined symmetrically. For a transfer arrangement to be implementable it must be incentive compatible in all states of the world. Thus

$$u(y_j - \tau_{jk}) + \frac{v^A(T)}{r} \geq u(y_j - \underline{\tau}_{jk}) + \frac{\bar{v}(\underline{T})}{r} \quad \forall j, k. \tag{1.6}$$

Rearranging this equation yields the familiar and intuitive result

$$u(y_j - \underline{\tau}_{jk}) - u(y_j - \tau_{jk}) \leq \frac{v^A(T) - \bar{v}(\underline{T})}{r}:$$

the current period gain from defection must be less than the discounted loss from terminating the informal sharing arrangement.

Let $T^* = \{\tau^*_{jk}\}$ represent the set of symmetric, constrained-Pareto-optimal transfer rules and consider those states of nature where the implementability constraint (1.6) is binding. I now consider the effect on T^* of changes to the mandatory transfer rules, i.e., what is $\partial\tau^*_{jk}/\partial\underline{\tau}_{lm}$. Define

$$\phi = u(y_j - \tau^*_{jk}) - u(y_j - \underline{\tau}_{jk}) + \frac{v^A(T^*)}{r} - \frac{\bar{v}(\underline{T})}{r} = 0. \tag{1.7}$$

By the implicit function theorem

$$\frac{\partial\tau^*_{jk}}{\partial\underline{\tau}_{lm}} = \frac{-\partial\phi/\partial\underline{\tau}_{lm}}{\partial\phi/\partial\tau^*_{jk}}.$$

First, note that

$$\frac{\partial\phi}{\partial\tau^*_{jk}} = -u'(y_j - \tau^*_{jk}) - \frac{\pi_{jk}u'(y_j - \tau^*_{jk})}{r} < 0.$$

Therefore $sign(\partial\tau^*_{jk}/\partial\underline{\tau}_{lm}) = sign(\partial\phi/\partial\underline{\tau}_{lm})$. Without loss of generality, consider states where $j > k$ and $l > m$. For $j \neq l \cup l \neq m$

$$\frac{\partial\phi}{\partial\underline{\tau}_{lm}} = [\pi_{lm}u'(y_l - \underline{\tau}_{lm}) - \pi_{lm}u'(y_m + \underline{\tau}_{lm})]/r.$$

Since $\pi_{lm} = \pi_{ml}$ this derivative is negative for all mandatory sharing rules up to full insurance. Mandatory coinsurance in one state of nature *reduces* informal insurance in other states. Intuitively, mandatory insurance reduces the cost of reversion to autarky and thus makes it harder to sustain cooperation.

When mandatory insurance is applicable for the state realized (i.e., $j = l \cap k = m$) this discouragement effect is offset by the fact that mandatory insurance reduces the current period gain for deviation from the informal sharing arrangement. The defecting agent cannot escape the mandatory insurance requirement, which serves to relax the implementability constraint (1.6). Evaluating the net effect by differentiating ϕ in (1.7) with respect to $\underline{\tau}_{jk}$ yields

$$\frac{\partial\phi}{\partial\underline{\tau}_{jk}} = u'(y_j - \underline{\tau}_{jk}) + [\pi_{jk}u'(y_j - \underline{\tau}_{jk}) - \pi_{kj}u'(y_k + \underline{\tau}_{jk})]/r,$$

which is positive if and only if

$$\frac{u'(y_k + \underline{\tau}_{jk})}{u'(y_j - \underline{\tau}_{jk})} < \frac{r + \pi_{jk}}{\pi_{jk}}.$$

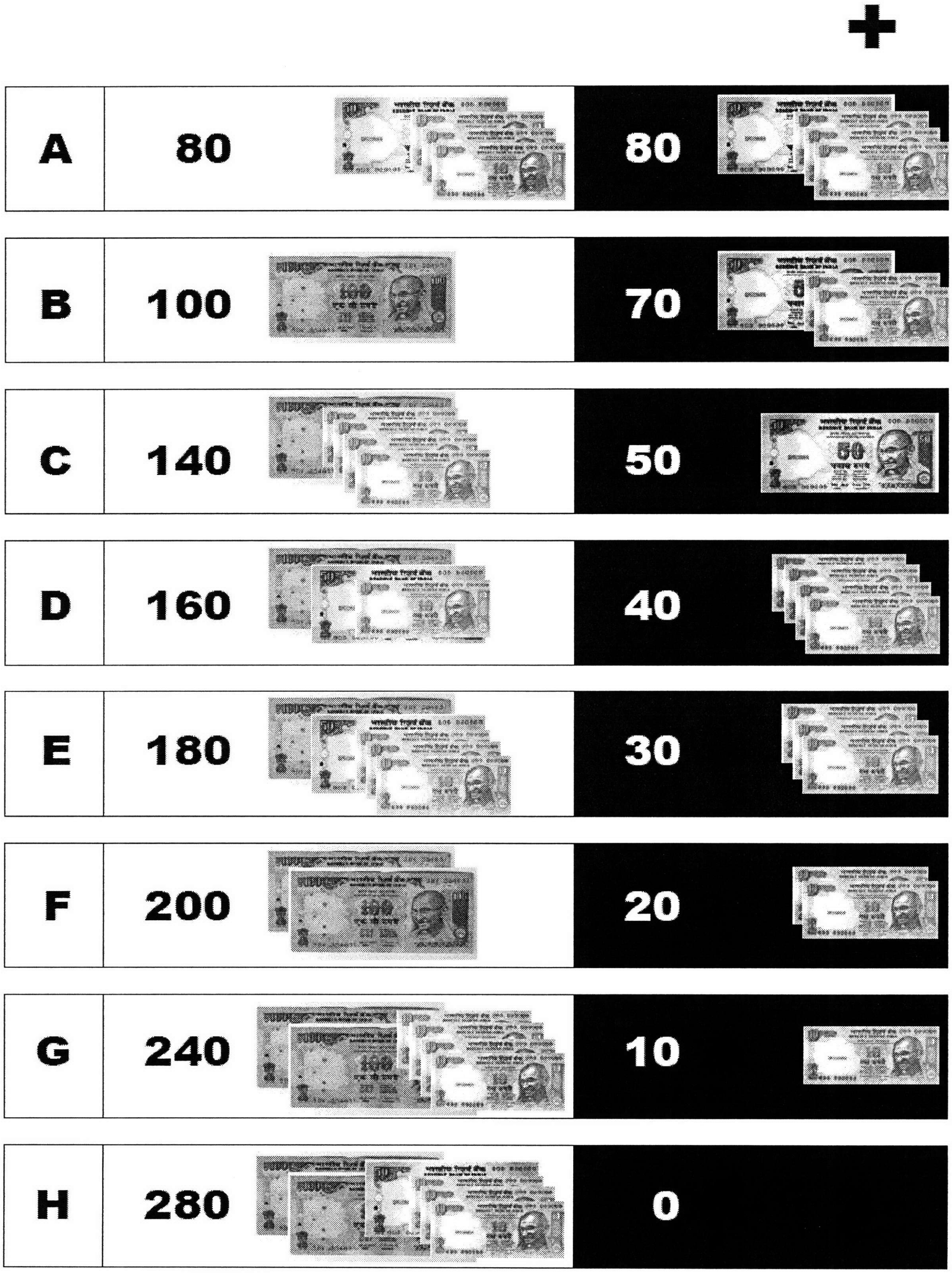
For CRRA utility, this implies that mandatory transfers will increase informal insurance if and only if

$$\frac{y_j - \underline{\tau}_{jk}}{y_k + \underline{\tau}_{jk}} < \left(\frac{r + \pi_{jk}}{\pi_{jk}}\right)^{\frac{1}{\rho}}. \tag{1.8}$$

When the ratio of the higher income to the lower income is relatively small or when individuals are relatively risk tolerant, mandatory transfers increase informal insurance.

Appendix

Figure A1: Presentation of Core Game Lotteries



Chapter 2

Investment Choice and Inflation Uncertainty

2.1 Introduction

This paper investigates the relationship between inflation uncertainty and the investment decisions of small, microfinance-funded firms in the Dominican Republic. The relationship between inflation and real economic activity has long been of interest to economists. Attention receded somewhat during the period of generally low and stable inflation in the 1990s and early 2000s, but with inflation resurging throughout the world, particularly in less developed countries, this question is returning to the fore.

A large and varied theoretical literature considers numerous channels through which inflation uncertainty could generate real economic effects. However, this literature has not produced unambiguous predictions about the sign of this relationship. Friedman (1977) argues that inflation volatility and uncertainty may "render market prices a less-efficient system for coordinating economic activity," thereby reducing allocative efficiency. When nominal rigidities are present, inflation uncertainty will generate uncertainty about the relative price of final goods and input costs. Even without nominal rigidities, Lucas (1973) argues, increased inflation uncertainty accentuates firms' real responses to observed price variation and worsens the tradeoff between output and inflation. Fischer and Modigliani (1978) systematically catalog a range of channels through which inflation can affect real outcomes, including what they consider to be the focus of "practical men": inflation makes it difficult to plan in the absence of knowledge about future prices. Drawing on option pricing theory, Pindyck (1988, 1991) generalizes this observation to show that uncertainty increases the option value of delaying irreversible investment. Huizinga (1993) draws on this result to build a theoretical link between inflation uncertainty and reduced investment.

However, the theoretical literature is far from settled. Hartman (1972) and Abel (1983) demonstrate that uncertainty increases investment when adjustment costs are convex and the profit function is convex in prices. Dotsey and Sarte (2000) show that precautionary savings can produce a positive correlation between inflation variability and investment, while Caballero (1991) shows the relationship between uncertainty and investment can depend on industry structure. Taken as a whole, the theory seems unlikely to produce convincingly unambiguous results.

In light of these ambiguities, the relationship between inflation uncertainty and investment is a fundamentally empirical question. The preponderance of empirical evidence points towards a negative relationship between inflation uncertainty and economic activity. Holland (1993) summarizes 18 studies of the empirical link between inflation uncertainty and real activity in the United States; 14 find a negative relationship, three are insignificant, and only one (Coulson and Robins 1985) finds a positive relationship. Pindyck and Solimano (1993) find that inflation uncertainty is closely correlated with volatility in the marginal product of capital—a direct input in firms' investment decisions—and with annual investment in a cross-country panel. They note that the negative relationship is particularly strong in less developed countries.

Yet despite this fact and perhaps owing to data limitations, nearly all of the empirical work on the link between inflation uncertainty and investment has focused on OECD countries. Moreover, these studies tend to focus on country or industry investment aggregates.[1]

[1] Bloom, Bond, and van Reenen (2007) is a notable exception. They numerically solve a model of partially irreversible investment for the effects of uncertainty on short-run investment dynamics and test this model on a simulated panel of firm-level data. They then apply the same approach to study the investment behavior

This paper looks beneath the aggregates at one particular channel through which inflation uncertainty may affect real economic activity: the investment decisions of individual firms. Using a panel of administrative loan data from a large Dominican microfinance institution, I find that periods of high inflation volatility are associated with reduced fixed asset investment and firms investing a larger share of loan proceeds in working capital. A one percentage point increase in inflation uncertainty, approximately 1.15 standard deviations, is associated with a reduction in intended fixed asset investment of between 15% and 37% relative to the mean. While inflation uncertainty may serve as a proxy for other forms of systemic risk or macroeconomic factors, the negative relationship between uncertainty and firm-level investment is robust to controlling for inflation levels, exchange rates, and aggregate economic activity. These results support the view that controlling inflation remains an important objective of economic policy and highlight the importance of uncertainty in the investment decisions of poor entrepreneurs.

For intuition behind this result, consider the following example. A Dominican microfinance client runs a *colmado* (a small corner store) from which she sells retail goods at a fixed markup over cost. With the proceeds from her loan, she considers two investment opportunities: buying more inventory for her store (working capital) or purchasing a refrigerator that will last many years and allow her to expand her product offerings (fixed asset investment). The resale value of the refrigerator is substantially below her cost, i.e., the investment is partially irreversible. When all prices are certain, her optimal choice is clear: make whichever investment generates the highest expected return. But the introduction of uncertainty distorts her choice. With a fixed markup, price volatility in the inventory she purchases is naturally hedged by corresponding changes in the price for which she sells it. In contrast, after paying a fixed price for the refrigerator, the returns to this investment are

of 672 publically traded U.K. manufacturing companies over the period 1972-1991, finding evidence of more cautious investment behavior for firms subject to greater uncertainty, as measured by the volatility of the firms' equity returns.

more sensitive to price volatility. As a consequence, she will demand a higher expected return from the fixed asset investment when prices are uncertain. As shown below, even when uncertainty does not affect the expected returns to different investment opportunities and even when borrowers are risk neutral, uncertainty can distort choices towards more flexible factors of production.

Section 2.2 discusses the theory of inflation uncertainty and investment behavior, extends this example of a borrower's investment choice under uncertainty, and presents a simple two-factor model of investment behavior. The rest of the paper is organized as follows. Section 2.3 examines the behavior of inflation uncertainty in the Dominican Republic using monthly price data. Using an GARCH model, I calculate the conditional variance of inflation, which will serve as the key measure of inflation uncertainty in the analysis of microfinance borrowers' investment decisions. Section 2.4 summarizes the source of borrower data, and section 2.5 describes the empirical strategy for estimating the effect of inflation uncertainty on investment choices and firm growth. Section 2.6 reports the results of this estimation, and the final section concludes.

2.2 A Model of Uncertainty and Investment Choice

This section summarizes some of the existing theory of uncertainty and investment, describes an example of a borrower's investment choice under uncertainty, and presents a simple two-factor model of investment behavior. As stated above, theory offers a number of competing perspectives on the issue. We will not resolve them here. Instead, the aim is to frame what is inherently an empirical question and provide a concrete, if stylized, example of how uncertainty can affect a firm's investment decisions.

One strand of the theoretical literature has pointed towards a positive relationship between uncertainty and investment (Abel 1983, Hartman 1972). In both cases, the result proceeds from the realization that if the firm's profit function is convex in prices and capital adjustment costs are convex, a mean-preserving spread of prices increases the optimal level of investment. Caballero (1991) shows how this relationship depends on market structures. When markets are competitive, he shows that investment decisions depend almost entirely on the price of capital and its expected marginal profitability, which, as in Abel and Hartman, is convex with respect to prices. A Jensen's inequality argument shows that the optimal response to uncertainty is to increase investment. In contrast, when competition is imperfect, an increase in investment today makes it more likely that a firm will tomorrow have too much capital relative to its desired level. When adjustment costs are asymmetric (i.e., net of direct costs, it is more costly to reduce capital than to increase it) having too much capital is worse than having too little. Here, the uncertainty-investment relationship can turn negative.

Zeira (1990) notes that the fixed discount rate assumption of other studies is tantamount to risk-neutrality. He builds a model of investment that incorporates shareholder risk aversion and demonstrates that the uncertainty-investment relationship becomes indeterminate in this framework.

Pindyck (1991) looks at the case of irreversible investments (i.e., largely sunk costs that cannot be recovered), focusing on those for which delay is possible and allows the firm to gather new information about prices and other market conditions before making the investment. While firms do not always have the opportunity to delay investments—they may, for example, be subject to a short-lived strategic window—he argues that in most cases delay is feasible. In such case, the standard rule of investment decisions, which says that a firm should invest in a project when the present value of its expected net cash flows exceeds its cost, is no longer optimal. When investments are irreversible and decisions to invest can be postponed, increased uncertainty makes firms more reluctant to invest.

The reasoning behind this argument is instructive and builds on an analogy between real and financial investment decisions. The opportunity to make a real investment is like a call option on the underlying capital. Making the investment is like exercising the option with the cost of the investment the strike price of the option. Standard techniques of financial asset valuation tell us how to price the option and when to exercise it optimally.

2.2.1 A Stylized Example of an Investment Decision

Consider the following example, similar to ones used in Pindyck (1991) and Huizinga (1993). Suppose a small, credit-constrained business with a discount rate of 2% per month has access to an 8,000 peso loan. It can allocate the proceeds from this loan either to working capital (short-term assets such as inventory for a store) or to a long-term asset (e.g., a refrigerator that would allow the store to expand its product offerings). Assume short-term assets just break even, returning 2% (plus the entire original investment) after one month, and this amount can be reinvested in either asset each month.

First, consider a certain environment where the incremental profits from the long-term asset are 200 pesos per month in perpetuity. With certain investment returns, the firm's investment decision is straightforward and can be derived from the standard net present value calculation. The NPV of the long-term investment is 2,000 pesos, while the NPV of the short-term investment (assuming the firm reinvests in short-term assets every month) is 0.

Now consider the case of uncertainty of a very simple form: after one month, the firm will discover whether the monthly incremental profits from the long-term investment are 300 or 100. Each state occurs with equal probability, so that the expected profits remain the same as in the certain case, 200 pesos per month. For simplicity, assume that regardless of whether or not the business makes the investment, this uncertainty is resolved after one month and that once realized, profits will remain at this level forever.[2] If the firm is risk neutral,

[2]Dixit (1989) extends the analysis to cases where uncertainty is resolved over time. For our purposes,

the net present value calculations are the same: 2,000 pesos for the long-term investment and 0 for the short-term investment. However, the borrower should not make the long-term investment now.

In the state of the world when profits are low, the business would have preferred not to make the long-term investment. The standard net present value calculations do not incorporate the possibility of waiting and preserving the option not to invest should profits obtain the lower value. Instead of investing today, the entrepreneur should wait one month until the uncertainty is resolved and invest only if profits attain the higher level. Table 1 presents these calculations.

The key insight here is that even for risk neutral businesses and positive NPV projects, firms should only invest today if the cost of delay exceeds the option value of waiting until uncertainty is resolved. Analogous to financial option theory, greater uncertainty increases the value of waiting, thus requiring a higher incremental profit for the firm to optimally invest today.

This effect is potentially quite economically significant. Continuing with the stylized example from above, in the absence of uncertainty, the long-term asset need only match the return of the short-term asset (26.8% per year or 160 pesos per month) in order for the firm to invest today. In contrast, suppose revenues are uncertain such that prices either rise or fall by 1%—roughly the median monthly standard deviation of inflation in the Dominican Republic as described in section 2.3—with equal probability. Assuming a 10% profit margin and fixed costs, this small variation in prices generates 10% variation in profits, and the expected incremental income of the long-term asset would have to be 177 pesos per month (11% higher) in order for the firm to invest today. At 20% profit variability, the threshold level of expected monthly profits rises to 198 pesos, 24% higher than in the absence of uncertainty.

there is no substantive difference.

