STRUCTURAL EXPERIMENTATION TO DISTINGUISH BETWEEN MODELS OF RISK SHARING WITH FRICTIONS IN RURAL PARAGUAY

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Abstract. We conduct dictator-type games in rural Paraguay; different treatments involve manipulating players' information and choice sets. From individuals' choices in the games, we draw inferences regarding impediments to efficient risk sharing in the larger village supergame. Outcomes from the experimental games suggest that players in most villages are reacting to the kinds of incentives we would predict from a private information model with hidden investments, while in others players act in a manner consistent with the predictions of a model with limited commitment. No single one of our models can explain outcomes in all villages, but outcomes in nearly every village are consistent with one or more of our models.

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1. Introduction

Accounts of difficulties faced by peasant households in developing countries often revolve around a belief that these households are constrained by market failures, particularly failures in markets for credit and insurance. Much of what is interesting in development economics (and perhaps in economics more generally) involves sharpening our understanding of what frictions impede otherwise mutually beneficial exchanges. In this paper we undertake what might be called “structural experimentation” in order to determine which of various possible impediments to risk sharing exist in rural Paraguay.

Townsend (1994) and Jalan and Ravallion (1999), among others, look at risk-sharing within villages as a whole. These papers tend to find much risk-sharing, but not full insurance. This suggests that either there are frictions preventing full insurance, or the village is not the level at which risk-sharing takes place. More recently, researchers with access to data with information on networks have documented the importance of risk-sharing within social networks (Dercon and De Weerdt, 2006; Fafchamps and Lund, 2003; Udry, 1994). Angelucci et al. (2018) find evidence that the shock of receiving a conditional cash transfer from Progresa in Mexico is shared only within the extended family. But, even with detailed information on social networks, researchers reject full insurance within the network, suggesting that there is still some important friction preventing optimal full insurance.

Fafchamps (1992) discusses risk sharing in the context of villages in developing countries, walking through the ramifications of two of the most commonly studied frictions: limited commitment and hidden information. Since then, there has been conflicting evidence on which of these frictions explains the lack of full insurance. Ligon et al. (2002) and Laczó (2015) show that observed changes in households’ income and consumption flows are consistent with a model of limited commitment. Ambrus et al. (2014) construct a model of risk-sharing in social networks with limited commitment and show that networks and transfers in Peruvian villages fit the predictions of this model. On the other hand, Ligon (1998) provides evidence that in at least some Indian villages private information may be important, while Ambrus et al. (2017) construct a model of risk-sharing in social networks with hidden information and Milán (2016) then shows that bilateral transfers in Bolivia are in accord with that hidden information model. Using a strategy related to ours, Jakiela and Ozier (2016) find that hidden information serves as a significant deterrent to full insurance in experiments in Kenya, while Kinnan (2017) argues that income and consumption survey data fits a model of hidden income better than a model of limited commitment or moral hazard for households in Thailand.

Potential explanations for these differing results include the idea that either multiple frictions are in play at the same time, or that in different countries (or even different villages) there are varying frictions at play. Along the lines of the first explanation, Chandrasekhar et al. (2011) and Attanasio et al. (2012) show that play in experiments in India and Colombia respectively are in line with a model including both limited commitment and hidden information. Along the lines of the second explanation, Ligon (1998) shows that income and consumption patterns in different villages better fit different models. Henrich (2000), Henrich et al. (2001), and Gurven et al. (2008) show that there is much variation in behavior across societies, and within societies but across villages, while relatively little variation is explained by individual-level variables. When we pool all the villages we cannot explain the outcomes we observe with a model having only one friction. Either different frictions must be important in different villages, or else one must appeal to a more complicated model, perhaps with multiple frictions.

How do we sort out which frictions are important in different villages? Our basic strategy is to visit villages and offer people in a randomly selected treatment group (i) some money; and (ii) the opportunity to invest some or all of this money with a high expected return, but only on behalf of others in the village. The decisions these people make in the experiment tell us something about both the magnitude and the type of frictions that apparently shape their decisions.

Our arrival in the villages and treatment of a random selection of subjects induces idiosyncratic shocks to the income of selected households. At one extreme, in the absence of any impediments to trade, one would expect the villagers to fully insure against these shocks, along the lines described in Townsend (1994). If the villagers are fully insured, the subjects should invest all of their stake, and the recipients of this largesse should in turn share their bounty with everyone else in the village according to some fixed, predetermined rule. At another extreme, impediments to trade might lead the subjects in our experiments to make no investments at all.

At either of the extreme outcomes, it is relatively easy to construct a model of the village environment. However, as it happens, few subjects in our experiments responded in such extreme ways. This tells us that the Paraguayan villages we investigated do not belong to the Panglossian world imagined by Townsend, but strongly hints that social networks and mechanisms exist in these villages which move the allocations toward the Pareto frontier.

When there is full risk sharing, final consumption will depend on how *much* one invests, but it won't depend on *whose* behalf the investment is made: any beneficiary will share the proceeds with the rest of the village in precisely the same way. In contrast, when there is limited commitment, the identity of the beneficiary may matter. In a model of limited commitment, making such investments might be a simple way for the subject to repay past debts, to curry favor with selected members of her social network, or to improve the sharing of future shocks. In addition, in a world of full insurance, final consumption will not depend on whether the recipient knows who sent him the transfer. In contrast, when investments are hidden information, the final consumption distribution will depend on whether the identity of transfer senders is revealed, but need not depend on the identity of the recipient.