This example is perhaps overly stylized. Nevertheless, it draws in stark relief the potential magnitude of the uncertainty effect on investment decisions. Moreover, this effect results entirely from the option value of delaying uncertain, irreversible investments. It assumes risk neutrality or complete markets such that the firm can completely diversify away all income risk, i.e., the firm maximizes net present value but with the added possibility of delay. Neither of these assumptions are likely to hold among small businesses in less developed countries, for whom risk markets are incomplete and risk aversion is important. Together, these factors accentuate the distortion of price uncertainty on investment decisions.

It is worth noting that these distortions do not necessarily imply a reduction in long-term capital stock. Bloom (2000) shows that while the real option effect of uncertainty can explain large elasticities of short-run investment, it does not affect long-term investment. He points out that while real option motives increase the investment threshold, reducing investment in times of strong demand, they also lower the disinvestment threshold, reducing the rate of disinvestment when demand is weak. In both cases, uncertainty has a cost—it pushes firms from their instantaneously optimal level of capital—but it does not reduce long-term investment through the real option effect. In the case of microenterprises, for which low levels of initial fixed assets limit the scope for downward adjustment, this reduced threshold for disinvestment may be less of a factor. As shown by a number of authors (e.g., Caballero 1991, Lee and Shin 2000, Pindyck 1993, Sakellaris 1994) when starting from a base of zero initial capital stock, the real option effect of uncertainty unambiguously reduces investment.

2.2.2 A Two-Factor Model of Investment Behavior

We conclude this section by examining an investment model with two lines of capital: long-term assets, which are partially irreversible; and working capital, which is freely adjustable.

This model is common through the irreversible investment literature and represents a special case of those presented by Abel and Eberly (1996), Eberly and Van Mieghem (1997) and Dixit (1997), among others. The firm's revenue function takes the form

$$R(X, K, S) = X^{\gamma} K^{\alpha} S^{\beta}, \tag{2.1}$$

where K represents long-term capital and S represents short-term or working capital, and X represents an index of demand and productivity conditions. Assume labor is fixed and normalized to one. This revenue function can be derived from an underlying Cobb-Douglas production function and a constant elasticity demand function.[3] We assume, as is standard, that the productivity index evolves according to a geometric Brownian motion with positive drift μ and variance σ^2. We assume that the cost of each type of capital is r. However, long-term capital is costly to reverse, such that the proceeds from selling a unit of K are $r(1-\theta)$, where $\theta \in [0, 1]$ represents adjustment frictions.[4]

We state the firm's optimization problem as

$$\begin{aligned} V(X_t, K_t, S_t) &= \max_{I_{Kt}, I_{St}} R(X_t, K_t, S_t) - C(I_{Kt}, I_{St}) \\ &\quad + \frac{1}{1+\rho} E_t \left[V(X_{t+1}, (K_t + I_{Kt})(1-\delta), (S_t + I_{St})(1-\delta) \right], \end{aligned}$$

where ρ is the discount rate, δ is the depreciation rate, I_{jt} is the investment in capital of type $j \in \{K, S\}$ at time t, and $C(I_K, I_S) = r\{I_S + I_K(1 - \theta\ \mathbf{1}(I_K < 0)\}$ is the investment cost function, where $I_K < 0$ implies disinvestment in the long-term asset. Both forms of capital evolve according to $I_{j,t+1} = (j_t + I_{jt})(1-\delta)$.

[3] Following Eberly and Van Mieghem (1997), this is the same function used by Bertola (1987) and Dixit (1989).

[4] Note that the cases $\theta = 0$ and $\theta = 1$ represent full flexibility and complete irreversibility, respectively.

In continuous time, the Bellman equation associated with this optimization problem is

$$\rho V(X,K,S) = X^{\gamma}K^{\alpha}S^{\beta} - \delta(V_K K + V_S S) + \mu X V_X + \frac{1}{2}\sigma^2 X^2 V_{XX},$$

where V_j represents the partial derivative of V with respect to j.

As is well known, the general solution to this problem is characterized by a regions of inaction over which K does not change. Figure 1 shows the optimal policy in the space of two variables, (k, s), defined as

$$k = \log(K/X), \quad s = \log(S/X).$$

In the region of inaction, marked by the bold segment in figure 1, the marginal gain to increasing K, $\partial V/\partial K$, is less than r, the unit cost of increasing K. Similarly, the marginal gain to decreasing K, $-\partial V/\partial K$, is less than $r(1-\theta)$. In this simple, two-factor model where only one of the capital inputs is subject to asymmetric adjustment costs, the optimal mix of capital will always reside along this bold segment. Abel and Eberly (1996) show that uncertainty increases the separation between the marginal product of capital that justifies investment and the marginal product of capital that justifies disinvestment. Graphically, this lengthens the region of inaction. In practice, increased uncertainty makes investment behavior in long-term assets more cautious. This implies that in periods of high uncertainty, we are likely to see fewer borrowers making *any* fixed asset investments.

As noted by Nilsen and Schiantarelli (2003) and Doms and Dunne (1998), empirical investigation of firm-level investment models under uncertainty are complicated by the rarity of observations with zero investment in any period. That is not the case for our data, where only approximately 5% of borrowers report intending to make a fixed asset investment during any loan cycle. While this allows us to directly test the prediction that fewer firms will make any fixed asset investments in periods of heightened uncertainty, limitations on our measurement of sales data and firm-level demand shocks prevent us from testing directly other predictions of this model, including convexity in response of investment to demand shocks.

In a more general setting, Eberly and Van Mieghem (1997) demonstrate that in the presence of uncertainty, $S/(K+S)$, the share of total assets in working capital, will be bounded above by its optimal level in the absence of uncertainty. This is because the firm prefers to use working capital, the flexible factor, when long-term assets are subject to asymmetric adjustment cost. This distorts investment away from its optimal composition in the absence of uncertainty.

2.3 Dominican Inflation Data

This section presents estimates of inflation uncertainty in the Dominican Republic. Inflation uncertainty is measured by the conditional variance of inflation, where inflation is modeled as an autoregressive conditional heteroskedastic (ARCH) process (Engle 1982). The ARCH family of models have a number of virtues for estimating time-series models, but for our purposes their most important feature is that they provide estimates of the conditional variance of disturbances in each period, $\widehat{u_t^2}$. It is these predicted values that will serve as our estimates of inflation uncertainty. This analysis follows closely a long line of similar work in the United States (Engle 1983, Cosimano and Jansen 1988, Huizinga 1993, Jansen 1989).

The basic structure of the univariate ARCH can be written as

$$\pi_t = \beta' \mathbf{x}_t + u_t, \tag{2.2}$$

with π_t as the dependent variable and $\mathbf{x}_t$ the vector of explanatory variables, which can include lagged values of π, and u_t, the stochastic disturbance term. Conditional on the information set, Ψ_{t-1}, this disturbance is distributed

$$u_t | \Psi_{t-1} \sim N(0, h_t). \tag{2.3}$$

Unlike standard models, the variance of the disturbance is allowed to evolve over time as a function of past realizations of variables, including disturbances. In the standard ARCH model introduced by Engle (1982), the conditional variance of the disturbance term follows an AR process such that

$$E(u_t^2 | \Psi_{t-1}) = h_t = \eta_0 + \eta_1 u_{t-1}^2 + \eta_2 u_{t-2}^2 + \cdots + \eta_p u_{t-p}^2, \tag{2.4}$$

where the lag length, p, defines the order of the ARCH process. By allowing h_t, the variance of the disturbance in period t, to be a function of past realizations of the disturbance itself, this formulation can capture explicitly the observed phenomenon that large and small forecast errors tend to cluster together in the inflation time series. Once we have specified equations (2.2) and (2.4), the model is easily estimated via maximum likelihood.

The generalized autoregressive conditional heteroskedastic (GARCH) model proposed by Bollerslev (2001) lets the conditional variance depend on an infinite number of lags of u_t^2 by amending equation (2.4) to include lags of the expected variance term itself,

$$h_t = \eta_0 + \eta_1 u_{t-1}^2 + \eta_2 u_{t-2}^2 + \cdots + \eta_p u_{t-p}^2 + \xi_1 h_{t-1} + \xi_2 h_{t-2} + \cdots + \xi_q h_{t-q}. \tag{2.5}$$

Disturbance terms of this form are said to follow a GARCH(q, p) process. Bollerslev demonstrates that a GARCH model with a small number of terms performs as well or better than an ARCH model with many. As shown below, that is also the case for this analysis of Dominican inflation data.

To calculate the measure of monthly inflation uncertainty that will serve as the key explanatory variable in the analysis to follow, I estimate univariate ARCH and GARCH models of the form described in equation (2.2) where π_t is the monthly percentage change in the consumer price index for the Dominican Republic as reported by the Central Bank of the Dominican Republic,[5] and $\mathbf{x}_t$ includes only lagged values of π_t. Figure 1 shows monthly and annual inflation levels over the period from January 1982 to February 2008.

I estimate both models with lag lengths of 1, 3, and 6 for the autoregressive terms of π in the main estimating equation. I consider ARCH processes (equation 2.4) of the same lag lengths as well as GARCH(1,1) and GARCH(1,3) processes (equation 2.5).

Table 2 presents summary statistics evaluating the fit—the log likelihood along with the Akaike and Bayesian information criteria—for selected models. Results are not sensitive to the model specification and so the remainder of the analysis will use the first-order GARCH model, which is preferred by both information criteria. The first-order GARCH model also achieves the best information criteria when the inflation process is estimated over the shorter period from January 1998 to February 2008, which overlaps with the period for which we have detailed loan data for Dominican microenterprises. Lagrange multiplier and l tests (Cumby and Huizinga 1992) cannot reject the hypotheses that the remaining residuals in this specification are homoskedastic.

Figure 2 plots the estimated inflation uncertainty, i.e., $\hat{u}_t$, from January 1983 through February 2008.[6] There is substantial variation in inflation uncertainty over the period, ranging from a low of 0.73 percent in August 1998 to a high of 4.80 percent in April 2004. While the series is punctuated by periods of extreme volatility, such as seen in the first half of 2004, the level of uncertainty is consistently high throughout. The mean conditional standard deviation of inflation is 1.30 percent. The comparable value for U.S. inflation

[5] *Indice de precios al consumidor.*

[6] The first twelve months of data are used to "season" the estimation.

volatility is 0.25 percent, less than 20% of that experienced in the Dominican Republic. In fact, the lowest level of Dominican inflation volatility recorded over the sample period is more the 60% larger than the highest level experienced in the United States. This highlights the importance of understanding the effect of inflation uncertainty on investment behavior in less developed countries, where prices tend to be relatively unstable.

2.4 Dominican Microenterprise Data

The primary firm-level data used in this analysis are an unbalanced panel of loan administrative data from the clients of ADOPEM, a large and well-performing microfinance institution based in the Dominican Republic. ADOPEM is a savings and credit bank based in Santo Domingo, Dominican Republic and serving primarily low-income, urban individuals. Ninety percent of ADOPEM's loans during 2006 were for amounts between RD$2,500 and RD$50,000 ($70-$1,400), and approximately 77% of their 50,000 active clients are women.

ADOPEM routinely collects summary balance sheet and profit and loss account data from all individuals that borrow from it at the time of any new loan solicitation. Traditionally, credit officers collected this information on paper in the field and then later entered it into a computer database. In 2001, ADOPEM introduced Palm Pilot-based data collection. This system collects the same information about the clients, utilizing real-time data validation and direct syncing with the central database to improve accuracy.

The available data span from January 1998 through February 2008; however, as described below, data coverage varies throughout the sample. The full sample includes 453,165 firm-loan observations on 172,017 unique firms. Of these, 104,907 firms have more than one loan recorded in the data.[7]

These data are quite rich and include information on sales, default and late performance,

[7] This includes all firms with a non-zero borrowing amount in ADOPEM's administrative loan database.

fixed asset and working capital balances at the time the loan is made, and business type.[8] Of note and unusual for a microfinance institution, for slightly more than 10% of our sample they also include self-reported use of proceeds at the time of the loan. Such self-reported investment intentions capture exactly the behavior of interest: borrowers' planned investment allocation between short- and long-term assets. This data was collected by the microfinance institution for purely informational purposes and had no bearing on the lending decision.[9] Borrowers were free to use the funds for another purpose at any time during the life of the loan. Thus we presume that borrowers did not have an incentive to misrepresent their intentions.

Table 3 presents summary statistics at the firm-loan level for the entire sample and for just those reporting use of proceeds. In real 2006 terms, the average loan size over the sample is RD$15,045, or approximately $440 at then-current exchange rates, for the sample of all loans and RD$21,031 among those loans for which use of proceeds data is available. Interest rates averaged 42.6% over the sample. The mean level of business fixed assets is RD$9,416; however, the distribution of assets is heavily right skewed, with a median of only RD$729. The median level of intended investment in additional business fixed assets is zero, with only 5% of borrowers expressing an intention to invest in *any* fixed assets. This is consistent with the theory of optimal investment under uncertainty, discussed in section 2.2.2, in which investments in assets with asymmetric adjustment costs exhibit hysteresis.

[8] All quantitative variables were truncated at the 1st and 99th percentiles in order to limit the effect of outliers and remaining errors in the data. All of the results presented below are robust to censoring rather than truncating these outliers.

[9] ADOPEM employs a formula-based lending system under which the maximum borrowing amout is determined as a function of monthly repayment capacity. Self-reported use of proceeds does not enter into this calculation, and both credit officers and potential borrowers are aware of this fact.

2.5 Empirical Strategy

This sections describes the empirical strategy for linking inflation uncertainty with the investment behavior and business outcomes of Dominican microfinance borrowers. The investment behavior outcomes of interest are borrowers' planned real investment in long-term assets, the share of loan proceeds they intend to allocate to working capital, and whether a borrower intends to make *any* long-term investments. The key explanatory variable in each case is our measure of inflation uncertainty at the time of loan origination, obtained as described in section 2.3. Turning to business outcomes, the panel aspect of the borrower-loan data allows assessment of sales and asset growth in response to inflation uncertainty over the term of the loan. Using the same framework, we can also analyze loan performance measures, in particular, late payments and default.

2.5.1 Uncertainty and investment choice

Denote y_{it} as the value of the outcome of interest (e.g., planned real investment in long-term assets) for individual i at time t and u_t as our measure of inflation uncertainty, obtained from the fitted GARCH residuals as described in section 2.3. The most basic specification simply considers the conditional mean of this outcome, y_{it}, with respect to inflation uncertainty, u_t, in regression form:

$$y_{it} = \alpha_1 + \beta_1 u_t + \varepsilon_{it}. \tag{2.6}$$

We can augment equation 2.6 in a number of ways. First, we can take advantage of the detailed microdata and control for a vector of firm characteristics, $\mathbf{X}$, including trailing sales, loan size, borrowing history and business type:

$$y_{it} = \alpha_2 + \beta_2 u_t + X_{it}\delta_2 + \varepsilon_{it}. \tag{2.7}$$

Repeat borrowers represent 60% of the unique firms in the data and 85% of all loan-borrower observations. For such borrowers we can also utilize the panel aspect of the data to control for unobserved borrower characteristics. The corresponding estimation equation that includes borrower-level fixed effects is

$$y_{it} = \alpha_3 + \beta_3 u_t + \tilde{X}_{it}\delta_3 + \lambda_i + \varepsilon_{it}. \tag{2.8}$$

Controls for other measures of systemic risk and general economic activity, including inflation levels, exchange rate levels and volatility, and national income can be included each of these specifications. In all of the regressions, standard errors are clustered to adjusted for possible correlation at the *barrio* (neighborhood) level. Following the same basic framework, I also estimate linear probability and probit models for the intention of borrowers to make *any* investment in fixed assets. As shown in section 2.2.2, increased uncertainty should be associated with a reduced probability of making any such investments.

2.5.2 Instrumenting for endogenous timing of borrowing decisions

To the extent that we find a relationship between inflation uncertainty and investment behavior, selection may provide part of the explanation. For example, an inflation-sensitive borrower may postpone taking a loan during periods of high uncertainty. This would lead us to underestimate the effect of inflation uncertainty on investment choice as such borrowers would only reappear in our sample once uncertainty had fallen. Such timing changes may themselves have policy relevance; however, we are interested in the direct relationship between inflation uncertainty and investment choice.

The repeat nature of microfinance borrowing provides an instrument which we can use to overcome this potential selection effect. Sixty five percent of borrowers take out another loan within one month of the due date of their previous loans. Thus I repeat the above analysis instrumenting for the uncertainty level at the time of borrowing with the uncertainty level at the time each borrower's previous loan came due.[10]

2.5.3 Uncertainty, business outcomes, and loan performance

Estimation of the relationship between inflation uncertainty, business outcomes and loan performance follows the same basic methodology described in section 2.5.1 above. Real sales, business fixed assets, and home fixed assets serve as the key measures of business and asset growth. For each, the associated dependent variable is calculated as the annualized real growth in the underlying measure

$$\Delta y_{it}^{ra} = \left(y_{it+1}^{r}/y_{it}^{r}\right)^{\tau_{it}} - 1,$$

where y_{it}^{r} is the value of y for borrower i at time t in real 2006 Dominican pesos and τ_{it} is inverse of the amount of time, in fractions of a year, between observations t and $t+1$. Because these measures evolve over the term of the loan, the mean level of inflation uncertainty over the six months after borrowing, $\bar{u}_t^6 = \frac{1}{6}\sum_{i=1}^{6}\hat{u}_{t+i}$, provides the key explanatory variable.[11] Using this measure, I estimates models of the form

$$\Delta y_{it}^{ra} = \alpha_4 + \beta_4 \bar{u}_t^6 + X_{it}\delta_4 + \varepsilon_4, \tag{2.9}$$

where X_{it} includes borrower characteristics as well as measures of GNP growth, inflation rates, and exchange rates, also over the life of the loan.

[10]The validity of this instrument relies on the identifying assumption that the uncertainty environment at the time of a borrower's previous loan affects her current investment decisions only through its effect on the timing of future borrowing. Under this assumption, the instrumental variables estimates provides an unbiased estimator for the effect of inflation uncertainty on investment decisions for those individuals who borrow again. It does not account for those borrowers who, in response to the uncertainty environment, never borrow again and hence do not reappear in the sample.

[11]Six months was chosen to cover the loan life for 90% of borrowers. The mean loan term is 10 months, and results are robust to extending to 9 or 12 months the window over which inflation volatility is measured.

Default rates and late payment days reported in the microfinance institution's administrative database provide indicators of loan performance. I calculate the effect of inflation uncertainty on these measures using specifications of the form described in (2.9).

2.5.4 Uncertainty and Investment Deferral

Finally, we look for evidence of deferred investment in response to past uncertainty. The combination of uncertainty and partially irreversible investment leads firms to be more cautions in their investment decisions. But if firms respond only by delaying investments until the uncertainty is resolved, the investment would rebound in subsequent periods and the long-term level of investment would equal that when delay was not possible (Bloom 2000). We would therefore expect that, conditional on the current environment, higher levels of past uncertainty would be associated with higher intended investment in long-term assets. Using the panel aspect of the date, we test for this by adding measures of uncertainty, demand growth (as measured by GNP), and their interaction to investment model specifications described above. We estimate models of the form

$$y_{it} = \alpha_5 + \beta_5 u_t + \phi^u \bar{u}^6_{t-1} + \phi^6 g_{t-1} + \phi^{ug} \bar{u}^6_{t-1} g^6_{t-1} + X_{it}\delta_5 + \varepsilon_{it}. \qquad (2.10)$$

Where g^6_{t-1} represents the level of GNP growth over the first six month of the previous loan's term. If firms long-term investments rebound after periods of uncertainty are resolved, we would expect $\phi^{ug} > 0$.

2.6 Results

This section explores the empirical relationship between inflation uncertainty and small firms' investment decisions. The results suggest that periods of high inflation volatility are associated with lower intended investment in fixed assets as well as reduced growth in both business fixed assets and revenues. This association is robust to controlling for inflation levels, GNP growth, and exchange rates, as well as restricting our attention to within-borrower behavior and instrumenting for the possibly endogenous timing of borrowing decisions.

2.6.1 Uncertainty and investment choice

Table 4 presents the results for the effect of inflation uncertainty on total intended investment in long-term assets (in real 2006 Dominican pesos) and the share of total loan proceeds used for working capital (short-term assets).[12] The first column presents the results from a regression that includes the level of inflation uncertainty (as measured by the estimated conditional standard deviation of inflation from the GARCH model described in section 2.3) and the inflation level in the month the loan originated. Consistent with the hypothesis that increased uncertainty distorts individuals' investment decisions away from long-term assets, the coefficient on inflation uncertainty is negative and significant. A one percent increase in inflation uncertainty, approximately 1.15 standard deviations over the analysis period, is associated with a reduction in intended fixed asset investment of RD$362. Column 2 presents results for a similar regression that extends the set of controls to include one-year trailing inflation and GNP growth as well as the current exchange rate and the level of exchange rate uncertainty (estimated using the same GARCH method employed for inflation uncertainty). Column 3 adds firm and loan characteristics including quintic polynomial for loan size and sales, an indicator for whether the loan was for a new or repeat borrower, and categorical variables for business type. Columns 4 and 5 report the results of panel data regressions that include borrower fixed effects. In all specifications, the coefficient on inflation uncertainty is negative and significant, ranging from a RD$145 to RD$362, relative to a mean investment

[12]The reported standard errors in all regressions are adjusted for heteroskedasticity and clustering at the neighborhood (*barrio*) level.

of RD$977.

The bottom of table 4 reports results with the same set of explanatory variables using the share of loan proceeds intended for working capital. The same pattern is evident. In all specifications, increased inflation uncertainty is associated with an increased share of loan proceeds intended for working capital and a corresponding decrease in the share intended for fixed assets.

We also consider the possibility that inflation uncertainty affects borrowers' decisions to make any long-term investment. Table 5 presents the results of probit and linear probability model specifications of this hypothesis, using the same set of explanatory variables described above. In each specification, the coefficient is negative and significant. A one percentage point increase in the standard deviation of inflation is associated with a reduction of 0.67% to 1.93% in the probability a borrower reports an intention to make any long-term investment. This effect is large relative to the mean value of 3.7%.

2.6.2 Instrumenting for endogenous timing of borrowing decisions

The consistency of parameter estimates over cross-sectional and fixed effects panel regressions suggests that increased uncertainty does affect borrowers' decisions. As described above, observed reductions long-term investments could be the result of both distortions to the investment choices of individuals who borrower regardless the level of uncertainty and distortions in the timing of borrowing decisions.

Table 6 reports the results from the instrumental variables specification, instrumenting for inflation uncertainty and the other included macro-level explanatory variables with the corresponding amounts at the time a borrower's previous loan came do. In all specifications, the coefficients on inflation volatility in the month of borrowing suggest reduced investment in long-term assets in periods of high uncertainty. The parameter estimates are broadly in line with those from the comparable OLS specifications, although they are no longer significant in the more demanding specifications.

2.6.3 Uncertainty and observed growth

Utilizing the panel aspect of the data, this section explores the relationship between inflation uncertainty and both sales and asset growth. First, this data allows us to investigate the correlation between stated use of proceeds and observed asset growth. Over the period in question, ADOPEM's loans were intended for business purposes (typically referred to as "income generating assets" by microfinance institutions). When soliciting a loan, potential borrowers needed to provide a valid business rationale for the loan proceeds.[13] Conditional on stating a general business purpose, self-reported use of proceeds at the time of the loan was collected by ADOPEM for purely informational purposes and had no bearing on the lending decision. Borrowers did not have an incentive to misrepresent their intentions and were free to use the funds for another purpose at any time during the life of the loan. Expressed intentions do offer some predictive power. A regression of observed changes in fixed assets on intended investment produces a coefficient of 0.15 with a standard error of 0.07, clustering errors at the *barrio* level.

Table 7 presents evidence on the relationship between business growth and inflation uncertainty over the life of the loan. The top panel reports results from a regression of the annualized percentage growth in sales on inflation volatility, GNP growth, and changes in inflation and exchange rates, all measured over the first six months of the loan.[14] Column 1 presents results from the basic specification, column 2 adds borrower and loan-level controls,

[13]Cash, however, is fungible and uses of proceeds are difficult to monitor. In practice, most microfinance institutions tacitly accept non-business uses of proceeds ranging from consumption to education and housing. Many are moving to offer loans specifically targeting such purposes.

[14]Six months was chosen because substantially all loans are outstanding for this duration. The results are robust to alternative window lengths. Note that for a borrower to be included in this analysis, she must have a future loan with income statement detail in the database.

and column 3 presents results using borrower fixed effects. In all specifications, increased inflation uncertainty over the first six months of the loan is associated with substantially and significantly lower real sales growth. A one-standard deviation increase in six-month volatility (0.65 percentage points) corresponds to a reduction in real, annualized revenue growth of between 9 and 19 percentage points, relative to a median growth rate of 11% and a mean of 76%.

Turning to the evolution of assets, the second panel of table 7 shows increased inflation uncertainty is also associated with large decreases in fixed asset growth in borrowers' businesses. A one-standard deviation increase in six-month volatility corresponds to a reduction of between 7 and 12 percentage points in fixed asset growth. GNP growth over the first six months of the loan is also consistently associated with larger real growth in both revenues and business fixed assets.

In contrast, growth in fixed assets for the home does not appear to vary with inflation uncertainty. Only in the fixed effects regression, shown in column 3, is the coefficient on inflation uncertainty significantly different from zero, and then only marginally. This is, perhaps, not surprising as firm profits tend to be more volatile than prices and thus the option value of deferring business investment is more sensitive to uncertainty than that of deferring consumption.

2.6.4 Uncertainty and loan performance

This final subsection looks at the relationship between inflation uncertainty and loan repayment performance as measured by default experience and late payments. The results in this area, as shown in table 8, are less clear to interpret. The first panel presents the results of an ordinary least squares regression of the number of days which payments were late over the loan cycle on inflation uncertainty, change in inflation, GNP growth, and the change in the peso-dollar exchange rate over the first six months of the loan. As before, column 1 presents results from the basic specification, column 2 adds borrower and loan-level controls, and column 3 presents results using borrower fixed effects. If inflation uncertainty causes repayment difficulty for microfinance borrowers, we would expect it to have a positive coefficient in these regressions. While this is the case for the specifications presented in columns 1 and 2, the effect disappears in the fixed effects specification. Late payments, which average 5.3 days throughout the sample, fall during periods of high GNP growth and when the value of the Dominican peso falls relative to the U.S. dollar. Many borrowers receive substantial remittances from emigrant family members and few purchase imported goods other than with these remittances. Thus, the large positive effect of the weakening peso may be the product of remittances sent in fixed dollar amounts. However, more evidence is required to test this hypothesis.

The second and third panels of table 8 show the results of the probit and linear probability regressions for an indicator of default on the same set of explanatory variables.[15] They are perplexing. Default rates average 3.1% throughout the sample, and tend to be lower during periods of inflation uncertainty. Moreover, the coefficients on both GNP growth and exchange rates are the reverse of what one would expect based on the late payment behavior. Periods of increased economic activity and a declining peso are associated with higher default rates despite reductions in late payments. Understanding the roots of this relationship offers an avenue for future research.

2.6.5 Uncertainty and Investment Deferral

Finally, we look for evidence of deferred investment in response to past uncertainty, estimating equation 2.10 with total fixed asset investment, share of investment intended for working

[15] I do not estimate the fixed effects regression for default behavior. Once a borrower defaults, she is unlikely to appear in the dataset again.

capital, and the probability of any fixed asset investment as the dependent variables. Table 9 reports the results of these regressions, and there is some evidence of deferred compensatory behavior in each case. In panel A, the coefficient on the interaction of inflation uncertainty and GNP growth during the prior loan cycle is positive in all specification, although it is significant at the 5% level only in the fixed effects regression without controls for other macroeconomic factors, column 4. Similarly, the coefficients on the interaction term in panel B are consistently negative, implying that the combination of high inflation uncertainty and positive aggregate demand shocks during the term of a borrower's previous loan is associated with a smaller share of loan proceeds going towards working capital during the current loan cycle. Panel C shows that such periods also correspond to a higher future probability of any fixed asset investment, but the effects are not evident in the fixed effects regressions shown in columns 4 and 5. Note that in each case the main effects of inflation uncertainty and GNP growth during the prior loan period push investment behavior in the opposite direction of the interaction term, and the combined effect does not offset the distortion away from long-term assets associated with contemporaneous uncertainty.

These results should not be taken as a rejection of the deferred investment prediction from some real options investment models. The period between loan cycles may be too short to capture any deferrals, and further research is required to fully test this hypothesis.

2.7 Conclusion

This paper presents evidence that in periods of high inflation uncertainty, microfinance borrowers reduce their investment in long-term assets. Moreover, increased inflation uncertainty over the term of the loan is associated with lower real sales growth, even after accounting for other sources of systemic uncertainty and general economic growth.

This line of research extends existing work on the relationship between inflation uncertainty and investment in two important directions. First, it utilizes a unique panel of microfinance borrower data to analyze the effect of inflation uncertainty on firm-level behavior. In doing so, it take a step towards understanding the empirical foundation of the relationship between inflation uncertainty and investment. Second, it extends our understanding of this relationship in less developed countries where inflation volatility tends to be high and the mechanisms available to cope with risk are limited.

Given the magnitude of borrowers' responses to inflation uncertainty, it is tempting to draw welfare conclusions. However any efforts to do so are subject to two important caveats. First, the measured declines in fixed asset growth, intended investment, and revenues are all relatively short term, occurring over a single loan cycle. Over the longer term, uncertainty may also dampen downward adjustment of capital stock in response to negative shocks leaving total investment unchanged. While such barriers to adjustment impose a cost on firms, we do not measure their effects here, and the long-term effect on capital stock remains ambiguous. Second, the welfare consequences of investment in micro-businesses are not well known. Their owners' alternative uses of capital include consumption smoothing and human capital investments, and understanding the relative welfare consequences for different uses of microloan proceeds remains an open and important research question. The decision not to invest in fixed assets may also move borrowers across the entry-exit margin. Exploration of the relationship between systemic uncertainty and occupational choice provides an interesting avenue for future research.

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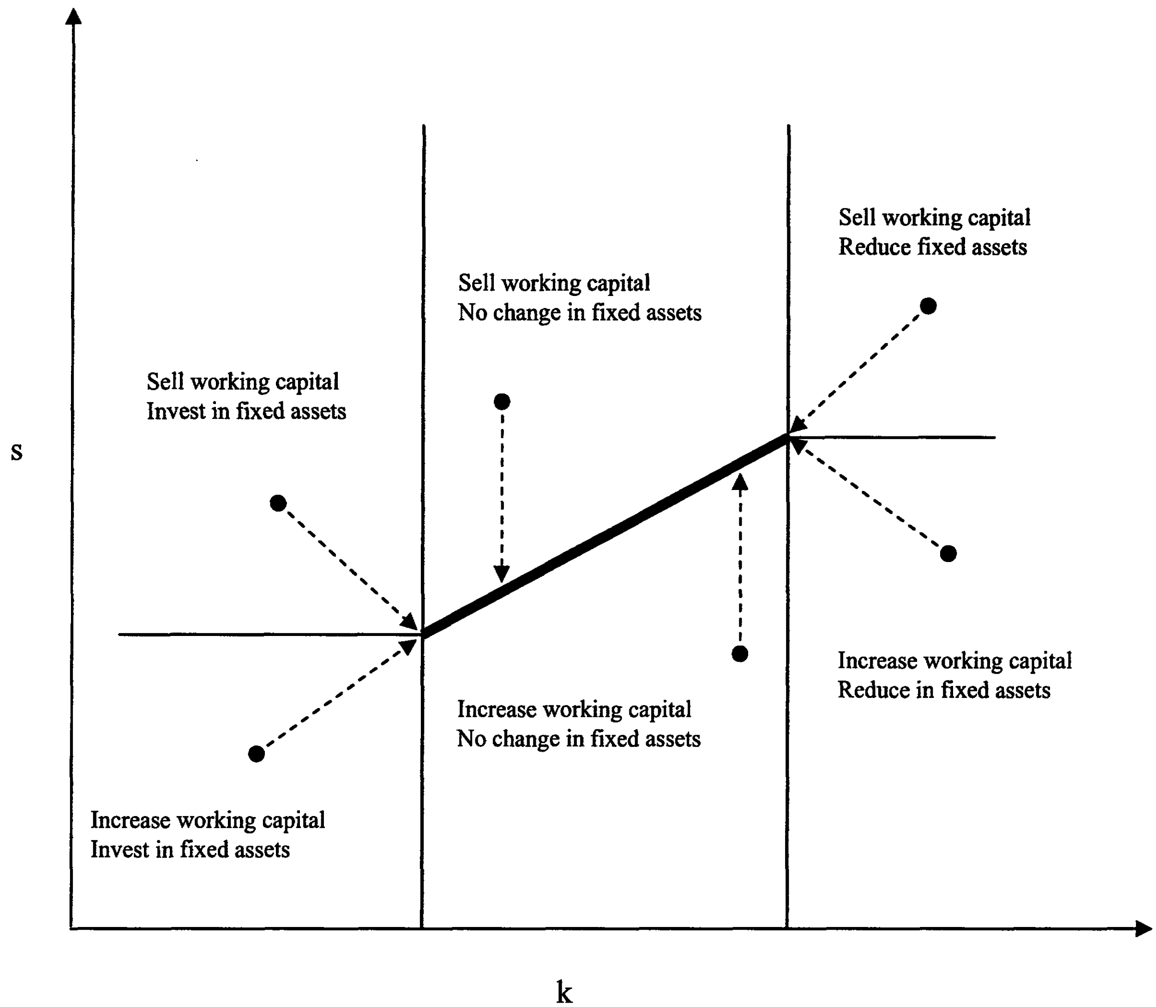
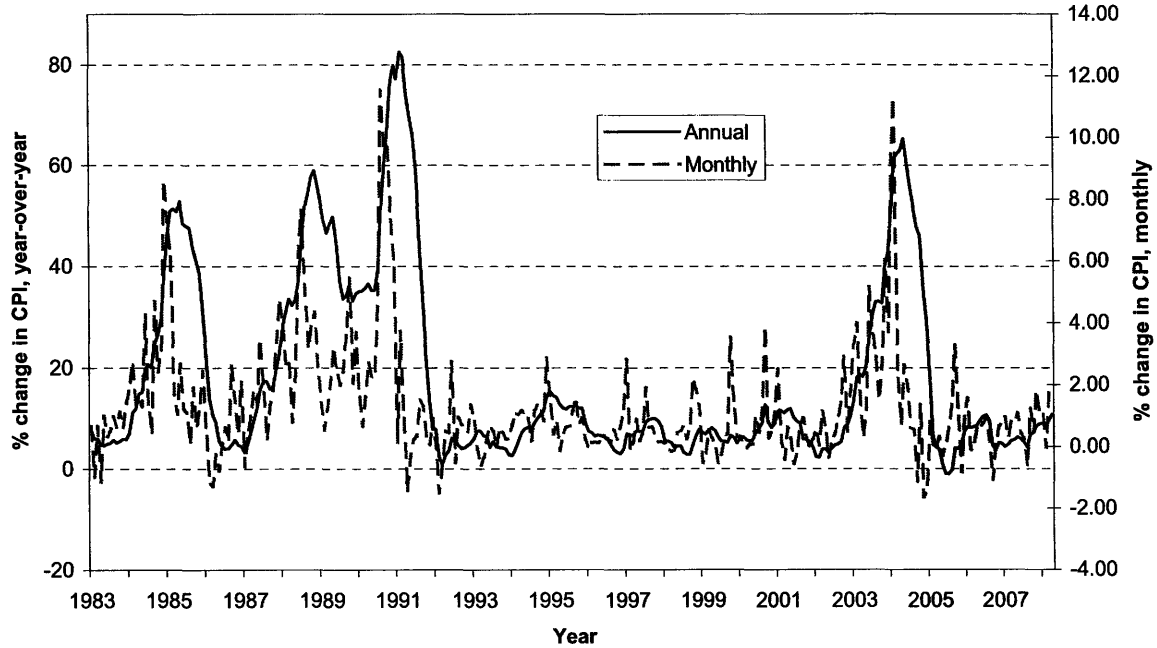
Figure 1: Optimal Investment Policy



Notes: s=log(S/X) and k=log(K/X) where S represents short-term assets (working capital), K represents long-term assets, and X represents the index of demand and productivity conditions. Dashed arrows indicate optimal policy responses.