This paper is a companion to Ligon and Schechter (2012) which used data from the same games to explore players' individual motivations for sharing. Both that paper and this rely on a strategy of varying whether the identity of the dictator is revealed, and whether the recipient is chosen by the dictator or chosen randomly. Other papers that play a combination of revealed and non-revealed games, and play games with different recipients but the same givers include Ado and Kurosaki (2014), which replicates Ligon and Schechter (2012) in Jakarta; Leider et al. (2009) with Harvard undergraduates; Hoel (2015) with Kenyan spouses; Ambler (2015) with transnational household members in Washington DC and El Salvador; and Porter and Adams (2016) with British parents and their children. These experiments all tease out players' types or preferences using differences in their behavior across games.

As in these other papers, Ligon and Schechter (2012) focuses on individual motives, using data from these experiments to separate out two preference-related motives and two incentive-related motives. We found in that paper that incentives were important, but from a higher-level point of view it's clear that the incentives individuals face are social constructs, or aspects of the equilibrium of the dynamic supergames that people in different villages are playing.

We design four games which are variants of dictator games to tease apart which frictions affect the equilibrium reached in each village. One game is similar to a traditional dictator game in which a player is given money and decides how much to keep and how much to give to an anonymous randomly chosen person in his village. The amount he sends is doubled and a random additional component is added before the recipient receives it. We have two variations of this most basic game, which we conduct in a 2 by 2 crossed design. In one variation, rather than having the recipient be chosen randomly, the dictator is able to choose the recipient. In another variation, rather than have the identities of the players be anonymous, we reveal the identity of both dictator and receiver *ex post*. In a fourth game, both variations are included at the same time.

We use the play in these games to learn something about the supergames played in each village. We structure our search by considering the incentives which emerge endogenously as part of the solution to Pareto programs under different constraints when individuals are risk averse. There will always be resource constraints in such problems, but there may also be additional constraints related to limited commitment and hidden investments, either of which gives rise to distinct kinds of incentives for sharing.

The full insurance model predicts that dictators' behavior will not vary across the four experimental games. The limited commitment model predicts that a dictator will send more to a recipient of his own choosing than to a randomly chosen recipient. The hidden investment model predicts implies that a dictator will send more when his identity is revealed than when he remains anonymous. Overall, in the sample pooled over all villages, we can reject all three models—in most villages there's a significant increase in amounts invested in the experimental game when the dictator's identity is revealed, but in many villages there's also an increase when the dictator can choose the recipient. Different villages appear to conform more to one model or another, with hidden investment being more common than limited commitment; we are able to reject all three of our models in only two of the fifteen villages.

In Section 2 we describe the environment of the Paraguayan villages and the frictions which may prevent full risk sharing. In Section 3, we describe a sequence of models of dynamic risk sharing under different combinations of impediments to trade. We begin with a benchmark model with no frictions; proceed to a simple model which introduces limited commitment; then turn to an alternative model which has full commitment but hidden investment. The data are more fully described in Section 4 and the experiment in Section 5. We describe the predictions each of our models makes regarding transfers in the game in Section 6 and compare this with the pattern of transfers observed within our experiment in Section 7. Section 8 concludes.

2. Villages and Frictions

This paper studies sharing within 15 rural villages in Paraguay, surveyed numerous times at irregular intervals over the last twenty years. We have survey-based evidence that there *is* sharing, in the form of respondents' reporting that they both gave and received transfers in various states of the world. For example, when someone in the village becomes sick, someone outside the family of the sick person will often collect contributions from community members, presenting the resulting sum as a gift to the household of the sick person from the community as a whole—individual credit isn't ordinarily given in these cases. What motivates this sort of apparently selfless sharing?

One possible answer to this question comes from the theory of repeated games; an eloquent early statement of this view is given by Fafchamps (1992). In a setting with risk and risk-averse individuals who interact and communicate with each other repeatedly over long periods of time we have a variety of "folk theorem" results which suggest that efficient sharing can emerge as an equilibrium, even if people are selfish, even if it's not possible to commit to long-term sharing arrangements (Ligon et al., 2002), and even if information is private and there's no centralized monitoring (Obara, 2009).

The villages we study seem to fit into this mold. Risk is a central concern for the people who live in these villages; there is certainly frequent communication among villagers; mobility is very low, so many of the people in these villages expect to be repeatedly interacting with each other into the indefinite future. And yet perhaps these folk-theorem results fail by predicting *too much* sharing. Schechter (2007) describes instances of destructive theft within villages, rather the opposite of sharing. And in experiments we've conducted in these villages we obtain direct evidence that when the proceeds of a lucrative investment must be shared then the observed level of investment is less than half of the efficient level, on average.

So what is it about these villages that encourages an inefficient level of sharing? Though we're inclined to think that the environment of these villages is a good match to the settings in which some folk-theorem results have been obtained, we also have reason to think that the factor by which future utility is discounted is bounded away from one.[1] Thus, even if the environment is such that a very patient population could in principle implement a Pareto efficient sharing rule, it's easy to imagine that the actual population is not sufficiently patient to do so.

Thus, we have reason to think that the allocational efficiency of the real-world allocation mechanisms in these Paraguayan villages is limited by unknown frictions, or impediments to exchange. We don't know what the complete list of possible impediments is, but there are two in particular which have been carefully studied, and where existing theory makes unambiguous predictions that we can exploit experimentally.

The first friction is *limited commitment*, which recognizes that when sharing arrangements involve exchange across periods or states, *ex post* incentives may lead people to renege on *ex ante* agreements. Commitment mechanisms (e.g., a legal and penal system for enforcing contracts) can solve the problem and deliver efficient outcomes, but it's not at all clear that people in the villages we study are able to inexpensively avail themselves of such mechanisms. However, the literature points to a powerful tool which can mitigate problems related to limited commitment: so long as it's possible to make side payments *ex ante* and save those payments, one can use such side payments to 'post a bond' *ex ante* to help guarantee contract performance *ex post*. Ligon et al. (2000) illustrates the welfare gains that can accrue in this case. Crucially for our present application, payoffs under limited commitment will depend not only on the identity of senders, but also the identity of transfer recipients.

The second friction is *private information*, which may encompass both the possibility that individuals may *observe* something others don't (hidden information), or may *do* something others don't observe (hidden action). A hallmark of models involving these frictions is that an individual with private information will have payoffs that vary with the realization of observable random variables whenever the probability distribution of those random variables

[1]Finan and Schechter (2012) report the results of offering a hypothetical payment delayed by one month in exchange for an immediate payment of 50,000 Guaraníes, and found that on average participants demanded a 400% monthly return.

is dependent on the private information. Conversely, when people are risk averse, payoffs will not depend on random variables that *are* independent.[2] For example, when the identity of dictators is revealed in our experiment, the amounts received are observable random variables with probability distributions that depend on the hidden investments made by those dictators. But these distributions are independent of who the recipient is.

3. Model

In this section we sketch a sequence of simple models, each of which generates some distinct hypotheses regarding the allocation of resources within the villages we study. Though the primitives of the models are simple and standard, the models are nevertheless designed to be general enough to serve as plausible descriptions of the villages as encountered *in situ*, as well as specifically accommodating the shocks we introduce via our experiments. However, the models described in this section do *not* correspond to the different treatments. Rather, the various treatments are designed to winnow the list of models—in Section 5 we will show that the predictions of some of the models we describe are inconsistent with outcomes observed in some villages within the experiment.

We will start with the standard benchmark model of sharing in rural villages, which is the full insurance model of Arrow-Debreu. This model can often be rejected by survey or experimental data. We then turn our attention to two sorts of models which have previously been used to try to explain deviations from full risk sharing, models with either limited commitment or private information.

Consider a set of individuals in a village; index these individuals by $i = 1, 2, \ldots, n$. Each individual lives for some indeterminate number of periods. In each period, some state of nature $s \in \mathcal{S} = \{1, 2, \ldots, S\}$ is realized. Given that the present state of nature is s, then individual i's assessment of the probability of the state of nature being $r \in \mathcal{S}$ next period is given by $\pi^i_{sr} \geq 0$.

At the beginning of the period, each individual i has some non-negative quantity x^m_i of assets indexed by $m = 1, \ldots, M$. Thus, each individual's portfolio of assets is an M-vector, written $\mathbf{x}_i$; conversely, all n individuals' holdings of asset m is an n-vector $\mathbf{x}^m$. The $n \times M$ matrix of all individuals' asset holdings is written as $\mathbf{X} \in \mathcal{X}$.

Each individual i may choose to save or invest quantity k^m_{ii} in asset m on her own behalf. Individual i can also make a non-negative contribution or transfer to the assets held by someone else—a contribution by person i of asset m held by person j is written k^m_{ij}. This allows us to treat "transfers" and "investments" in a single consistent fashion. A given individual i can make different investments on his own behalf, and also receive transfers or

[2]Risk aversion is a requirement because if people are risk loving they'd prefer a fair lottery to a sure thing, and so would prefer to condition payoffs on the realization of some independent variable.

investments from others. As a consequence, the total investment for person i and asset m is $k^m_{\cdot i} = \sum_{j=1}^n k^m_{ji}$, while the portfolio of investments held by i is $\mathbf{k}_{\cdot i} = [k^1_{\cdot i} \dots k^M_{\cdot i}]$.

The $n \times M$ matrix of person i's investments (whether made on her own behalf or on others') is written $\mathbf{k}_{i\cdot}$, which is assumed to be drawn from a convex, compact set $\Theta^i_s(\mathbf{X})$ in state s (this allows us to impose restrictions such as requiring non-negative investments or state-dependent borrowing constraints on the problem should we wish). The sum of investments over all n individuals yields another $n \times M$ matrix, written $\mathbf{K} = \sum_{j=1}^n \mathbf{k}_{j\cdot}$. It will sometimes be convenient to consider the sum of all investments *except* for i's. We write this as $\mathbf{K}^{-i} = \sum_{j \neq i} \mathbf{k}_{j\cdot}$.

Investments matter because they're an input into production. The $n \times M$ matrix of investments $\mathbf{K}$ yields an $n \times M$ matrix of returns $\mathbf{f}_r(\mathbf{K})$ in state r, which becomes next period's initial matrix of assets $\mathbf{X}$. The production function $\mathbf{f}_r$ is assumed to be a continuous function of $\mathbf{X}$ for all $r \in \mathcal{S}$.

Individual i discounts future utility using a possibly idiosyncratic discount factor $\delta_i \in (0, 1)$. Thus, if i's discounted, expected utility in state r is U^i_r, then i's discounted, expected utility in state s can be computed by using the recursion

$$U^i_s = u^i_s + \delta_i \sum_{r \in \mathcal{S}} \pi^i_{sr} U^i_r$$

for all s.