Figure 2: Dominican Republic Consumer Price Inflation

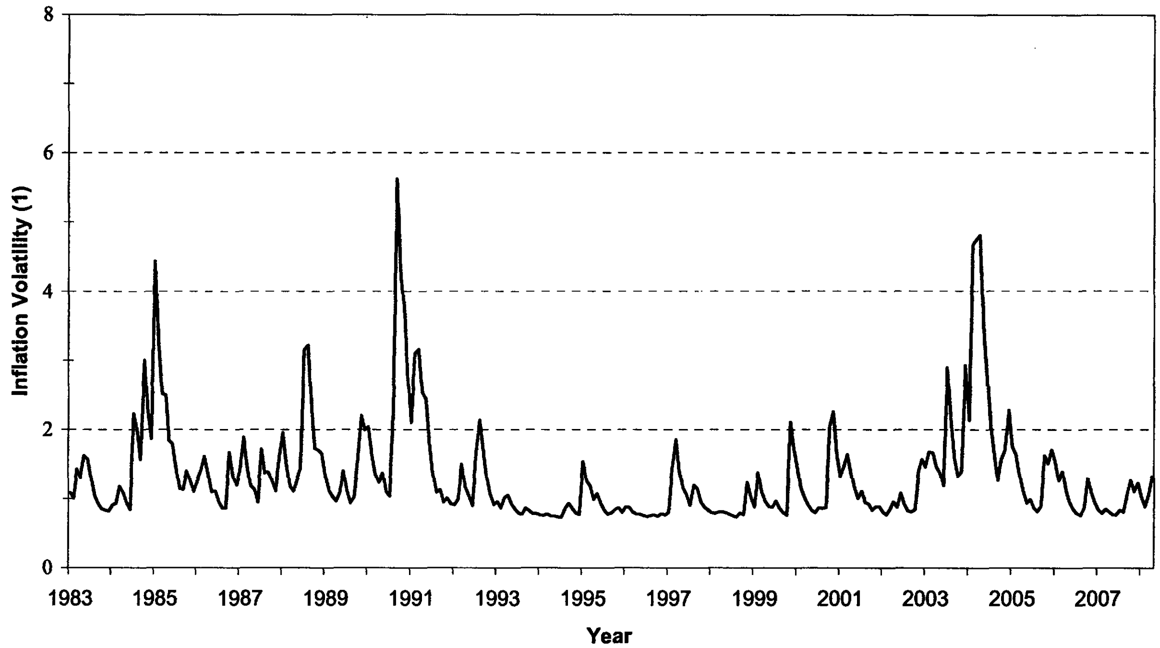
January 1983 to April 2008



Notes:

(1) Percent change in seasonally adjusted consumer price index *indice de precios al consumidor* .

Figure 3: Dominican Republic Monthly Consumer Price Inflation Volatility
January 1983 to April 2008



Notes:

(1) Conditional standard deviation of seasonally adjusted consumer price index indice de precios al consumidor, calculated based on GARCH(1,1) model.

Table 1: Investment Decision, The Effect of Uncertainty

Initial capital expenditures	8,000		
Monthly discount rate	2%		

	Certain Profit Stream	Uncertain Profit Stream	
		Profit stream ±50% resolved in one month	
Invest today	Certain	High	Low
Probability	- -	0.50	0.50
Monthly expected profits	200	300	100
Discounted value of profits	10,000	15,000	5,000
Expected NPV	2,000	2,000	
Wait for one month and decide			
Monthly expected profits	200	300	100
Discounted value of profits	10,000	15,000	5,000
NPV		7,000	(3,000)
Expected NPV	2,000	3,500	(1,500)
Make investment	*yes*	*yes*	*no*
Expected NPV		3500	0
Expected NPV	2000	3500	
Discounted NPV	1,961	3,431	
Optimal strategy	***Invest today***	***Wait***	

Notes: Corresponds to the investment choice and uncertainty example discussed in section 2, which follows closely work by Huizinga (1993) and Pindyck (1991).

Table 2: ARCH Model Diagnostics

	ARCH Model 1 (1)	ARCH Model 2 (2)	ARCH Model 3 (3)	GARCH Model 1 (4)	GARCH Model 2 (5)
AR (p)	1	1	3	1	1
ARCH (q)	1	3	3	1	3
GARCH (r)	- -	- -	- -	1	1
Full Inflation Series (1982m1-2008m4)					
Unconditional variance	2.64	2.29	2.24	2.29	2.32
log likelihood	927.6	945.7	947.0	946.5	947.4
AIC	-1847.1	-1879.5	-1878.0	-1882.9	-1880.8
BIC	-1832.1	-1856.9	-1848.0	-1864.2	-1854.6
Investment Data Period (1998m1-2008m2)					
Unconditional variance	2.88	n/a	n/a	2.08	n/a
log likelihood	367.5	n/a	n/a	374.6	n/a
AIC	-727.0	n/a	n/a	-739.2	n/a
BIC	-715.7	n/a	n/a	-725.1	n/a

Notes: These are estimation results for equations (x) through (x) with lag lengths as indicated. AIC is the Akaike Information Criterion and BIC is the Bayesian Information Criterion.

Table 3: Summary Statistics for Borrower Data

A. Loan Characteristics	All Loans Mean (1)	Median (2)	Standard Deviation (3)	n (4)	Use of Proceeds Data Available Mean (4)	Median (5)	Standard Deviation (6)	n (7)
Loan size, real	15,045	9,951	16,297	453,165	21,031	15,443	18,016	47,443
Sales, real	32,563	21,758	35,553	414,886	36,571	29,000	27,435	47,443
Annual interest rate (%)	42.6	48.0	19.2	453,165	53.7	60.0	9.7	47,443
Default rate (%)	3.1	0.0	17.4	453,165	1.4	0.0	11.7	47,443
Days late payment during loan	5.3	0.0	27.5	451,363	1.0	1.0	0.2	47,443
Share of loan intended for working capital					96.6	100.0	18.0	47,443
Amount of loan request intended for working capital					18,767	12,000	45,728	47,443
Amount of loan request intended for fixed assets					977	0	9,910	47,443

B. Business Types	All Loans n	%	Use of Proceeds Data Available n	%
Clothing store	111,267	24.3%	9,408	19.8%
Convenience store or grocery	139,998	30.6%	13,879	29.3%
Restaurant	24,312	5.3%	4,511	9.5%
Personal care	54,250	11.9%	8,293	17.5%
Other	127,912	27.9%	11,352	23.9%
Total	457,739		47,443	

Notes: Real amounts based on Dominican consumer price index, January 2006.

Table 4: Inflation Uncertainty and Investment Choice

Intended Asset Allocation

	(1)	(2)	(3)	(4)	(5)
A. Intended investment, fixed assets (real)					
Inflation uncertainty, month of borrowing	-362.6 ***	-157.0 ***	-176.4 ***	-273.7 ***	-145.6 *
	(66.1)	(38.1)	(40.0)	(72.8)	(88.1)
Inflation level, month of borrowing	-44.8 ***	-70.0 ***	-78.2 ***	-46.6 *	-151.7 ***
	(13.4)	(21.3)	(18.7)	(24.4)	(36.8)
Inflation level, year-over-year		-30.2 ***	-31.6 ***		-64.8 ***
		(9.8)	(8.2)		(16.7)
GNP Growth, year-over-year		7.0	6.4		16.2 **
		(4.5)	(4.1)		(8.0)
Exchange rate, month of borrowing		46.3 ***	57.2 ***		98.1 ***
		(13.2)	(12.5)		(27.5)
Exchange rate uncertainty, month of borrowing		3.0 ***	3.5 ***		6.1 ***
		(0.8)	(0.8)		(1.5)
B. Share of loan intended for working capital (%)					
Inflation uncertainty, month of borrowing	1.25 ***	0.64 ***	0.63 ***	0.78 ***	0.90 ***
	(0.30)	(0.13)	(0.13)	(0.22)	(0.22)
Inflation level, month of borrowing	0.18 ***	0.25 ***	0.24 ***	0.10 *	0.33 ***
	(0.04)	(0.06)	(0.05)	(0.06)	(0.08)
Inflation level, year-over-year		0.11 ***	0.10 ***		0.14 ***
		(0.03)	(0.03)		(0.04)
GNP Growth, year-over-year		-0.02	-0.02		-0.04 **
		(0.02)	(0.01)		(0.02)
Exchange rate, month of borrowing		-0.19 ***	-0.19 ***		-0.24 ***
		(0.05)	(0.04)		(0.07)
Exchange rate uncertainty, month of borrowing		-0.01 ***	-0.01 ***		-0.02 ***
		(0.00)	(0.00)		(0.00)
Controls					
Sales (quintic polynomial)	-	-	x	x	x
Loan size (quintic polynomial)	-	-	x	-	-
New or repeat borrower	-	-	x	-	-
Business type	-	-	x	-	-
Individual Fixed Effects	-	x	-	x	x
N	47,443	40,144	40,144	31,076	25,998

Notes: Dependent variable listed in italicized panel heading; regressors below. Table reports coefficient estimates with robust standard errors, clustered at *barrio*, in parentheses. *** Significant at 1%; ** significant at 5%; * significant at 10%. Loan size is quintic polynomial of total real loan amount, business type includes indicators for clothing stores, food stores, restaurants, beauty & fashion and other. Fixed effects regressions include only those borrowers reporting multiple loans. GNP data available through 2005.

Table 5: Inflation Uncertainty and Investment Choice

Any Intended Fixed Asset Investment

	(1)	(2)	(3)	(4)
A. Any fixed asset investment, Probit Marginal Effect at means (%)				
Inflation volatility, month of borrowing	-1.66 ***	-0.80 ***	-0.75 ***	
	(0.10)	(0.10)	(0.09)	
Inflation level, month of borrowing	-0.25 ***	-0.23 ***	-0.19 ***	
	(0.04)	(0.03)	(0.03)	
Inflation level, year-over-year		-0.09 ***	-0.08 ***	
		(0.01)	(0.01)	
GNP Growth, year-over-year		0.01 ***	0.01 **	
		(0.01)	(0.00)	
Exchange Rate		0.17 ***	0.16 ***	
		(0.02)	(0.01)	
Exchange Rate Volatility		0.01 ***	0.01 ***	
		(0.00)	(0.00)	
B. Any fixed asset investment, Linear Probability Model (%)				
Inflation volatility, month of borrowing	-1.22 ***	-0.69 ***	-0.67 ***	-0.89 ***
	(0.06)	(0.09)	(0.09)	(0.16)
Inflation level, month of borrowing	-0.17 ***	-0.25 ***	-0.22 ***	-0.31 ***
	(0.02)	(0.03)	(0.03)	(0.05)
Inflation level, year-over-year		-0.10 ***	-0.10 ***	-0.14 ***
		(0.01)	(0.01)	(0.02)
GNP Growth, year-over-year		0.02 ***	0.02 **	0.04 ***
		(0.01)	(0.01)	(0.01)
Exchange Rate		0.19 ***	0.18 ***	0.23 ***
		(0.02)	(0.02)	(0.03)
Exchange Rate Volatility		0.01 ***	0.01 ***	0.02 ***
		(0.00)	(0.00)	(0.00)
Controls				
Loan Size	-	-	x	-
New or repeat borrower	-	-	x	-
Business type	-	-	x	-
Individual Fixed Effects	-	-	-	x

Notes: Dependent variable listed in italicized panel heading; regressors below. Table reports coefficient estimates with standard errors in parentheses. Linear probability model errors are clustered at the *barrio* level. *** Significant at 1%; ** significant at 5%; * significant at 10%. Loan size is quintic polynomial of total real loan amount, business type includes indicators for clothing stores, food stores, restaurants, beauty & fashion and other. Fixed effects regressions include only those borrowers reporting multiple loans.

Table 6: Inflation Uncertainty and Investment Choice

Instrumenting based on due date of previous loan

	(1)	(2)	(3)	(4)	(5)
A. Total investment, fixed assets					
Inflation volatility, month of borrowing	-472.4 ***	-148.8	-196.9	-285.7	-129.5
	(141.7)	(174.9)	(173.8)	(207.0)	(310.2)
Inflation level, month of borrowing	-125.3 **	-113.9 ***	-85.0 **	-67.6	-192.3 ***
	(62.1)	(39.6)	(41.1)	(77.2)	(47.9)
Inflation level, year-over-year		-51.3 ***	-38.7 ***		-87.4 ***
		(8.8)	(10.1)		(14.1)
GNP Growth, year-over-year		-5.0	-11.0		13.8
		(22.3)	(22.1)		(42.4)
B. Share of loan used for working capital (%)					
Inflation volatility, month of borrowing	1.47 ***	0.65 **	0.63 **	0.71 **	0.64
	(0.26)	(0.31)	(0.31)	(0.31)	(0.50)
Inflation level, month of borrowing	0.46 ***	0.30 ***	0.22 ***	0.26 **	0.36 ***
	(0.12)	(0.07)	(0.07)	(0.12)	(0.08)
Inflation level, year-over-year		0.15 ***	0.11 ***		0.19 ***
		(0.02)	(0.02)		(0.02)
GNP Growth, year-over-year		-0.03	-0.01		-0.08
		(0.04)	(0.04)		(0.07)
C. Any fixed asset investment, Linear Probability Model (%)					
Inflation volatility, month of borrowing	-1.41 ***	-0.66 *	-0.68 **	-0.72 **	-0.63
	(0.27)	(0.34)	(0.34)	(0.32)	(0.52)
Inflation level, month of borrowing	-0.45 ***	-0.31 ***	-0.23 ***	-0.25 **	-0.35 ***
	(0.12)	(0.08)	(0.08)	(0.12)	(0.08)
Inflation level, year-over-year		-0.15 ***	-0.11 ***		-0.20 ***
		(0.02)	(0.02)		(0.02)
GNP Growth, year-over-year		0.03	0.01		0.11
		(0.04)	(0.04)		(0.07)
Controls					
Sales (quntic polynomial)	-	-	x	x	x
Loan size (quintic polynomial)	-	-	x	-	-
New or repeat borrower	-	-	x	-	-
Business type	-	-	x	-	-
Individual Fixed Effects	-	-	-	x	x
N	30,396	24,564	24,564	23,922	18,525

Notes: Dependent variable listed in italicized panel heading; regressors below. Table reports coefficient estimates with robust standard errors, clustered at *barrio*, in parentheses. *** Significant at 1%; ** significant at 5%; * significant at 10%. Loan size is quintic polynomial of total real loan amount, business type includes indicators for clothing stores, food stores, restaurants, beauty & fashion and other. Fixed effects regressions include only those borrowers reporting multiple loans. GNP data available through 2005. Inflation uncertainty and all other macro economic variables at time of loan instrumented for with corresponding variables at time prior loan came due.

Table 7: Inflation Uncertainty, Asset and Revenue Growth

	(1)		(2)		(3)	
A. Sales, annualized percentage change						
Inflation volatility, first 6 months of loan	-14.92	***	-29.36	***	-21.52	***
	(3.85)		(6.14)		(4.25)	
Inflation level, month of borrowing	-0.57		1.74	***	1.71	***
	(0.45)		(0.64)		(0.46)	
GNP Growth, first 6 months of loan	0.74	***	0.92	***	1.55	***
	(0.12)		(0.19)		(0.28)	
Change in inflation, first 6 months of loan	-1.31	***	-0.65	***	-1.03	***
	(0.14)		(0.24)		(0.17)	
Change in exchange rate, first 6 months	-0.21		1.19	***	-0.12	
	(0.32)		(0.32)		(0.38)	
B. Business fixed assets, annualized percentage change						
Inflation volatility, first 6 months of loan	-11.77	*	-13.75	**	-18.85	***
	(6.07)		(5.40)		(7.10)	
Inflation level, month of borrowing	3.42	***	4.18	***	6.34	***
	(1.00)		(1.09)		(1.44)	
GNP Growth, first 6 months of loan	0.97	***	0.72	***	1.36	***
	(0.28)		(0.21)		(0.26)	
Change in inflation, first 6 months of loan	-0.63		-0.11		-0.41	
	(0.41)		(0.40)		(0.40)	
Change in exchange rate, first 6 months	1.13		1.20		1.54	
	(1.00)		(0.89)		(1.00)	
C. Home fixed assets, annualized percentage change						
Inflation volatility, first 6 months of loan	1.82		0.58		-8.24	*
	(4.25)		(4.14)		(4.59)	
Inflation level, month of borrowing	-0.34		-0.18		1.98	**
	(0.84)		(0.84)		(1.00)	
GNP Growth, first 6 months of loan	0.18		0.11		0.75	***
	(0.12)		(0.11)		(0.15)	
Change in inflation, first 6 months of loan	-0.59	*	-0.41		-0.39	
	(0.36)		(0.35)		(0.38)	
Change in exchange rate, first 6 months	-1.23	**	-1.08	*	-0.72	
	(0.62)		(0.60)		(0.60)	
Controls						
Sales (quntic polynomial)	-		x		x	
Loan size (quintic polynomial)	-		x		-	
New or repeat borrower	-		x		-	
Business type	-		x		-	
Individual Fixed Effects	-		-		x	

Notes: Dependent variable listed in italicized panel heading; regressors below. Table reports coefficient estimates with robust standard errors, clustered at *barrio*, in parentheses. *** Significant at 1%; ** significant at 5%; * significant at 10%. Loan size is quintic polynomial of total real loan amount, business type includes indicators for clothing stores, food stores, restaurants, beauty & fashion and other. Fixed effects regressions include only those borrowers reporting multiple loans. GNP data available through 2005.