The values of $\{U^i_s\}$ which satisfy the above recursion depend on the more primitive momentary utilities $\{u^i_s\}$. These, in turn, must be feasible given the resources $\mathbf{X}$ brought into the period and the resources $\mathbf{K}$ taken out. Given these resources, we denote the set of feasible utilities for all n villagers in state s by $\Gamma_s(\mathbf{X} - \mathbf{K})$. The n-vector of all individuals' momentary utilities is written as $\mathbf{u}$.[3]

Assumption 1. For any $s \in \mathcal{S}$ the correspondence Γ_s maps the set of possible asset holdings $\mathcal{X}$ into the collection of sets of possible utilities $\mathcal{U}$. We assume that the set $\Gamma_s(\mathbf{X}) \in \mathcal{U}$ is compact, convex, has a continuously differentiable frontier, and a non-empty interior for all $s \in \mathcal{S}$ and all $\mathbf{X} \in \mathcal{X}$.

Given $\mathbf{X}$, $\mathbf{K}$, and the state s, any feasible assignment of momentary utilities must lie within the set $\Gamma_s(\mathbf{X} - \mathbf{K})$. Let $g_s : \mathbb{R}^n \to \mathbb{R}$ be a function describing the distance from a point $\mathbf{u}$ in $\Gamma_s(\mathbf{X} - \mathbf{K})$ to the frontier. Any feasible utility assignment will satisfy $g_s(\mathbf{u}; \mathbf{X} - \mathbf{K}) \geq 0$, while any efficient utility assignment $\mathbf{u}$ will satisfy $g_s(\mathbf{u}; \mathbf{X} - \mathbf{K}) = 0$.

[3]Note that by specifying payoffs in terms of utils we can easily accommodate a variety of other-regarding preferences; e.g., non-paternalistic altruism just involves a linear transformation of the recursion. Further, because each individual's utility reflects a preference ordering over the global allocation of resources this approach also automatically encompasses any sort of other-regarding preferences.

3.1. **Full Risk Sharing.** Now, let us consider the problem facing some arbitrarily chosen individual i in the absence of any impediments to trade.

Problem 1. Individual i solves

$$V_s^i(\mathbf{U}^{-i}, \mathbf{X}) = \max_{\{\{\mathbf{U}_r^{-i}\}_{r \in \mathcal{S}}, \mathbf{u}_s, \mathbf{K}\}} u_s^i + \delta_i \sum_{r \in \mathcal{S}} \pi_{sr}^i V_r^i \left(\mathbf{U}_r^{-i}, \mathbf{f}_r\left(\mathbf{K}\right)\right) \tag{1}$$

subject to the promise-keeping constraints

$$u_s^j + \delta_j \sum_{r \in \mathcal{S}} \pi_{sr}^j U_r^j \geq U^j \tag{2}$$

for all $j \neq i$ where U^j is i's promise to j regarding his utility and with multiplier λ^j; subject also to the requirement that assigned utilities be feasible,

$$g_s\left(u_s^1, \ldots, u_s^n; \mathbf{X} - \mathbf{K}\right) \geq 0, \tag{3}$$

and that each individual's investments are feasible,

$$\mathbf{k}_{j\cdot} \in \Theta_s^j(\mathbf{X}) \quad \text{for all } j = 1, \ldots, n. \tag{4}$$

We associate Kuhn-Tucker multipliers $(\underline{\eta}_{ij}^m, \overline{\eta}_{ij}^m)$ with the choice variable k_{ji}^m in (4).

Problem 1 is very like the problem facing a social planner, and like the social planner's problem can be used to characterize the set of Pareto optimal allocations. In one standard special case we might think of individual i's problem as one of allocating consumption across individuals in different states, as in, e.g., Townsend (1994).

Proposition 1. *A solution to Problem 1 exists, and for any current state $s \in \mathcal{S}$ satisfies*

$$\lambda_s^j = \frac{\partial g_s / \partial u^j}{\partial g_s / \partial u^i}, \tag{5}$$

$$\lambda_r^j = \frac{\delta_j}{\delta_i} \frac{\pi_{sr}^j}{\pi_{sr}^i} \lambda_s^j \qquad \textit{for all } r \in \mathcal{S} \textit{ such that } \pi_{sr}^i \pi_{sr}^j > 0. \tag{6}$$

Proof. The payoffs u_s^i are bounded, the discount factor δ_i is less than one in absolute value, and the constraint set is convex and compact, all by assumption, so that Problem 1 is a convex program to which a solution exists. The Slater condition is satisfied and the objective and constraint functions are all assumed to be continuously differentiable in u_s^i and x, so that the first order conditions will characterize any solution. The first order condition associated with the choice object u_s^i is given by (5). Combining the first order conditions for U_r^i with the envelope condition with respect to U_s^i yields (6). □

This model implies that all idiosyncratic risk is pooled and only community-level risk matters. Agents all have an incentive to invest the efficient amount, and it will neither matter in whose behalf they invest nor whether the recipient is told the identity of the investor.

3.2. **Limited Commitment.** Now, suppose that after making an investment in state s and the realization of any subsequent state r any individual j can deviate from the existing agreement. The value of the deviation depends on his portfolio of investments $\mathbf{k}_{\cdot j}$, and is given by $A^j_s(\mathbf{k}_{\cdot j})$. Then for any arrangement to be respected, after any state s the continuation utilities received by j must satisfy

$$U^j_r \geq A^j_r(\mathbf{k}_{\cdot j}), \tag{7}$$

for all $j \neq i$ and for all r, while for individual i the arrangement must satisfy

$$V^i_r(U^{-i}_r, \mathbf{f}_r(\mathbf{K})) \geq A^i_r(\mathbf{k}_{\cdot i}) \tag{8}$$

for all r. This arrangement assumes that the investment decision k^m_{ji} is public, so that i can tell j to make the investment that maximizes i's discounted, expected utility, subject only to resource constraints; the requirement that i keep his promises; and the requirement that, given the investments chosen or recommended by i, j's continuation payoffs be greater than the payoffs to deviating (after every date-state).

Problem 2. Individual i solves (1) subject to (2), (3), (4), and the limited commitment constraints (7) (with multipliers $\lambda^j_s \delta_j \pi^j_{sr} \phi^j_r$) and (8) (with multipliers $\delta_i \pi^i_{sr} \phi^i_r$).

This is essentially the model of Ligon et al. (2000), and similar results follow. In particular, we have:

Proposition 2. *For any pair of individuals (i, j) any solution to Problem 2 given the current state $s \in \mathcal{S}$ will satisfy*

$$\lambda^j_s = \frac{\partial g_s/\partial u^j}{\partial g_s/\partial u^i}, \tag{9}$$

$$\lambda^j_r = \frac{\delta_j}{\delta_i} \frac{\pi^j_{sr}}{\pi^i_{sr}} \left(\frac{1+\phi^j_r}{1+\phi^i_r} \right) \lambda^j_s \qquad \text{for all } r \in \mathcal{S} \text{ such that } \pi^i_{sr}\pi^j_{sr} > 0. \tag{10}$$

Proof. Payoffs u^i_s are bounded, discount factors are less than one in absolute value, and the constraint set is compact. Further, for any fixed $\mathbf{K}$ the constraint set is convex in both current and future utilities $\mathbf{u}_s$ and $\mathbf{U}^{-i}$. The Slater condition is satisfied, the objective and frontier of the constraint sets are all continuously differentiable in $\mathbf{u}_s$ and $\mathbf{U}^{-i}$, and so the utilities $\mathbf{u}_s$ which solve Problem 2 will satisfy the first order conditions $\lambda^j_s + \mu_s \partial g_s/\partial u^j = 0$, where μ_s is a multiplier associated with (3), and where $\lambda^i_s \equiv 1$. Combining these conditions for i and j yields (9). Promised future utilities U^j_r must also satisfy first order conditions

$-\delta_i \pi^i_{sr} \partial V^i_r / \partial U^j (1 + \phi^i_r) + \delta_j \pi^j_{sr} \lambda^j_r (1 + \phi^j_r) = 0$. The envelope condition with respect to U^j implies that $\partial V^i_s / \partial U^j = -\lambda^j_s$; advancing this forward a period into state r and subsituting into the previous first order condition then yields the result. □

When an adequate commitment technology is available, Proposition 1 tells us that the 'planning weights' λ^j_r will remain fixed across dates and states. In contrast, when commitment is limited, individuals may sometimes be able to negotiate a larger share of aggregate resources. More precisely, the weights λ^j_r will satisfy a law of motion given by (10). Furthermore, i will do his best to structure asset holdings across the population so as to avoid states in which others can negotiate for a larger share. He can control this to some extent by assigning asset ownership to those households who are least likely to otherwise have binding limited commitment constraints in the next period. This introduces a distortion into the usual intertemporal investment decision.

When we add limited commitment to the basic model we see that an agent will want to direct his investment so that it will benefit him most. In the best case, this means sending it to someone who will *not* be able to use the proceeds to renegotiate. Updating in the limited commitment case depends on the multiplier on the constraints for *both* person j and also the residual claimaint, person i. The latter multiplier, ϕ^i_r, in turn depends on the entire distribution of promised utilities in state r, or U^{-i}_r, and these in turn depend whether any other persons l have multipliers $\phi^l_r > 0$, and *this* depends on the assets held by l in state r. The general conclusion we can draw is that the identity of the person holding assets in different states matters in the limited commitment case, in a way it doesn't in the Pareto optimal or hidden investment cases.

3.3. **Hidden Investments.** Let us now add a diffent sort of friction to the problem described in Section 3.1. We allow some of the villagers to make *unobserved* investments and to mis-report the realized state. These unobserved investments result in a realized stock of assets in the subsequent period which we assume is observable, so there is a hidden action (investment) problem within each period. A variety of private information problems known from the literature could be shoehorned into our hidden investment model; our intention here is to introduce a fairly general information friction that may encompass a variety of more specific information problems. For example, the private information model of Ligon (1998) is accommodated by restricting hidden investments to those which affect own outcomes; the "altruistic siblings" model of Alger and Weibull (2010) can be implemented by adding a thoughtful specification of the momentary payoffs $\mathbf{u}_s$; similarly, the models of hidden actions without hidden savings/income of Attanasio and Pavoni (2011) or Kinnan (2017) are immediate special cases. We imagine that investments or other actions being hidden may be a general feature of the villages, but also note that some of our experimental treatments introduce hidden investment possibilities by design.

We imagine that only the first $\bar{n} < n$ agents may have the opportunity to make hidden investments, so that for any $j \leq \bar{n}$, agent j chooses a matrix of investments $\mathbf{k}_{j\cdot} \in \Theta^j_s$. Note that we assume that the nth agent (and possibly others) can *not* make hidden investments—though n may make investments $\mathbf{k}_{n\cdot}$, his investments are public information. This simplifies our modeling task by allowing us to set up n as the "principal" in a more-or-less standard principal-agent model.