Table 8: Inflation Uncertainty and Default Rates

	(1)	(2)	(3)
A. Days Late			
Inflation uncertainty, first 6 months of loan	6.13 ***	5.84 ***	0.03
	(0.10)	(0.11)	(0.33)
Change in inflation, first 6 months of loan	0.08 ***	0.08 ***	-0.13 ***
	(0.01)	(0.01)	(0.04)
GNP Growth, first 6 months of loan	-0.25 ***	-0.25 ***	-0.23 ***
	(0.01)	(0.01)	(0.02)
Change in exchange rate, first 6 months	-0.94 ***	-0.93 ***	-0.68 ***
	(0.02)	(0.02)	(0.08)
B. Default Rate, Probit Marginal Effect at means (%)			
Inflation uncertainty, first 6 months of loan	-3.52 ***	-2.92 ***	
	(0.09)	(0.08)	
Change in inflation, first 6 months of loan	-0.01	-0.01 *	
	(0.01)	(0.01)	
GNP Growth, first 6 months of loan	0.20 ***	0.17 ***	
	(0.01)	(0.01)	
Change in exchange rate, first 6 months	0.23 ***	0.21 ***	
	(0.02)	(0.02)	
C. Default Rate, Linear Probability Model (%)			
Inflation uncertainty, first 6 months of loan	-2.56 ***	-2.21 ***	
	(0.05)	(0.05)	
Change in inflation, first 6 months of loan	-0.05 ***	-0.05 ***	
	(0.01)	(0.01)	
GNP Growth, first 6 months of loan	0.11 ***	0.10 ***	
	(0.00)	(0.00)	
Change in exchange rate, first 6 months	0.23 ***	0.21 ***	
	(0.01)	(0.01)	
Controls			
Loan size (quintic polynomial)	-	x	-
New or repeat borrower	-	x	-
Business type	-	x	-
Individual Fixed Effects	-	-	x

Notes: Dependent variable listed in italicized panel heading; regressors below. Table reports coefficient estimates with robust standard errors, clustered at *barrio*, in parentheses. *** Significant at 1%; ** significant at 5%; * significant at 10%. Loan size is quintic polynomial of total real loan amount, business type includes indicators for clothing stores, food stores, restaurants, beauty & fashion and other. Fixed effects regressions include only those borrowers reporting multiple loans. GNP data available through 2005.

Table 9: Inflation Uncertainty and Investment Choice

Intended Asset Allocation, Long Term Effects and Postponement

	(1)	(2)	(3)	(4)	(5)
A. Intended investment, fixed assets (real)					
Inflation uncertainty, month of borrowing	-229.0 ***	-181.8 *	-233.1 ***	-206.4 **	-109.8
	(49.5)	(94.1)	(84.0)	(83.3)	(198.5)
Inflation uncertainty, prior loan period	-92.7	-115.1	-294.9 *	197.9	245.3
	(142.7)	(183.8)	(155.9)	(241.5)	(273.2)
GNP growth, prior loan period	-188.5 ***	-134.5	-64.8	-355.5 ***	-324.4 **
	(64.0)	(85.8)	(63.6)	(100.7)	(125.7)
Inflation uncertainty x GNP growth, prior loan period	94.9 *	61.3	8.1	195.0 **	180.6 *
	(55.7)	(69.2)	(57.3)	(85.6)	(103.3)
B. Share of loan intended for working capital (%)					
Inflation uncertainty, month of borrowing	0.85 ***	1.00 ***	1.01 ***	0.70 ***	1.23 ***
	0.23	0.29	0.26	0.21	0.34
Inflation uncertainty, prior loan period	0.22	0.59	1.07 ***	-0.41	-0.07
	0.28	0.41	0.34	0.31	0.36
GNP growth, prior loan period	0.63 ***	0.36 ***	0.14	0.61 ***	0.40 ***
	0.13	0.13	0.10	0.18	0.15
Inflation uncertainty x GNP growth, prior loan period	-0.33 ***	-0.16 **	0.01	-0.33 ***	-0.19 **
	0.07	0.08	0.08	0.09	0.08
C. Any fixed asset investment, Linear Probability Model (%)					
Inflation uncertainty, month of borrowing	-0.86 ***	-0.93 ***	-0.67 ***	-0.81 ***	-0.85 ***
	0.07	0.14	0.07	0.12	0.12
Inflation uncertainty, prior loan period	-0.36 **	0.52 *	-0.38 **	-0.70 ***	-1.02 ***
	0.16	0.31	0.16	0.21	0.21
GNP growth, prior loan period	-0.37 ***	-0.54 ***	-0.43 ***	-0.21 **	-0.09
	0.09	0.16	0.09	0.10	0.10
Inflation uncertainty x GNP growth, prior loan period	0.14 **	0.28 **	0.19 ***	0.05	-0.04
	0.07	0.11	0.07	0.07	0.07
Controls					
Sales (quintic polynomial)	-	-	x	x	x
Loan size (quintic polynomial)	-	-	x	-	-
New or repeat borrower	-	-	x	-	-
Business type	-	-	x	-	-
Individual Fixed Effects	-	x	-	x	x
Other macro environment†	-	x	x	-	x
N	47,443	40,144	40,144	31,076	25,998

Notes: Dependent variable listed in italicized panel heading; regressors below. Table reports coefficient estimates with robust standard errors, clustered at barrio, in parentheses. *** Significant at 1%; ** significant at 5%; * significant at 10%. Loan size is quintic polynomial of total real loan amount, business type includes indicators for clothing stores, food stores, restaurants, beauty & fashion and other. Fixed effects regressions include only those borrowers reporting multiple loans. GNP data available through 2005. † Coefficients for current inflation levels, current GNP growth, and exchange rates are supressed.

Chapter 3

Efficiency and Rent Seeking in Local Government: Evidence from a Randomized Policy Experiments in India[1]

3.1 Introduction

One of the traditional trade-offs about whether local public good provision should be decentralized is between efficiency and rent seeking or elite capture. Decentralized governments might have an absolute advantage at eliciting people's preferences relative to a centralized government, but they may also have a higher chance of being captured by local elites and politically powerful groups, to the detriments of weaker segments of the population. It may then be more difficult in a decentralized government than in a centralized government to ensure that minorities and disadvantaged groups get any share of public goods. Minorities may be able to form a pressure group at the national level to ensure that protective legislation is passed, but if decisions are taken at the local level, minorities may be too weak in most villages to be able to claim their fair share of the public goods. Moreover, if they are not adequately represented in the institutions of local governance, they may not only not get as much goods, but they may be unable to adequately convey their preferences over what goods they may want, thereby receiving not only fewer public goods but also the wrong ones.

This raises the question of whether it is possible to correct for this potential imbalance by increasing the bargaining power of minorities or disadvantaged groups in local government,

[1]This chapter is co-authored with Esther Duflo.

for example by mandating their representation in elected councils.

The objective of this paper is to shed light on this debate by answering several related questions in the context of decentralization in India. First, is mandated representation effective at increasing the share of public goods that reach minorities in a decentralized government?[2] Is this increase, if any, temporary, and is it compensated by a "backlash" when the scheduled castes lose the reservations, or does it persist? Second, does the allocation of public goods by local governments appear to be efficient? In other words, even if minorities are disadvantaged in terms of the share of the goods they receive, are they getting the mix of goods that they want? Third, is there evidence that powerful groups are getting more public goods than weak groups or that elected officials take advantage of their position to provide more goods to their own constituencies?

To answer these questions, the paper takes advantage of a nationwide randomized policy experiment in India. In 1993, the 73rd amendment to the constitution of India ordered the states both to devolve more power over expenditures to local village councils (*Gram Panchayats*, henceforth GPs) and to reserved a fraction of all positions of chief (*pradhan*) to scheduled castes (SC) and scheduled tribes (ST) in proportion to their representation in the population. The seats to be reserved were randomly chosen. Taking advantage of the same set up, Besley, Pande, and Rao (2007) find that in South India , individuals from traditionally disadvantaged groups received more relatively "private" goods, specifically, Below Poverty Line ration cards, when the *pradhan* is from the same group. Chattopadhyay and Duflo (2004) show that reservation for women increased investment in public goods preferred by women and present preliminary evidence that reservations for scheduled castes increase the share of goods invested in the scheduled caste's hamlet. In contrast, Pandey (2005) argues that this was not the case in Uttar Pradesh, a large Northern state, although the situation in

[2] At the state level, Pande (2003) finds that a larger share of scheduled castes in legislative assembly does lead to an increase of transfers targeted to scheduled castes.

Uttar Pradesh is more complicated since this state did not implement the random selection of seats for reservation.

We conducted two detailed surveys of all local public goods investments in a sample of villages in Birbhum, West Bengal, including information on the location of the public goods to the level of the village within the GP and the hamlet within the village. The surveys were conducted in 2000 and in 2005, in both cases two years after the election. Scheduled castes, scheduled tribes, religious minorities, and other groups live in segregated hamlets, and many public goods (such as wells) provide benefits only locally. We are thus able to estimate whether scheduled caste *pradhans* tend to put more goods in scheduled caste hamlets, whether they change the mix of public goods provided in the villages, and whether they change the quantity and the mix of goods available in scheduled castes hamlets. Because reserved constituencies were randomly assigned, we can confidently attribute any difference between the location or the types of public goods to the reservation policy.

We find that SC *pradhans* tend to invest more goods in scheduled castes hamlets: On average over the two election cycles, the share of public goods investment in scheduled caste hamlets is 6 percentage points higher when the GP is reserved for an SC. The effect appears to be larger in the first cycle (11 percentage points) than in the second (5 percentage points). However, there is no sign that the increase in public goods provided in SC hamlets under reservation provokes a decrease in the next cycle. In fact, on average over all goods, the allocation to SC hamlets remains higher in villages that were previously reserved than in those that have never been reserved. Our evidence for the effects of reservation on the mix of public goods provided is mixed. In the broad sample, we cannot reject that the increase in public good provision in the SC hamlets is proportional to what is provided to the SC hamlet in the non-reserved *Panchayats*; however, the change in mix during the second election cycle does not appear proportional. This suggests that the allocation to SC non-reserved hamlets is not only lower than what it would be without reservation, it is also different.

The second part of the paper investigates whether *pradhans* put more goods in their own villages. We find that, after correctly instrumenting for whether a village is a *pradhan's* village, this does not appear to be the case, though the standard errors are large.

3.2 Institutional Background and Data Collection

3.2.1 The *Panchayat* System

The *Panchayat* is a system of village-level (*Gram Panchayat*), block-level (*Panchayat Samiti*), and district-level (*Zilla Parishad*) elected councils that are responsible for the administration of local public goods. In West Bengal, the area on which we focus, each *Gram Panchayat* (GP) encompasses roughly 10,000 people across five to fifteen villages. The GPs do not have jurisdiction over urban areas, which are administered by separate municipalities. Voters elect a council, which then elects among its members a *pradhan* (chief) and an *upa-pradhan* (vice-chief). Candidates are generally nominated by political parties but must be residents of the villages they represent. The council makes decisions by majority voting. The *pradhan* does not have veto power but is the only member of the council with a full-time appointment.

Some form of the *Panchayat* system has existed in most of the major states of India since the early 1950s; however, in most states, the system was not an effective body of governance until the early 1990s. Elections were not held, and the *Panchayats* did not assume any active role Ghatak and Ghatak (1999). In 1993, the 73rd amendment to the Constitution of India formalized the framework of a three-tiered *Panchayat* system with regular elections throughout India.[3] It gave the GP, the lowest of these tiers, primary responsibility for implementing development programs, administering local infrastructure (public buildings, water, roads), identifying targeted welfare recipients, and defining the needs of the villages

[3]The 73rd Amendment to the Indian Constitution was passed in 1991, added to the Constitution in 1992, and came into force in 1993. Each state then passed or amended its own Panchayat Act by 1994.

under its jurisdiction. Between 1993 and 2003, all major states but two (Bihar and Punjab) held at least two elections. The main source of financing remains the state, but most of the money previously earmarked by the state for specific uses is now allocated to GPs through four block grants: the Jawhar Rozgar Yojana (JRY) for infrastructure (irrigation, drinking water, roads, repairs of community buildings, etc.), a small additional drinking water scheme, funds for welfare programs (widow's, old age, and maternity pensions, etc.), and a grant for GP functioning.[4] GPs have, in principle, complete flexibility to allocate these funds. Currently, GPs have no direct control over the appointments of government paid teachers or health workers, but in some states (Tamil Nadu and West Bengal, for example), there are Panchayat-run informal schools.

Each year, the *panchayat* is required to organize two *Gram Samsads*, meetings of villagers and village heads in which all voters may participate. The GP council submits the proposed budget to the *Gram Samsad* and reports on its activities in the previous six months. The *pradhan* also must set up regular office hours during which villagers can lodge complaints or requests.

In West Bengal, the three-tiered *Panchayat* system put in place across India by the 73rd amendment was already well established by the political reforms of the Left Front (communist) government, which came to power in 1977. The first *Panchayat* elections in West Bengal took place in 1978 and have taken place at five-year intervals ever since. Following the amendment, GPs in West Bengal were given additional responsibilities. In particular, they were entrusted to establish and administer informal education centers (called SSKs), an alternative form of education for children who do not attend school.[5]

[4]According to the balance sheets we could collect, in 40 GPs in West Bengal, the JRY accounts for 30% of total GP income, the drinking water scheme, 5%, the welfare programs, 15%, the grant for GP functioning, 33%, and the GP's own revenue for 8%. GPs can also apply for some special schemes, for example, a housing program for SCs and STs.

[5]An instructor who is not required to have any formal qualification teaches children three hours a day in a temporary building or outdoors.

3.2.2 Reservation for Women and Disadvantaged Groups

The 73rd amendment mandated that *pradhan* positions and seats in all Panchayat councils must be reserved for scheduled castes and scheduled tribes, historically disadvantaged minorities in India, in proportions to each minority's population share in the district. The amendment also reserves one-third of seats in *Panchayat* councils and *pradhan* positions for women. These reservations have been implemented in all major states except Bihar and Uttar Pradesh.

In 1993, West Bengal took the first steps to conform to the requirements of the 73rd amendment, modifying its *Panchayat* Constitution Rule to reserve one-third of all council positions for women and a share for SCs and STs in proportion to their population in each district. While raising the number of minorities elected to *Panchayat* councils, the experience was considered a disappointment as very few minorities rose to the position of *pradhan*. For example, the proportion of women councilors increased to 36% after the 1993 election, but in only 6% of the GPs did women advance to the position of *pradhan* (Kanango (1998)). To conform to the 73rd amendment, West Bengal again modified its Panchayat Constitution Rule in April 1998 Government of West Bengal (1998) to introduce reservations for the *pradhan* position itself.

A specific set of rules ensures the random selection of GPs in which the office of *pradhan* will be reserved for SCs or STs. All GPs in a district are ranked in consecutive order according to their serial legislative number, an administrative number pre-dating this reform. GPs where SCs (STs) represent less than 5% of the population are excluded from the reservation pool. Within the remaining GPs, a table of random numbers is used to choose the right number of GPs to be reserved. For example, if SCs represent one-third of a districts population, every third GP starting with the first on the list is reserved for an SC in the first election.[6]

From discussions with the government officials at the Panchayat Directorate who devised the system and district officials who implemented it in individual districts, it appears that these instructions were successfully implemented. More importantly, in the district we study in West Bengal, we could verify that the policy was strictly implemented sorting all GPs by their serial number and reconstructing the list of reserved GPs. This verifies that the allocation of GPs to the reserved list was indeed random, as intended.

In Birbhum district, where we collected our data, all GPs meet the minimum population share constraint for SCs so all are included in the reservation pool; however, a significant fraction of GPs have very few ST, so that the sample of GPs in the study for ST reservation would be very low. We therefore focus on the impact of scheduled caste reservation. Within the district, 35% of the population is SC, so a comparable share of the *pradhan* positions are reserved. The reservation had an important impact on the caste of the *pradhan*. Table 1 shows that in 1998, 100% of the GPs reserved for SCs have an SC *pradhan*, in contrast to only 11 (10.1%) of the unreserved GPs. Panel B shows that in 2000 more SC *pradhans* (22.3%) were elected in unreserved GPs. Four reserved GPs do not appear to have a SC *pradhan*, however.[7] The effect of reservation on the probability to have a SC *pradhan* is lower for both reasons (69.5%). One might expect the increased proportion of SC *pradhans* in unreserved GPs results from prior exposure to reservation—once an SC holds the *pradhan* position, he or another SC is more likely to do so in the future. However, we see in the second row of panel A that GPs previously reserved for an SC *pradhan* are no more likely than others to have an SC *pradhan* in 2003.

[6]For the next election, every third GP starting with the second on the list was reserved for a woman, etc. The Panchayat Constitution Rule has actual tables indicating the ranks of the GPs to be reserved in each election.

[7]We are currently investigating the reason for this; this may be due to a data problem.

3.2.3 Data Collection

In the summer of 2000, we conducted a survey of all GPs in the district of Birbhum, West Bengal. Birbhum is located in the western part of West Bengal, about 125 miles from the state capital, Calcutta. At the time of the 1991 census, it had a population of 2.6 million. Agriculture is the main economic activity, and rice is the main crop. Male and female literacy rates were 50% and 37%, respectively. The district is known to have a relatively well-functioning *Panchayat* system.

There are 166 GPs in Birbhum, of which five were reserved for pre-testing, leaving 161 GPs in our study. Table 2 offers some descriptive statistics for the villages in our sample. We collected the data in two stages. First, interviewed the GP *pradhans*, asking each one a set of questions about his or her family background, education, previous political experience, and political ambitions, as well as a set of questions about the activities of the GP since his or her election in May 1998 (with support from written records). Table 3 summarizes the *pradhans'* characteristics in reserved and unreserved GPs. Of note, *pradhans* in reserved villages tend to have less education, lower literacy rates, live below the poverty line and have fewer household assets, and are less likely to have been elected to the GP council or to have known how the GP functioned before they were elected.

We then surveyed three villages in the GP: two randomly selected as well as the *pradhan's* own village. During the village interview, we drew a resource map of the village with a group of 10 to 20 villagers. The map featured all the available infrastructure in the village, and we asked whether each of the available public goods had been built or repaired since the previous election. Importantly, we collected the location of the investment and were able to allocate the good to a particular hamlet within the village. Previous experience of one of the authors, as well as experimentation during the pre-testing period, suggested that this method yields extremely accurate information about the village.

The following year, we conducted a second survey on public goods, this time covering all the villages in the 52 *Panchayats* where the position of *pradhan* is unreserved. The survey was very similar, but we collected some additional data on recipients of transfers programs and inequality in the village. This second round of data collection focused on the allocation of goods across villages within GPs.