Adapting the model we've described above to allow for hidden investments implies not only that investment behavior is unobservable, but that some aspects of the state of nature must also be private. We thus refine our description of the state of nature by assuming that the complete description of that state at time t is given by a pair (s_t, h_t). The element $s_t \in \mathcal{S}$ is observable, just as before, and is a stationary Markovian process governed by a set of probabilities which person j believes to be $\pi^j_{sr} = \Pr^j(s_{t+1} = r | s_t = s)$. The element h_t is a vector of hidden shocks. In contrast to the discrete event space $\mathcal{S}$ the space of hidden shocks $\mathcal{H}$ may be continuous, with Lebesgue measure. The probability distribution of hidden shocks may in general depend on the public shock s_t, but is conditionally independent over time.[4] Thus, in person j's assessment the joint probability that the realization of the public state at $t + 1$ is r and the vector $h_{t+1} \in A$ for some set A can be written as $\Pr^j(s_{t+1} = r, h_{t+1} \in A | s_t = s) = \pi^j_{sr} H_r(A)$ for a family of S distributions $\{H_s\}_{s \in \mathcal{S}}$.

A related required refinement is that production must now depend on both public and private shocks. Adapting our notation from above, let $\mathbf{f}_{(r,h)}(\mathbf{K})$ denote the matrix of returns to investments given realizations (r, h). Since next period's stock of assets is entirely determined by $(s_{t+1}, h_{t+1}, \mathbf{K}_t)$ it's convenient to directly describe the beliefs of j regarding the conditional probability of stocks $\mathbf{X}_{t+1}$ being in the set $\mathbf{B} \subseteq \mathbb{R}^{n \times m}$ by $\Pr^j(X_{t+1} \in \mathbf{B} | s_t = s, \mathbf{K}) = F^j_s(\mathbf{B}|\mathbf{K})$, a probability measure which now implicitly accounts for the uncertainty in outcomes due to the realization of the hidden shocks h_{t+1}.

With these refinements to our description of the stochastic environment, the fact that investments (and realizations of h) are hidden means that we must add a collection of incentive compatibility constraints to ensure that the incentive mechanism designed by the principal induces agents to obediently make the investments recommended by the principal.

Recall from above that we'd written the sum of all agents' investments as $\mathbf{K}$, and all agents' except agent j's investments as $\mathbf{K}^{-j}$. Now, to focus attention on j's choice of investments

[4] Allowing for arbitrary dependence over time would lead to a generalization along lines explored by Ábrahám and Pavoni (2005, 2008); Cole and Kocherlakota (2001); Doepke and Townsend (2006), and Fernandes and Phelan (2000). But the characterization of outcomes in these models remains a work in progress, with existing results relying on some very restrictive assumptions which are unpalatable in our setting (e.g., Doepke-Townsend assume only a single agent and a risk-neutral principal).

taking all other investments as given, we write the sum of all investments as $\mathbf{K} = (\mathbf{K}^{-j}, \mathbf{k}_{j\cdot})$. Similarly, the collection of asset portfolios is $\mathbf{X} = (\mathbf{X}^{-j}, \mathbf{x}_j)$ for any $j = 1, \ldots, n$.

We now consider the problem facing individual n when there's full commitment, but when agents $j \leq \bar{n}$ can make (or fail to make) a hidden investment which affects the probability distribution over assets in the next period. Individual n, acting as an uninformed principal, can recommend to j that she make some particular investment $\mathbf{k}_{j\cdot}$. Individual j can deviate and invest $\hat{\mathbf{k}}_{j\cdot}$; if the realization of the hidden states is h then this results in assets in the next period observed to be $\mathbf{X}_r = \mathbf{f}_{(r,h)}((\mathbf{K}^{-j}, \mathbf{k}_{j\cdot}))$.

An individual j who fails to follow the principal's recommendation regarding investment can obtain a momentary deviation utility which depends on the aggregate stock of resources net of investments $\mathbf{X} - \mathbf{K}$ that the principal expects, and on the amount of resources actually available given her deviation (e.g., her embezzlement), which we denote by some $\mathbf{X} - (\mathbf{K}^{-j}, \hat{\mathbf{k}}_{j\cdot})$. Thus, let $d_s^j(\mathbf{X} - (\mathbf{K}^{-j}, \hat{\mathbf{k}}_{j\cdot}))$ be the largest momentary deviation utility available to individual j in state s given her deviation investment $\hat{\mathbf{k}}_{j\cdot}$. Finally, promises regarding future utilities may depend both on the realization of the public state as well as the realized stocks of assets.

We now formulate our problem in a recursive form analogous to that of Problem 1 or Problem 2, yielding

Problem 3. For any present state s individual n solves

$$V_s^n(\mathcal{U}^{-n}, \mathbf{X}) = \max_{\{\{\mathcal{U}_r^{-n}(\mathbf{X}')\}_{r\in\mathcal{S}}\}_{\mathbf{X}'\in\mathcal{X}}, \mathbf{u}_s, \mathbf{K}} u_s^n + \delta_n \sum_{r\in\mathcal{S}} \pi_{sr}^n \int_{\mathcal{X}} V_r^n\left(\mathcal{U}_r^{-n}, \mathbf{X}'\right) dF_r^n\left(\mathbf{X}'|\mathbf{K}\right) \tag{11}$$

subject to the promise-keeping constraints

$$u_s^j + \delta_j \sum_{r\in\mathcal{S}} \pi_{sr}^j \int_{\mathcal{X}} \mathcal{U}_{sr}^j(\mathbf{X}') dF_r^j\left(\mathbf{X}'|\mathbf{K}\right) = \mathcal{U}^j(\mathbf{X}) \qquad \text{for all } j \neq n. \tag{12}$$