Finally, in 2005, as part of a joint project with Lori Beaman, Rohini Pande, Petia Topalova designed to investigate the long-run impact of reservations, we collected very similar data from randomly selected villages in the same set of *Panchayats*. The data collection followed the same process as before, with a *pradhan* interview and mapping exercise in each villages.

Table 4 displays information about the availability of public goods in SC hamlets before 1998, when the reservation policy for *pradhans* was first implemented. We also display information on private goods that may substitute for public goods. Column 1 displays the absolute share of these goods in GPs that were not reserved for SCs between 1998 and 2003. Column 2 reports the same information for reserved GPs (standard errors are displayed in parentheses below the mean or the difference in the means). Because reservations were randomly assigned, we do not expect any significant difference in the initial allocation of public goods between reserved and unreserved GPs and do not find any in the data, which is reassuring. Two facts emerge from this table. First, there appears to be some discrimination against scheduled castes. On average, SCs get smaller share of public goods than non-SCs; they receive 29.7% of all public goods but comprise an average of 40.0% of the population in each village. The level of investment varies greatly across goods. SC hamlets appear to have relatively more of those public goods such drinking water wells, sanitation equipment (primarily latrines), and informal education centers over which the *Panchayat* has some budgetary authority and for which there are private substitutes. Second, for those goods on which we have data, water and irrigation, SC hamlets have significantly fewer privately provided equivalents of public goods.

3.3 SC reservation and Efficiency

3.3.1 Empirical Strategy

Owing to the randomization built into the reservation policy, the basic empirical strategy to determine whether SC *pradhans* build different goods or tends to place these goods in the SC hamlets is straightforward. The reduced form effect of the reservation status can be obtained by comparing the means of the outcomes of interest in reserved and unreserved GPs. Note that this reduced form difference is not an estimate of the comparison between a system with reservation and a system without reservation. The policy decisions in unreserved GPs can be different than what they would have been if there was no reservation whatsoever. They will be different, for example, in the presence of dynamic incentives which may induce a *pradhan* to behave differently knowing he can't be reelected to a seat that will be reserved in the next election. What we are trying to estimate is the effect of being reserved for a SC, rather than not reserved, *in a system where there is reservation.* In particular, it is possible that *pradhans* were not favoring their communities before the reservation, but they do so after the reservation because they are worried the other communities will do it.

3.3.1.1 Type and amount of goods provided

Denoting Y_{ij} as the value of the outcome of interest for good i (say, investment in drinking water between 1998 and 2000) in village j and R_j a dummy equal to 1 if the GP is reserved for an SC, the effect of reservation status is simply:

$$E[Y_{ij}|R_j = 1] - E[Y_{ij}|R_j = 0]. \qquad (3.1)$$

We run village-level regressions using only the data for the two randomly selected villages in each GP, since the *pradhans'* villages were not randomly selected and may be determined differently in reserved and unreserved GPs. We cluster errors at the GP level to account for possible correlation among villages.[7]

Since all the reserved GPs for this period have an SC *pradhan* and only very few of the unreserved GPs do, this reduced form coefficient is very close to the coefficient that one would obtain by using the reservation policy as an instrument for the *pradhans'* castes. We will therefore focus on the reduced form estimates, which are directly interpretable as the effect of the reservation policy.

3.3.1.2 Location of goods provided

We know from the resource maps where in the village public goods were located, therefore we can estimate whether reservation affected the placement of goods within the village. Specifically, were reserved villages more likely to place public goods investments in SC hamlets. Note that we exclude the village of the *pradhan* from this regression, so we are testing whether he or she tends to favor people from his/her ethnic group, not whether he is placing more goods in his own village.

The following expression gives the impact of the caste of the *pradhan* on the share of public goods that are located in the SC hamlet. Using the subscript s to denote investment in the SC hamlet, we have:

$$E[Y_{isj}/Y_{ij}|R_j = 1] - E[Y_{isj}/Y_{ij}|R_j = 0]. \tag{3.2}$$

Denoting s_{ij} the share of good i that is invested in the SC hamlet in village j such that

[7]The outcomes we consider are jointly determined, since they are linked by a budget constraint. However, because the regressor (R) is the same in all outcome equations, a joint estimation of the system of equations produces coefficients and standard errors numerically identical to OLS estimation equation-by-equation.

$s_{ij} = Y_{isj}/Y_{ij}$, the regression counterpart is:

$$s_{ij} = \alpha + \beta_i R_j + \varepsilon_{ij}. \tag{3.3}$$

We estimate these equations jointly across all goods.[8] Since we are interested in testing the hypothesis that, *on average* across all goods, SC pradhans invest a larger share of goods in SC hamlets than in non-SC hamlets, we then follow Kling, Liebman, and Katz (2007) and compute the average effect as the weighted average of all the coefficients β_i, using the number of observations for each goods as the weight. The standard errors of this weighted average are calculated using the covariance matrix obtained from estimating the equations for all the public goods as a system.

Equation 3.3 can be modified in a number of ways. First, we control for the share of the village population in the SC hamlet, since it is likely an important driver of the share of the investments that go to the hamlet:

$$s_{ij} = \alpha + \beta_i R_j + X_j \delta_i + \varepsilon_{ij}. \tag{3.4}$$

We first estimate equation 3.3 and 3.4 in the 2000 data. We then estimate a modified version in the 2005 data, controlling for prior reservation status:

$$s_{ij} = \alpha + \beta_{2i} R_j + \theta_i PR_j + X_j \delta_{2i} + \epsilon_{ij}, \tag{3.5}$$

where PR_j indicates whether the GP was reserved for a SC *pradhan* from 1998 to 2003. We then compute both β_2, the average of the β_{2i}s across different goods, and θ, the average of the θ_i across different goods. A negative θ would indicate that, after the reservation switch, the SC hamlet is penalized,while a positive θ would indicate a long-term positive effect of

[8]The standard errors are clustered at the GP level.

prior reservation.

Finally, we estimate equation 3.3 pool both rounds together, with and without controls for previous reservation status and for the share of the village population living in the SC hamlet.

The coefficient β gives us the average effect of reservation across all villages. The effect is likely to vary, however, depending on the proportion of the village population that resides in the SC hamlet. In particular, the GP may allocate the public goods on roughly a per capital basis, and SC *pradhans* may increase the allocation per capita in the SC hamlet. To capture these effects, we estimate the following equation for the effect of reservation on the allocation of public goods in the SC hamlet.

$$s_{ij} = \alpha_i + \beta_i R_j + \gamma_i \frac{P_{sj}}{P_j} + \delta_i R_j \frac{P_{sj}}{P_j}, \tag{3.6}$$

where P_{sj} represents the number of SC households in village j and P_j the total number of households in the village.

3.3.1.3 Efficiency of allocation

Previous work (Chattopadhyay and Duflo 2004) has shown that when an area is reserved for a female *pradhan* the allocation of public goods changes. This suggests that the allocation of public goods in the village is not efficient in a Coasian sense, since the villagers should choose public good to maximize their overall usefulness and then redistribute resources among themselves according to everyone's bargaining power. However, it is plausible that villagers are credit constrained, and weaker groups find it difficult to compensate the stronger with monetary transfers in order to get the mix of goods they want. In the case of women, the public good mix therefore *has* to change when women's bargaining power increases, since there is no other way to compensate them if they don't get goods more in line with their preferences.

For scheduled castes, however, there are two policy instruments: the type of public goods and their location. Recall that SCs tend to live in segregated hamlets. For public goods whose benefits are primarily local (e.g., wells) an efficient *Panchayat* that is restricted in its ability to extract monetary transfers will still deliver the efficient local bundle, but the size of the local bundle will depend on each group's relative bargaining power.

With the assumption that the preferences for public goods are homothetic, at least in the range that will be affected by the policy, we can derive a test of the hypothesis that the village administration efficiently allocates public goods. The idea of the test is that if the *Panchayat* administration knows what the SC population wants, it should give them the right mix of public goods. When the village becomes reserved for an SC and the SC *pradhan* is indeed successful at directing resources to SCs, they should receive more goods. But if the prior administration was efficient, any increase should be proportional across all goods.

To be concrete, assume that villagers have preferences over two goods, schools (S) and wells (W). Though it is not critical for the test, assume that all goods are specific to the hamlet. This assumption does not seem overwhelmingly restrictive, since we do not include in this test goods that are specified as being for "common use" irrespective of where they are located.

An efficient *Panchayat* maximizes $u^g(S^g, W^g) + \lambda u^{sc}(S^{sc}, W^{sc})$, subject to the budget constraints for the *Panchayat*: $p_S(S^g + S^{sc}) + p_W(W^g + W^{sc}) \leq B$

Reservation leads to an increase in bargaining power of SCs to $\lambda' > \lambda$. With homothetic preferences, this should lead to a proportional increase in S^{sc} and W^{sc}.

This gives us a simple test for efficiency. For any public goods i and k, it should be true that:

$$\frac{E[Y_{isj}/Y_{ij}|R_j = 1]}{E[Y_{isj}/Y_{ij}|R_j = 0]} = \frac{E[Y_{ksj}/Y_{kj}|R_j = 1]}{E[Y_{ksj}/Y_{kj}|R_j = 0]} \tag{3.7}$$

This expression can be evaluated using either simple averages of the allocation in treatment or control villages or, for increased precision, using predicted value of the shares for the village with the average population, using the parameters from equation 3.4 or from equation 3.6. Our main test uses the predicted allocations from this equation, computing the ratio for each good as:

$$\frac{\hat{\alpha}_i + \hat{\beta}_i + \hat{\gamma}_i\overline{SC} + \hat{\delta}_i\overline{SC}}{\hat{\alpha}_i + \hat{\gamma}_i\overline{SC}} \tag{3.8}$$

where $\overline{SC}$ is the population-weighted average share of SC households in the villages, 34%.

3.3.2 Results

Table 5 presents the results of estimating equation 3.1 at the village and GP levels for the first round of reservation, the second round, and both pooled together. Columns 3, 6, and 7 report the differences between reserved and unreserved villages in each sample. It appears that, unlike reservation for women, reservation for SC *pradhans* has little effect on the types of public goods provided. Only the coefficient on formal education is significant at the 5% level, and here only in the first round and when both rounds are pooled.

Table 6 presents the results of estimating equation 3.3 and 3.4 for the first round of reservation. We focus on column 4, which calculates the difference between reserved and unreserved GPs controlling for the share of SCs in the village. SC *pradhans* do invest more in SC areas. On average, the share of public goods built or repaired in SC hamlets is 10.9 percentage points higher in villages from reserved GPs. This difference is significant at the 1% level. When we look across the different types of public goods, there are no goods that the SC *pradhans* choose to reduce when they have more bargaining power. Out of six types of public goods investment, three (education, sanitation, and drinking water) are significantly higher in the SC hamlet at the 5% level, and the point estimates for two others (irrigation and informal education) are economically large but not significant at the 10% level.

There does not appear to be a commensurate reduction in private goods. The levels of private investment in drinking water and irrigation for SC hamlets are not significantly different in reserved and unreserved GPs. On balance, total investments in public goods and direct substitutes are 6.7 percentage points higher in reserved GPs.

Table 7 presents the coefficient of estimating equation 3.5, the impact of past and present reservations on investments realized between 2003 and 2005. Column 1 shows the proportion of goods invested in the SC hamlets in GPs that were neither reserved in 1998 (first election) nor in 2003. Column 2 shows the difference between these villages and those reserved in 2003 (coefficients β_{2i}). Column 3 shows the difference between these villages and those previously reserved in 1998 (coefficients θ_i). Columns 4 and 5 display the same calculations, but from a regression that controls for the share of SC population in the hamlet. Several things stand out in this table.

First, in the second round, investments in SC hamlets continue to be larger in reserved GPs (columns 2 and 4), although the overall effect is smaller than in the first round (5.1 percentage points compared to 10.9 in the first round) and only borderline statistically significant. As in the first round, the share of investment to the SC hamlet is higher for drinking water and education, though in contrast to the first round, the increase in educational investment appears most noticeably in informal education. Public irrigation investments in SC hamlets also increase substantially (10 percentage points), though the number is not significant. Sanitation shows a marked difference between rounds: the coefficient, which was positive in the first round, is now negative and insignificant, perhaps owing to a large district-wide latrine building initiative.[9]

Second, villages that were previously reserved for SCs and have now gone back to being unreserved do not experience a "backlash" against scheduled castes. On the contrary, controlling for the SC share of population (column 5), the share of all public goods placed in SC hamlets is 4.6 percentage in previously reserved GPs than in those that have never been reserved, roughly the same increase as for those GPs that are currently reserved. Although this is not significant, we can reject even a small negative effect. This fairly large positive effect is entirely driven by investment in formal education, which remain much higher in SC hamlets from previously reserved GPs. This is due both to repair of previously constructed buildings and to new construction. Of the five other public goods, three maintain positive coefficients and two are negative. None is close to being statistically significant. Villages in previously reserved GPs do experience a small reduction in private investment. Both private drinking water and private irrigation have negative coefficients, but neither is significant. On balance, with the exception of formal education, there do not appear to be long lasting effects from prior investment on current investment. Certainly, there is no evidence of a backlash against SCs.

Because future reservation status is known in advance, there is also the possibility of anticipatory behavior. *Pradhans* in currently unreserved GPs that will become reserved in the next election cycle could direct investment away from SC hamlets, offsetting future benefits. Table 8 compares public goods investments for unreserved GPs in the first round based on their reservation status in the next elections. If anything, there appears a tendency for soon-to-be reserved villages to receive a slightly larger share of investment, although when controlling for the share of SC population, none of the effects are significant at conventional

[9]The number of villages that had built latrines and the number they built changed radically across periods, from an average of 0.25 latrines built or repaired between 1998 and 2000 to an average of 15 latrines built or repaired between 2003 and 2005. During this second period, a special scheme for latrine construction provided subsidies from the *Panchayat* to anyone who contributed Rs. 200 to the cost of a latrine.

levels.

Table 9 pools both rounds, controlling for prior reservation status in the 2003 data, though the results are virtually identical without this. The average effect is an increase of 6.2 percentage points (significant at the 1% level) in the investment in public goods to the SC hamlet in the GP reserved for SC, and small, insignificant negative effects on private water, sanitation, and biogas investments. Public drinking water as well as both formal and informal education experience the largest gains. The effect on irrigation is also substantial, though it is not significant individually.

Table 10 presents the estimation of equation 3.6, where the effect of reservation is allowed to increase in proportion to the share of inhabitants of the SC hamlet. For most goods, reservation affects both the intercept and slope effect. Although the coefficients are not individually significant for only public drinking water and informal education, the weighted average effect at the mean represents an increase of 5.6 percentage points and is significant at the 1% level.

In row two of panel B, we present the ratios between the estimated share of investment going to an SC hamlet with average population in the reserved and unreserved GP. The ratios differ quite a bit from good to good, ranging from 0.569 for biogas to 1.748 for informal education. Using White's technique for seemingly unrelated estimation (see Appendix for details), we calculate the non-linear chi-squared statistic for the equality of the ratios. The chi-squared statistic (5 degrees of freedom) is 9.57 and we can reject the hypothesis of equality at the 10% level.

The next two rows of the panel examine the same ratios, but this time they are computed from the estimates in table 9 (simple difference in means, with and without controls for the GP population and its interaction with reservation status). The ratios are very similar to those computed starting from equation 3.6 and provide borderline rejections of equality; the p-values are now 6% and 14%.

There are, however, noticeable difference between the two rounds. Table 10a repeats the analysis above, restricting attention to the second round of data. Again, there is quite substantial variation in the calculated ratios but noticeably different investment patterns in education, sanitation, and biogas projects. As shown in the first row of panel B, the non-linear chi-squared statistic for the equality of the ratios across all six goods is fairly high (13.1, with 5 degrees of freedom) and rejects equality with a p-value of 0.02. The other specifications are noisier, but the ratios themselves are roughly consistent across all three versions.

It thus appears that reservation helps scheduled castes make their voices heard in two separate ways. First, they get a greater share of the pie, receiving a substantial increases in public goods investment when the *pradhan* shares their group identity. Second, there is suggestive evidence in the second round of our data that reservation helps SCs get their preferred part of the pie. Moreover, there does not appear to be a backlash after SCs lose the reservation or anticipatory redirection before they receive it. These gains are appear real and durable.

3.4 Rent Seeking

In this section, we ask the second question of the paper—"Do elected officials tend to allocate more goods to their own villages?"—using data collected in the summer 2001 covering public goods investments in all villages of 55 GPs where the position of *pradhan* was not reserved for either SCs, STs, or women.

3.4.1 Empirical Strategy

There is prima facie evidence that *pradhans* put more goods in their own village. Denote S_{ij} the share of public goods expenditure on good i for village k in *Panchayat* j, so that

$S_{ijk} = Y_{ijk}/Y_{ij}$, where Y_{ij} is the sum of investment in good i for all the villages of the Panchayat, P_j is the *Panchayat*'s population, and P_{jk} is village k's population. Column 1 of table 11 presents the estimates of β in a regression of the form

$$S_{ijk} = \alpha + \beta T_j + \gamma \frac{P_{ijk}}{P_{jk}} + \varepsilon_{ijk}, \tag{3.9}$$

where T_j is a dummy for whether the village is the *pradhan's* village. After account for different village sizes, *pradhans'* villages receive 5.2 percentage points more of all public goods than other villages. The effect is broadly distributed, but largest from biogas, sanitation, adult education and irrigation.

These results are not easily interpretable, however, since the *pradhan's* village is not randomly selected. The *pradhan* is chosen among all council members, and it is conceivable that the *pradhan's* village is just more powerful and better able to impose its preferences on others. This coefficient may therefore reflect the strength of the village rather than the *pradhan's* ability to extract goods for his own village.

To overcome this problem, we use the reservation system to construct a randomly assigned instrument for the *pradhan's* village. The instrument is based on the reservation of council seats at the village level. All the *pradhan* positions for the GPs in this data are unreserved. In almost all, the *pradhan* is a non-SC, non-ST male. This implies that the *pradhan* is very unlikely to originate from a village where the council seat is currently reserved for a woman, SC or ST. Suppose that a village is that of the previous *pradhan*. Because many incumbent *pradhans* continue in the position if they can, if the particular seat of the *pradhan* is currently unreserved, it is likely that the village is still the *pradhan's* village. But if this particular seat is now reserved, the previous *pradhan* cannot run as council member, unless he happens to be from the category for which the seat is reserved. This is very unlikely as few women, SCs or STs rise to the position of *pradhan* without reservation. Therefore, if his seat is now reserved, he cannot be *pradhan* again, and the village is less likely to remain the *pradhan's* village than had his seat been unreserved.[10]

Reservation of seats is randomly assigned at the council level, which suggests using seat reservation status as an instrument for the *pradhan's* village. However, there may also be a direct effect of the reservation of the village council seat on the allocation of public goods to a village. For example, female, SC or ST council members may be less able to bargain for public goods, so reservation may have a direct negative effect on public investment irrespective of its effects on reducing a village's chances to be the *pradhan's* village. To control for this, we include a dummy for reservation of the village's ward(s). In effect, the strategy is a differences-in-differences, where we allow for a direct impact of reservation of the seat in public good allocation, but ask whether there is a larger negative impact in villages which used to be the *pradhan's* village.

To summarize, we run the following regressions. The first-stage regression is:

$$T_{jk} = \pi_1 + \pi_2 L_{jk} + \pi_3 Z_{kj} L_{kj} + \sum_{l=1}^{5} N_{jkl}\gamma_l + \sum_{l=1}^{5} N_{jkl} * Z_{jkl}\lambda_l, \tag{3.10}$$

where T_{jk} is a dummy for whether or not village k in GP j is the *pradhan's* village, L_{jk} is a dummy for whether or not village k in GP j is the previous *pradhan's* village, Z_{kj} is a variable indicating whether or not the previous *pradhan's* seat is now reserved, [11] N_{jkl} is a dummy indicating whether ward l exists in village k in GP j,[12] and Z_{jkl} is a dummy indicating whether ward l, if it exists, is now reserved. The coefficient of interest in the first-stage equation is π_3, which tells us whether or not a previous *pradhan's* village where

[10]If the village has more than one seat (most villages in our data have only one), it may be possible for this village to be the new *pradhan's* village, if the new *pradhan* is the council member elected from another ward in the same village. But in general, previous *pradhan's* villages where the previous *pradhan's* seat is now reserved will be less likely to be the *pradhan's* village than previous *pradhan's* villages where the previous *pradhan's* seat is unreserved.

[11]The interaction $Z_{kj}L_{kj}$ is always defined, since it is equal to zero if the village is not the previous *pradhan*'s village

[12]Most villages have only one ward, but some have up to five.

the *pradhan's* seat is now reserved is more or less likely to remain the *pradhan's* village than one where the seat is not reserved.

The reduced-form equation for good i is simply:

$$S_{ijk} = \pi_{i1} + \pi_{i2}L_{jk} + \pi_{i3}Z_{kj}L_{kj} + \sum_{l=1}^{5} N_{jkl}\gamma_{il} + \sum_{l=1}^{5} N_{jkl} * Z_{jkl}\lambda_{il}. \tag{3.11}$$

Again, the coefficient of interest is π_{i3} which tells us whether, controlling for the direct effect of being reserved, village k which used to be the *pradhan's* village get a smaller share of public goods than a village that used to be *pradhan* village and remained unreserved.

The structural equation of interest is:

$$S_{ijk} = \delta_{i1} + \delta_{i2}L_{jk} + \delta_{3i}T_{jk} + \sum_{l=1}^{5} N_{jkl}\gamma_{il} + \sum_{l=1}^{5} N_{jkl} * Z_{jkl}\lambda_{il}. \tag{3.12}$$

We estimate this equation with OLS and by instrumental variables, where the excluded instrument is the interaction $Z_{kj}L_{kj}$. The coefficient of interest is δ_{3i}, which tells us whether a village that was not randomly rotated out of being a *pradhan's* village gets more public goods than one that was. It is important that the effect is estimated for the subset of villages that used to be *pradhan's* village as it is possible that the effect of the being the *pradhan's* village is different for strong and weak villages.

3.4.2 Results

Table 12 shows the results of the first stage regression. Indeed, being a village where the seat of the previous *pradhan* is reserved reduces the likelihood of being the current *pradhan's* village by 22.0%. The result is significant at the 1% level.

As described above, column 1 of table 11 estimates

$$S_{ijk} = \pi_{i1} + \delta T_{jk} + \sum_{l=1}^{5} N_{jkl}\gamma_{il} + \sum_{l=1}^{5} N_{jkl} * Z_{jkl}\lambda_{il} + \phi\frac{P_{ijk}}{P_{jk}}$$

and confirms that *pradhans'* villages do in fact receive on average 5.2% more public goods than non-*pradhan* villages, when weighting the average by the number of observations for each good.

Column 2 adds an indicator for the village of the previous *pradhan*, estimating

$$S_{ijk} = \pi_{i1} + \delta T_{jk} + \pi L_{jk} + \sum_{l=1}^{5} N_{jkl}\gamma_{il} + \sum_{l=1}^{5} N_{jkl} * Z_{jkl}\lambda_{il} + \phi\frac{P_{ijk}}{P_{jk}}$$

with OLS. The coefficient of the current *pradhan's* village remains positive and significant. Column 3 reports the reduced-form coefficients, π_{i3}, for the estimation of equation 3.11. Only the coefficients on biogas projects and health facilities, 33.0% and -77.0%, respectively, are significant at the 5% level, however these are two goods for which very few GPs have any sort of investment.[13] Contrary to the OLS results, the weighted average is insignificant and indistinguishable from 0. This suggest that the previous-*pradhan* effect reflected village selection, rather than the causal effect of being the *pradhan's* village. The previous *pradhan's* village is as likely to receive public goods investments if it is currently reserved (and therefore no longer the *pradhan's* village) as when it is not.

Column 4 in table 11 shows the instrumental variable estimates of the effect of being the *pradhan's* village on the share of public goods received by the village. After instrumenting, only the coefficient on biogas projects remains significant, and it suggests that *pradhans* are *less* likely to put such projects in their own villages. The remaining coefficients loose signifi-

[13]Note that because villages for which the previous *pradhan*'s seat is reserved are *less* likely to be the village of the current *pradhan*, a positive coefficient in the reduced form implies that *pradhans* are putting *less* of the good in their own village.

cance, while the average is statistically indistinguishable from zero. Overall, these estimates do not suggest that the *pradhan's* village receive any more goods than other villages, while strong villages have the power to affect public good allocations, irrespective of whether they actually have the *pradhan's* post. However, the standard errors of these estimates are so large that it hardly a firm conclusion. Additional evidence is needed to provide a conclusive answer to this question.

3.5 Conclusion

This paper establishes that mandated representation of scheduled castes increases the share of public goods they receive. This suggests that it is possible to effect redistribution to disadvantaged groups by ensuring they have a voice in decision making.

Moreover, the paper suggest that local governments may not efficiently elicit and respond to the preferences of disadvantage groups. When the bargaining power of scheduled castes increases through mandated representation, their share of public goods increase, and this increase in not proportional across goods. This suggests that there may have been misallocation of resources within the goods they received in the absence of agency.

Like previous work by two of the authors on reservations for women, this study confirms that *pradhans* have decision making power. Policies that seek to influence the identity of these leaders will therefore have a direct impact on the distribution of goods within the village. However, decision making authority does not appear to lead to gross capture of public goods by the politically empowered. While villages of the current *pradhan* receive more public goods than others, this effect disappears when correctly instrumenting for selection as the *pradhan's* village. Strong villages are both more likely place one of their citizens as a *pradhan* and to garner a larger share of public goods, but we find no evidence that *pradhans* themselves are abusing their power to redirect spending to their own villages. An additional effect of reservation is to take away power from the strong villages, since SC *pradhans* tend to be poorer and come from smaller villages. Taken as a whole, these results suggest that mandated representation for politically disadvantaged groups can be an effective policy tool.

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Table 1: Fraction of Underrepresented Constituencies among Pradhans in Reserved and Unreserved GPs

	Reserved GP	Unreserved GP	Difference
	(1)	(2)	(3)
A. Effect of 1998 Reservation			
Short Term			
Total Seats in 1998 election	52	109	
Scheduled Caste Seats	52	11	
% Scheduled Caste	100.0%	10.1%	89.9%
Long Term			
Total unreserved seats in 2003 election	49	63	
Scheduled castes seats	11	14	
	22.4%	22.2%	0.2%
B. Effect of 2003 Reservation			
Total Seats	49	112	
Scheduled Caste Seats	45	25	
	91.8%	22.3%	69.5%

Table 2: Village Characteristics of Reserved and Unreserved GPs (1991 census, 1998 reservation)

	Scheduled Caste		
	Unreserved	Reserved	Difference
	(1)	(2)	(3)
A. GP Level			
Total Population	12,985	13,193	207
			(666)
Number of public health facilities	0.98	0.90	-0.08
			(0.26)
Number of health facilities (total)	6.78	6.75	-0.03
			(1.11)
Number of Hospitals	0.06	0.06	0.00
			(0.05)
Number of High Schools	1.10	1.69	0.59
			(0.29)
Number of Middle Schools	0.62	0.71	0.09
			(0.13)
Number of Primary Schools	11.88	11.85	-0.03
			(0.90)
B. Village level			
Total Population	985	1,079	94
			(82)
Female Literacy Rate	0.35	0.35	0.00
			(0.01)
Male Literacy Rate	0.57	0.58	0.01
			(0.01)
% Cultivated land that is irrigated	0.43	0.45	0.02
			(0.04)
Pucca Road	0.16	0.16	0.00
			(0.03)
Bus or train stop	0.28	0.28	0.00
			(0.04)
Number of public health facilities	0.07	0.07	0.00
			(0.02)
Number of tubewells and hand pumps	1.11	1.29	0.18
			(0.16)
Number of drinking water wells	0.45	0.48	0.03
			(0.08)
Number of Primary Schools	0.90	0.97	0.07
			(0.06)
Number of Middle Schools	0.05	0.06	0.01
			(0.01)
Number of High Schools	0.08	0.14	0.05
			(0.03)

Notes:
(1) n=2073 for village-level statistics and 161 for GP-level. ST-reserved GPs included.
(2) Village standard errors in parentheses are corrected for clustering at the GP level.

Table 3: Pradhan's Characteristics in Reserved and Unreserved GP (2000 Pradhans)

	GP Mean		
	Reserved	Unreserved	Difference
	(1)	(2)	(3)
A. PRADHAN'S BACKGROUND			
Age	36.00	37.61	-1.61
	(1.35)	(0.89)	(1.61)
Years of Education	7.92	9.49	-1.56
	(0.52)	(0.31)	(0.60)
Literacy	0.85	0.95	-0.11
	(0.05)	(0.02)	(0.05)
Married	0.92	0.85	0.07
	(0.04)	(0.03)	(0.05)
Number of children	2.22	2.62	-0.40
	(0.18)	(0.16)	(0.24)
Below poverty line	0.56	0.24	0.32
	(0.07)	(0.04)	(0.08)
Number of household assets	1.48	2.47	-0.99
	(0.17)	(0.14)	(0.21)
Population of Pradhan's own village	1866	1948	-81
	(249)	(168)	(300)
Hesitates when answering the questions (interviewer's impression)	0.76	0.43	0.33
	(0.06)	(0.05)	(0.08)
B. PRADHAN'S POLITICAL ASPIRATIONS AND EXPERIENCE			
Was elected to the GP council before 1998	0.13	0.41	-0.28
	(0.05)	(0.05)	(0.07)
Was elected Pradhan before 1998	0.00	0.12	-0.12
		(0.03)	(0.03)
Took part in Panchayat activities prior to being elected	0.63	0.60	0.04
	(0.07)	(0.05)	(0.08)
Knew how GP functioned	0.12	0.28	-0.17
	(0.04)	(0.04)	(0.06)
Did not receive any formal training	0.02	0.02	0.00
	(0.02)	(0.01)	(0.02)
Will not run again	0.27	0.24	0.03
	(0.06)	(0.04)	(0.07)
C. PRADHAN'S POLITICAL PARTY			
Left Front	0.71	0.68	0.03
	(0.06)	(0.05)	(0.08)
Right (Trinamul or BJP)	0.21	0.17	0.05
	(0.06)	(0.04)	(0.07)
Observations	52	109	

Notes:
(1) Village standard errors in parentheses are corrected for clustering at the GP level.

Table 4: Absolute Initial Public Goods Allocations in Reserved & Unreserved GPs [1][2]

	Absolute Share of Public Goods Available Before 1998 in SC Hamlets			
	Unreserved	Reserved	Difference	Diff Cont for Share SC
	(1)	(2)	(3)	(4)
Public Goods Available				
Public Drinking Water	0.369	0.338	-0.031	-0.008
	(0.020)	(0.028)	(0.034)	(0.028)
Private Drinking Water	0.140	0.146	0.006	0.025
	(0.019)	(0.028)	(0.034)	(0.033)
Public Irrigation	0.234	0.227	-0.007	0.004
	(0.025)	(0.033)	(0.041)	(0.036)
Private Irrigation	0.169	0.126	-0.043	-0.031
	(0.028)	(0.036)	(0.045)	(0.037)
Informal Education	0.395	0.353	-0.042	-0.001
	(0.037)	(0.056)	(0.067)	(0.061)
Formal Primary & Secondary Schools	0.261	0.278	0.017	0.035
	(0.030)	(0.049)	(0.058)	(0.053)
Sanitation	0.463	0.500	0.037	0.049
	(0.075)	(0.137)	(0.156)	(0.153)
Biogas	0.147	0.129	-0.019	-0.014
	(0.026)	(0.041)	(0.049)	(0.044)
Averages				
Wtd. Average all goods[3]	0.261	0.248	-0.013	0.006
	(0.015)	(0.026)	(0.030)	(0.023)
Wtd. Average all public goods[3][4]	0.297	0.283	-0.014	0.006
	(0.016)	(0.029)	(0.033)	(0.026)
Wtd. Average all private goods[3]	0.150	0.139	-0.011	0.006
	(0.018)	(0.027)	(0.033)	(0.028)

Notes:

(1) Excludes with no SC households. Excludes pradhan villages.

(2) Standard errors in parentheses corrected for clustering at the GP level. Errors for averages calculated using maximum likelihood seemingly unrelated estimation.

(3) Weighted by number of observations.

(4) Public goods comprise public drinking water and irrigation, education, sanitation and biogas.

Table 5: Effect of SC Reservation on the Types of Village-level Public Goods Provided

	2000			2005			2000 & 2(pooled
	Unreserved	Reserved	Difference	Unreserved	Reserved	Difference	Differen
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ing water facilities built or repaired	16.35	22.85	6.50	15.36	13.55	-1.81	1.54
	(2.20)	(4.36)	(4.88)	(1.98)	(1.84)	(2.71)	(2.66)
: drinking water facilities built or repaired	7.90	7.26	-0.64	7.33	6.91	-0.42	-0.50
	(0.94)	(0.88)	(1.28)	(0.93)	(0.75)	(1.19)	(0.98)
e drinking water facilities built or repaired	9.20	15.87	6.67	8.19	7.12	-1.07	2.05
	(1.75)	(3.72)	(4.11)	(1.44)	(1.60)	(2.16)	(2.18)
:ion facilities built or repaired	3.15	4.24	1.09	2.10	1.72	-0.38	0.22
	(0.61)	(1.42)	(1.54)	(0.52)	(0.39)	(0.65)	(0.78)
: irrigation facilities built or repaired	0.31	0.39	0.08	0.90	0.60	-0.30	-0.15
	(0.08)	(0.14)	(0.16)	(0.19)	(0.19)	(0.27)	(0.18)
e irrigation facilities built or repaired	2.83	3.85	1.01	1.20	1.13	-0.07	0.38
	(0.61)	(1.39)	(1.52)	(0.47)	(0.28)	(0.55)	(0.73)
tion facilities, built or repaired	0.25	0.38	0.13	14.96	10.00	-4.96	-3.03
	(0.08)	(0.14)	(0.17)	(3.84)	(2.20)	(4.43)	(2.83)
›iogas facilities	0.52	1.46	0.95	0.64	0.51	-0.12	0.31
	(0.16)	(0.54)	(0.57)	(0.17)	(0.20)	(0.26)	(0.28)
ıal ed. centers built or repaired	0.23	0.21	-0.03	0.17	0.20	0.03	0.01
	(0.04)	(0.07)	(0.08)	(0.03)	(0.05)	(0.06)	(0.05)
.l school buildings built or repaired	0.46	0.72	0.26	0.43	0.47	0.04	0.13
	(0.05)	(0.12)	(0.13)	(0.05)	(0.08)	(0.09)	(0.07)
	205	97	302	315	144	459	761

:s villages reserved for ST. Excludes pradhan villages from 2000 survey.
:d errors given in parentheses, corrected for clustering at the GP level

Table 6: Effect of SC Reservation on Share of Public Goods Built or Repaired Since 1998 [1]

	Absolute Share of Goods Built or Repaired in SC Hamlets			
	Unreserved	Reserved	Difference	Diff. Controlling for Share SC
	(1)	(2)	(3)	(4)
Goods Built or Repaired				
Public Drinking Water	0.360	0.409	0.049	0.079
	(0.022)	(0.041)	(0.046)	(0.037)
Private Drinking Water	0.157	0.130	-0.026	-0.001
	(0.024)	(0.032)	(0.040)	(0.039)
Public Irrigation	0.252	0.298	0.046	0.133
	(0.072)	(0.095)	(0.119)	(0.088)
Private Irrigation	0.168	0.186	0.018	0.007
	(0.037)	(0.057)	(0.068)	(0.059)
Informal Education	0.263	0.338	0.076	0.062
	(0.067)	(0.105)	(0.124)	(0.115)
Formal Primary & Secondary Schools	0.213	0.335	0.122	0.181
	(0.047)	(0.072)	(0.086)	(0.082)
Sanitation	0.525	0.751	0.226	0.303
	(0.074)	(0.114)	(0.136)	(0.126)
Biogas	0.198	0.150	-0.049	-0.009
	(0.071)	(0.076)	(0.104)	(0.101)
Averages[2]				
Wtd. Average all goods[4]	0.253	0.292	0.039	0.070
	(0.017)	(0.024)	(0.030)	(0.023)
Wtd. Average all public goods[3] [4]	0.305	0.373	0.068	0.109
	(0.020)	(0.033)	(0.039)	(0.030)
Wtd. Average all private goods[4]	0.160	0.149	-0.012	0.001
	(0.022)	(0.030)	(0.037)	(0.034)

Notes:

(1) Includes villages reserved for ST. Excludes pradhan villages.