We associate the multipliers λ_s^j with these constraints. As before, we require that allocations and investments be feasible given the actual asset stocks $\mathbf{X}$, or that allocations satisfy (3). In addition consumption and investments must be feasible, or

$$g_s(\mathbf{u}_s; \mathbf{X} - \mathbf{K}) \geq 0. \tag{13}$$

Individual n will recommend investments $\mathbf{k}_{j\cdot}$ to j. But since these investments may be unobservable, the recommendation must be incentive compatible, or

$$\mathbf{k}_{j\cdot} \in \operatorname*{argmax}_{\hat{\mathbf{k}}_{j\cdot}\in\Theta_s^j(\mathbf{X})} d_s^j(\mathbf{X} - (\mathbf{K}^{-j}, \hat{\mathbf{k}}_{j\cdot})) + \delta_j \sum_{r\in\mathcal{S}} \pi_{sr}^j \int_{\mathcal{X}} \mathcal{U}_{sr}^j(\mathbf{X}') dF_r^j\left(\mathbf{X}'|(\mathbf{K}^{-j}, \hat{\mathbf{k}}_{j\cdot})\right) \tag{14}$$

for all $j \leq \bar{n}$.

In general, characterizing solutions to problems such as Problem 3 is difficult because the constraint set isn't guaranteed to be convex. Numerical approaches involving lotteries (which convexify the constraint set) are advocated by Phelan and Townsend (1991) and Doepke and Townsend (2006). However, when convexity (and less controversially differentiability) obtain, then solutions can be characterized using first order conditions; when this is so one says that the "first order approach is valid." Rogerson (1985) and Jewitt (1988) provide distinct sets of conditions which are sufficient for the validity of the first order approach in a one period problem with a hidden action. Ábrahám et al. (2011) give sufficient conditions in a model with hidden investments such as Problem 3, but with only two periods. No conditions sufficient to guarantee the validity of the first order approach in the infinite period case are known, but Werning (2001) and Ábrahám and Pavoni (2008) argue for an approach which *assumes* the validity of the first order approach to compute proposed solutions, and verifies the correctness of these solutions. In this same spirit, we offer the following first order characterization of the solution to Problem 3.

Proposition 3. *Any interior solution to Problem 3 satisfies*

$$\lambda_s^j(\mathbf{X}) = \frac{\partial g_s/\partial u^j}{\partial g_s/\partial u^n} \tag{15}$$

for any current state $s \in \mathcal{S}$*. Further, when the first order approach is valid,*

$$\lambda_r^j(\mathbf{X}') = \frac{\delta_j}{\delta_n}\frac{\pi_{sr}^j}{\pi_{sr}^n}\lambda_s^j(\mathbf{X})\left[1 + \sum_{i=1}^n \sum_{m=1}^M \mu_{ji}^m \phi_{ji}^m\left(\mathbf{X}'|\mathbf{K}\right)\right] \tag{16}$$

for all $r \in \mathcal{S}$ *such that* $\pi_{sr}^i \pi_{sr}^j > 0$ *and all* $j \leq \bar{n}$*, where the numbers* μ_{ji}^m *are non-negative. Further, if a density* $f_s^j\left(\mathbf{X}'|\mathbf{K}\right)$ *corresponding to the distribution* $F_s^j\left(\mathbf{X}'|\mathbf{K}\right)$ *exists and this density is differentiable with respect to investments, then the functions* $\phi_{ji}^m\left(\mathbf{X}'|\mathbf{K}\right)$ *have the properties*

(1) $\phi_{ji}^m\left(\mathbf{X}'|\mathbf{K}\right) = \frac{\partial f_s^j(\mathbf{X}'|\mathbf{K})/\partial k_{ji}^m}{f_s^j(\mathbf{X}'|\mathbf{K})}$*; and*
(2) $\int_{\mathcal{X}} \phi_{ji}^m\left(\mathbf{X}'|\mathbf{K}\right) dF_s^j\left(\mathbf{X}'|\mathbf{K}\right) = 0$ *for all* $s \in \mathcal{S}$*, for all* $j = 1, \ldots, n$*, for all* $i = 1, \ldots, n$*, for all* $m = 1, \ldots, M$*, and for all* $(\mathbf{X}', \mathbf{K})$*.*

Proof. Problem 3 is convex in $\mathbf{u}_s$, since these choice variables don't enter the incentive compatibility constraints (14), and is differentiable in these variables by assumption. The result (15) then is implied by taking the ratio of the first order conditions with respect to u_s^j and u_s^n.

When the first-order approach is valid, j's choice of transfer of asset m to person i is characterized by the first order conditions to the maximization problem (14) with respect to

k_{ji}^m. This first order condition is

$$-\frac{\partial d_s^j}{\partial x_j^m} + \delta_j \sum_{r\in\mathcal{S}} \pi_{sr}^j \int_{\mathcal{X}} \mathcal{U}_r^j(\mathbf{X}')\phi_{ji}^m(\mathbf{X}'|\mathbf{K})dF_r(\mathbf{X}'|\mathbf{K}) = 0, \tag{17}$$

where the functions $\phi_{ji}^m(\mathbf{X}'|\mathbf{K})$ give an indication of how the probability of outcome $\mathbf{X}'$ changes when there's a small increase in the total investment k_{ji}^m. When the density of F exists these are the likelihood ratios described in property (1) of the proposition, and so integrate to zero, as described in property (2) of the proposition.