(2) Standard errors in parentheses and corrected for clustering at the GP level. Errors for averages calculated using maximum likelihood seemingly unrelated estimation.

(3) Public goods comprise public drinking water and irrigation, education, health facilities, sanitation and biogas.

(4) Weighted by number of observations.

Table 7: Effect of SC Reservation on Share of Public Goods Built or Repaired, 2003-2005[1]

	Absolute Share of Goods Built or Repaired in SC Hamlets				
	No controls			Controlling for SC population share	
		Difference		Difference	
	Never Reserved (constant)	Reserved-Never Reserved	Previously Reserved-Never Reserved	Reserved-Never Reserved	Previously Reserved-Never Reserved
	(1)	(2)	(3)	(4)	(5)
Goods Built or Repaired					
Public Drinking Water	0.286	0.080	0.029	0.064	0.027
	(0.027)	(0.040)	(0.041)	(0.036)	(0.037)
Private Drinking Water	0.201	-0.029	-0.037	-0.046	-0.043
	(0.029)	(0.051)	(0.043)	(0.040)	(0.039)
Public Irrigation	0.118	0.102	0.100	0.099	0.085
	(0.051)	(0.085)	(0.080)	(0.085)	(0.075)
Private Irrigation	0.160	0.014	-0.113	0.041	-0.097
	(0.059)	(0.083)	(0.073)	(0.086)	(0.073)
Informal Education	0.281	0.263	0.020	0.274	0.035
	(0.089)	(0.133)	(0.128)	(0.132)	(0.118)
Formal Primary & Secondary Schools	0.110	0.072	0.159	0.073	0.168
	(0.046)	(0.077)	(0.075)	(0.076)	(0.071)
Sanitation	0.297	-0.028	-0.028	-0.031	-0.024
	(0.041)	(0.058)	(0.055)	(0.052)	(0.052)
Biogas	0.218	-0.115	0.111	-0.120	0.037
	(0.068)	(0.099)	(0.121)	(0.073)	(0.097)
Averages[2]					
Wtd. Average all goods[4]	0.226	0.041	0.025	0.035	0.022
	(0.021)	(0.032)	(0.030)	(0.024)	(0.022)
Wtd. Average all public goods[3] [4]	0.237	0.058	0.049	0.051	0.046
	(0.023)	(0.035)	(0.034)	(0.028)	(0.027)
Wtd. Average all private goods[4]	0.189	-0.016	-0.059	-0.021	-0.059
	(0.027)	(0.045)	(0.038)	(0.037)	(0.035)

Notes:

(1) Drops villages with no SC households. Includes villages reserved for ST. Includes pradhan villages.

(2) Source: C:\Documents and Settings\Fish\My Documents\Research\EstherSCST\2008Update\do\06Table7.do

(3) Public goods comprise public drinking water and irrigation, education, health facilities, sanitation and biogas.

(4) Weighted by number of observations.

Table 8: Absolute Share of Public Goods Allocations in Unreserved GPs [1][2]
Based on Future Reservation Status

	Absolute Share of Public Goods Built or Repaired in SC Hamlets			
	Future Reservation Status			
	Unreserved	Reserved	Difference	Diff Cont for Share SC
	(1)	(2)	(3)	(4)
Public Goods Available				
Public Drinking Water	0.350	0.356	0.007	0.025
	(0.029)	(0.034)	(0.045)	(0.035)
Private Drinking Water	0.141	0.175	0.034	0.057
	(0.032)	(0.038)	(0.050)	(0.040)
Public Irrigation	0.184	0.350	0.166	0.086
	(0.079)	(0.129)	(0.151)	(0.045)
Private Irrigation	0.149	0.192	0.043	-0.063
	(0.057)	(0.051)	(0.077)	(0.051)
Informal Education	0.280	0.227	-0.053	-0.069
	(0.086)	(0.108)	(0.138)	(0.074)
Formal Primary & Secondary Schools	0.174	0.217	0.042	0.089
	(0.054)	(0.073)	(0.091)	(0.061)
Sanitation	0.356	0.674	0.318	0.126
	(0.090)	(0.100)	(0.135)	(0.141)
Biogas	0.256	0.124	-0.131	-0.048
	(0.115)	(0.075)	(0.138)	(0.052)
Averages				
Wtd. Average all goods[3]	0.235	0.266	0.031	0.027
	(0.023)	(0.025)	(0.034)	(0.026)
Wtd. Average all public goods[3][4]	0.286	0.314	0.028	0.030
	(0.028)	(0.026)	(0.038)	(0.028)
Wtd. Average all private goods[3]	0.144	0.181	0.037	0.017
	(0.027)	(0.036)	(0.045)	(0.034)

Notes:

(1) Excludes villages in currently reserved GPs, with no SC households. Excludes pradhan villages.

(2) Standard errors in parentheses corrected for clustering at the GP level. Errors for averages calculated using maximum likelihood seemingly unrelated estimation.

(3) Weighted by number of observations.

(4) Public goods comprise public drinking water and irrigation, education, sanitation and biogas.

Table 9: Effect of SC Reservation on Share of Public Goods Built or Repaired during Pradhan's Tenure, Pooled Data[1]

	Absolute Share of Goods Built or Repaired in SC Hamlets			
	Unreserved	Reserved	Difference	Diff. Controlling for Share SC
	(1)	(2)	(3)	(4)
Goods Built or Repaired				
Public Drinking Water	0.329	0.382	0.053	0.055
	(0.017)	(0.025)	(0.027)	(0.025)
Private Drinking Water	0.172	0.149	-0.023	-0.013
	(0.021)	(0.027)	(0.029)	(0.028)
Public Irrigation	0.178	0.250	0.072	0.090
	(0.046)	(0.056)	(0.073)	(0.069)
Private Irrigation	0.166	0.180	0.015	0.018
	(0.030)	(0.042)	(0.051)	(0.047)
Informal Education	0.267	0.462	0.194	0.196
	(0.056)	(0.078)	(0.092)	(0.090)
Formal Primary & Secondary Schools	0.169	0.257	0.088	0.108
	(0.033)	(0.050)	(0.060)	(0.059)
Sanitation	0.340	0.335	-0.005	-0.003
	(0.038)	(0.045)	(0.058)	(0.055)
Biogas	0.208	0.125	-0.083	-0.057
	(0.049)	(0.054)	(0.073)	(0.061)
Averages[2]				
Wtd. Average all goods[4]	0.244	0.280	0.035	0.044
	(0.014)	(0.018)	(0.022)	(0.019)
Wtd. Average all public goods[3] [4]	0.274	0.327	0.054	0.062
	(0.017)	(0.021)	(0.027)	(0.023)
Wtd. Average all private goods[4]	0.170	0.159	-0.011	-0.003
	(0.018)	(0.024)	(0.027)	(0.026)

Notes:

(1) Excludes villages with no SC households and pradhan villages from the 2000 survey. Includes villages in ST-reserved GPs.

(2) Standard errors in parentheses corrected for clustering at the GP level. Errors for averages calculated using maximum likelihood seemingly unrelated estimation.

(3) Public goods comprise public drinking water and irrigation, education, health facilities, sanitation and biogas.

(4) Weighted by number of observations.

Table 10: Efficiency of Public Goods Investments

	Absolute Share of Good in SC Hamlets						
	Public Drinking Water	Public Irrigation	Informal Education	Formal Primary & Secondary Schools	Sanitation	Biogas	
	(1)	(2)	(3)	(4)	(5)	(6)	
ameter Estimates							
;erved for Scheduled Caste (a)	-0.011	0.079	0.222	-0.050	0.021	-0.031	
	(0.039)	(0.107)	(0.156)	(0.096)	(0.090)	(0.087)	
;C Households in Village (b)	0.555	0.537	0.549	0.252	0.498	0.755	
	(0.068)	(0.150)	(0.245)	(0.127)	(0.125)	(0.170)	
;ervation x % SC Households (c)	0.166	0.012	-0.081	0.367	0.016	-0.094	
	(0.101)	(0.317)	(0.416)	(0.240)	(0.210)	(0.251)	
ıstant (d)	0.098	-0.024	0.071	0.093	0.109	-0.114	
	(0.026)	(0.048)	(0.084)	(0.051)	(0.049)	(0.073)	
:nber of Observations	580	135	107	269	229	95	
culated Effects							Mean
ɛct of Reservation at Mean(2)	0.047	0.083	0.195	0.076	0.027	-0.063	0.056
	(0.024)	(0.063)	(0.088)	(0.057)	(0.050)	(0.049)	(0.022)
							Chi2 test for Equality(4)
io (Reserved:Unreserved) at mean(2) (3)	1.161	1.515	1.748	1.424	1.095	0.569	9.57
	(0.088)	(0.439)	(0.409)	(0.355)	(0.183)	(0.251)	0.088
io without controls for % SC or ıteraction term	1.164	1.323	1.693	1.344	1.079	0.554	10.60
	(0.088)	(0.403)	(0.406)	(0.332)	(0.177)	(0.243)	0.060
io without interaction term	1.197	1.517	1.737	1.466	1.099	0.527	8.39
	(0.095)	(0.463)	(0.420)	(0.371)	(0.185)	(0.293)	0.136

ludes villages with no SC households and pradhan's villages from the 2000 survey. Includes villages in ST-reserved GPs.
ıdard errors corrected for clustering at the GP-level. Standard errors for ratio and the test for equality are based on maximum likelihood, seemingly unrelated estimation.
Appendix for detailed description.
;o = (a + b*SC% + c*SC% + d)/(d + b*SC%) where SC% is weighted average SC share of households, which equals .3447.
-squared test for equality reports test statistic and p-value with 5 degrees of freedom.

Table 10a: Efficiency of Public Goods Investments, 2003 Survey Only

	Absolute Share of Good in SC Hamlets						
	Public Drinking Water	Public Irrigation	Informal Education	Formal Primary & Secondary Schools	Sanitation	Biogas	
	(1)	(2)	(3)	(4)	(5)	(6)	
ameter Estimates							
served for Scheduled Caste (a)	0.050	0.246	0.477	0.090	-0.096	0.002	
	(0.060)	(0.157)	(0.245)	(0.125)	(0.075)	(0.109)	
SC Households in Village (b)	0.602	0.480	0.685	0.336	0.486	1.004	
	(0.103)	(0.193)	(0.353)	(0.164)	(0.125)	(0.168)	
servation x % SC Households (c)	-0.020	-0.456	-0.553	-0.206	0.185	-0.310	
	(0.155)	(0.380)	(0.654)	(0.292)	(0.186)	(0.346)	
istant (d)	0.056	-0.026	0.022	0.056	0.086	-0.183	
	(0.035)	(0.061)	(0.118)	(0.054)	(0.048)	(0.070)	
mber of Observations	327	91	61	152	203	53	
culated Effects							Mean
ect of Reservation at Mean(2)	0.043	0.090	0.288	0.019	-0.033	-0.105	0.034
	(0.032)	(0.078)	(0.125)	(0.076)	(0.045)	(0.057)	(0.027)
							Chi2 test for Equality(4)
io (Reserved:Unreserved) at mean(2) (3)	1.164	1.656	2.122	1.112	0.871	0.347	13.06
	(0.127)	(0.633)	(0.632)	(0.448)	(0.171)	(0.234)	0.023
io without controls for % SC or iteraction term	1.193	1.412	1.905	1.082	0.947	0.425	8.14
	(0.134)	(0.542)	(0.591)	(0.431)	(0.181)	(0.301)	0.149
io without interaction term	1.158	1.486	2.010	1.070	0.921	0.239	10.18
	(0.140)	(0.615)	(0.633)	(0.447)	(0.187)	(0.292)	0.070

ludes villages with no SC households and pradhan's villages from the 2000 survey. Includes villages in ST-reserved GPs.
idard errors corrected for clustering at the GP-level. Standard errors for ratio and the test for equality are based on maximum likelihood, seemingly unrelated estimation. Appendix for detailed description.
o = (a + b*SC% + c*SC% + d)/(d + b*SC%) where SC% is weighted average SC share of households, which equals .3421.
squared test for equality reports test statistic and p-value with 5 degrees of freedom.

Table 11: Allocation to Pradhans' Villages

	OLS		Reduced Form	2SLS
	Pradhan's Village	Pradhan's Village	Previous Pradhan's Seat is Reserved	Pradhan's Village
	(1)	(2)	(3)	(4)
Public Goods, Share of:				
Public Drinking Water	0.030	0.029	0.037	-0.169
	(0.013)	(0.013)	(0.023)	(0.126)
Public Irrigation	0.095	0.064	-0.049	0.128
	(0.045)	(0.046)	(0.081)	(0.208)
Informal Education	0.019	0.023	0.014	-0.067
	(0.029)	(0.030)	(0.052)	(0.257)
Formal Primary & Secondary Schools	0.017	0.013	-0.026	0.119
	(0.010)	(0.010)	(0.018)	(0.090)
Adult Education Programs	0.086	0.049	0.129	-0.493
	(0.079)	(0.084)	(0.149)	(0.647)
Health Facilities	0.026	-0.168	-0.770	5.054
	(0.240)	(0.209)	(0.227)	(7.645)
Sanitation	0.053	0.056	0.001	-0.006
	(0.042)	(0.042)	(0.072)	(0.341)
Biogas	0.211	0.194	0.330	-0.818
	(0.067)	(0.068)	(0.114)	(0.395)
Roads	0.039	0.035	-0.017	0.069
	(0.019)	(0.019)	(0.034)	(0.140)
Weighted Average	0.052	0.043	0.015	-0.009
	(0.017)	(0.017)	(0.033)	(0.175)
Employment, Share of:				
# workers in public works projects	0.031	0.038	-0.036	0.166
	(0.023)	(0.023)	(0.040)	(0.187)
Person-day in EGS(3)	-0.014	-0.017	0.177	-0.683
	(0.109)	(0.110)	(0.198)	(0.899)
Person-days in public works projects	0.036	0.033	-0.030	0.135
	(0.021)	(0.021)	(0.037)	(0.170)
Control Variables				
Number of Seats in Village	Yes	Yes	Yes	Yes
Number of Reserved Seats in Village	Yes	Yes	Yes	Yes
Village share of GP Households	Yes	Yes	Yes	Yes
Village of Previous Pradhan	No	Yes	Yes	Instrument

Notes:

(1) Reported values are the coefficient of the variable in the column heading (Pradhan's Village or Previous Pradhan's Seat Reserved), in the regression of the dependent variable on this and the listed control variables.

(2) Standard errors for averages are based on maximum likelihood, seemingly unrelated estimation.

(3) Employment generation schemes.

Table 12: First Stage

Variable	Pradhan's Village (1)
Previous pradhan's village	0.281
	(0.059)
Village of previous pradhan reserved	-0.220
	(0.074)
Village share of households	0.116
	(0.174)
Number of observations	574

Notes:

(1) Standard errors corrected for clustering at the GP-level.

(2) First-stage R-squared equals 0.162.

A Testing Cross-equation Restrictions

In order to test cross-equation restrictions, models are estimated jointly using the seemingly unrelated estimation technique proposed by White (1982) and White (1994), which utilizes the scores obtained from equation-by-equation maximum likelihood estimation of the set of equations to allow testing of cross-equation restrictions in the presence of non-overlapping observations.

Assume we have estimated K different models where the estimators $\widehat{\beta}_k$ are defined as the solutions to

$$L_j = \sum_i w_{ik} s_{ik}(\widehat{\beta}_k) = 0, \qquad k = 1, ..., K, \tag{3.13}$$

where s_{ik} is the score, the derivative of the log likelihood, associated with observation i in equation k, w_{ik} is a set of weights with $w_{ik} = \frac{1}{n_k}$ if observation i is included in estimation estimating equation k and $w_{ik} = 0$ otherwise, and n_k is the number of observations available to estimate equation k. Under regularity conditions (see White (1982) and White (1994)), the variance of the parameter vector can be consistently estimated by

$$\text{var}(\widehat{\beta}_k) = \hat{J}_k^{-1} \sum_i w_{ik} s_{ik} s_{ik}^{'} \; \hat{J}_k^{-1}, \tag{3.14}$$

where $\hat{J}_k$ is the Jacobian of L_k evaluated at $\widehat{\beta}_k$ which consistently estimates the Fisher information matrix J_k. If the model is correctly specified, then $\sum_i w_{ik} s_{ik} s_{ik}^{'} \underset{p}{\rightarrow} J_k$, and $\text{var}(\widehat{\beta}_k)$ can be consistently estimated by $\hat{J}_k^{-1}$.

Consider the stacked estimation equation $L(\widehat{\beta}) = \left\{ L_1(\widehat{\beta}_1), ..., L_K(\widehat{\beta}_K) \right\} = 0$. The Jacobian of L, $J(\widehat{\beta}) = dL/d\beta|_{\beta=\widehat{\beta}}$, is block diagonal with blocks $J_1, ...J_K$. Thus we also obtain the familiar sandwich-type estimator for the covariance of $\widehat{\beta}_k$ and $\widehat{\beta}_h$ with

$$\text{cov}(\widehat{\beta}_k, \widehat{\beta}_h) = J_k^{-1} \sum_i w_{ik} s_{ik} s_{ih}^{'} \; J_h^{-1}. \tag{3.15}$$

This formula allows us to test cross-equation restrictions and to create more efficient estimates when cross-equation restrictions are imposed. Note that for this approach to be valid, observations must be missing at random. The left-hand side variable of interest is the share of a particular good i that is located in a particular region (e.g., the number of wells in a SC hamlet divided by the total number of wells in the village). Many of our missing observations result from division by zero (e.g., when there are no wells in the village). If poorer villages, which would be more likely to have none of any given public good, tended to treat SCs differently or if villages with SC *pradhans* or a high share of SC population were more likely to not have any of a particular good, then the assumption of randomly missing observations would break down. To test this, we regress indicators for missing data against measures of wealth, *pradhan* caste, and the share of SC population. These results do not indicate any pattern to missing observations, so the required assumption appears to be valid.