When the first-order approach is valid, a solution to Problem 3 will also be a solution to the "relaxed" problem of maximizing (11) subject to (12), (13), and (17). Associate with last constraints (17) multipliers μ_{ji}^m. Then the first order conditions with respect to future promised utilities $\mathcal{U}_r^j(\mathbf{X}')$ are

$$\delta_n \pi_{sr}^n \frac{\partial V_r}{\partial \mathcal{U}_r^j(\mathbf{X}')} dF_r(\mathbf{X}'|\mathbf{K}) + \delta_j \pi_{sr}^j dF_r(\mathbf{X}'|\mathbf{K})\lambda_s^j(\mathbf{X}) + \delta_j \pi_{sr}^j \left(\sum_{i=1}^n \sum_{m=1}^M \mu_{ji}^m \phi_{ji}^m(\mathbf{X}'|\mathbf{K}) \right) dF_r(\mathbf{X}'|\mathbf{K}) = 0. \tag{18}$$

In addition we have the envelope condition $\frac{\partial V_r}{\partial \mathcal{U}_r^j(\mathbf{X})} = -\lambda_s^j(\mathbf{X})$. Combining the envelope condition with (18) gives the result (16). □

Notice that (15) is identical to the analogous characterization in the Pareto optimal program, (5). The updating rule for the Pareto optimal case, (6) is a special case of (16); the only difference here is the additional factor $\left[1 + \sum_{i=1}^n \sum_{m=1}^M \mu_{ji}^m \phi_{ji}^m (\mathbf{X}'|\mathbf{K})\right]$, where the μ_{ji}^m can be interpreted as the Lagrange multipliers associated with the first order characterization of person j's hidden investment decision. Larger values of these multipliers indicate a higher social cost associated with the hidden investments, in a logic familiar from Spear and Srivastava (1987); however these costs will depend not only on preferences but also critically on the functions ϕ_{ji}^m. This can be seen from the fact that the proposition tells us that when the conditions of property (1) are satisfied the functions ϕ_{ji}^m have the interpretation of likelihood ratio statistics. In a simpler model, Kim (1995) establishes that a necessary and sufficient condition for one (otherwise similar) environment to have more "efficient" outcomes than another is that the distribution of these statistics in the first environment be a "mean preserving spread" of those in the second environment. A special case in which j could benefit from privately consuming more while investing less would imply a lower marginal utility of consumption today, but a higher marginal utility tomorrow.

A rough interpretation of this is that when we add hidden investment, agent j may have an incentive to invest less than the efficient amount, and that these incentives will depend on the distribution of the ϕ_{ji}^m. To offset this disincentive, she can be offered a reward for large *received* transfers (or punished for small ones), both now and in the future. The size of the incentive will depend on how informative the amount received is as a signal of j's investment, and is measured by the functions $\phi_{ji}^m(\mathbf{X}'|\mathbf{K})$, which can be interpreted as the effect of a small increase by person j in investment in asset m on behalf of person i on the likelihood of observing investment outcome $\mathbf{X}'$.

4. Data

In 1991, the Land Tenure Center at the University of Wisconsin in Madison and the Centro Paraguayo de Estudios Sociológicos in Asunción worked together in the design and implementation of a survey of 285 rural Paraguayan households in fifteen randomly chosen villages across three disparate departments (comparable to US states) across the country. The original survey was followed up by subsequent rounds of data collection in 1994, 1999, 2002, and in 2007. All rounds include detailed information on production and income. In 2002, questions on theft, trust, and gifts were added. Only 223 of the original households were interviewed in 2002.[5]

In 2007, new households were added to the survey in an effort to interview 30 households in each of the fifteen randomly selected villages for a total of 450 households. Villages ranged in size from around 30 to 600 households. In the smallest village only 29 households were surveyed. These 449 households were given what was called the 'long survey'. This survey contained most of the questions from previous rounds and also added many questions measuring networks in each village.

The process undertaken in each village was the following. We arrived in a village and found a few knowledgeable villagers and asked them to help us collect a list of the names of all of the household heads in the village. Every household in the village was given an identifier. At this point we randomly chose new households to be sampled to complete 30 interviews in the village. (This meant choosing anywhere between 6 and 24 new households in any village in addition to the original households.) These villages are mostly comprised of smallholder farmers. There are no tribes, castes, village chiefs, professional moneylenders, plantation owners, or the like.

We invited all of the households which participated in the long survey to send a member of the household (preferably the household head) to participate in a series of economic experiments. These experiments will be described in more detail in the next section.

[5]Comparing the 2002 data set with the national census in that year we find that the household heads in this data set were slightly older, which is intuitive given the sample was randomly chosen 11 years earlier. The households in the 2002 survey were also slightly more educated and wealthier than the average rural household, probably due to the oversampling of households with larger land-holdings.

5. Experiment

A day or two after conducting the long survey with 30 households in a village, we invited them to send one member of their household, preferably the household head, to participate in a series of economic experiments. Decisions made in these experiments were first analyzed in Ligon and Schechter (2012). The games were held in a central location such as a church, a school, or a social hall. Of 449 households, 371 (83%) participated in the games. This share is quite similar to the 188 out of 223 (or 84%) who participated in the games carried out in 2002. The games carried out in 2002 were different from those carried out in 2007 and so the participants had no previous experience with the specific games in 2007. See Appendix A for the full game protocol.

Table 1. Relation of different experimental games.

		Recipient Selection	
		Random	Chosen
Dictator's Identity	Anonymous	Anonymous-Random	Anonymous-Chosen
	Revealed	Revealed-Random	Revealed-Chosen

Using a two-by-two design we constructed four experimental games, each of which is a variant of the dictator game. Together, these can be used to distinguish between the different frictions that villagers may face. In each of the four games a dictator is asked to allocate 14 thousand guaranies (KGs; at the time the experiments were conducted, one thousand Guaranies was worth approximately 20 US cents), deciding how to divide it between himself and an anonymous partner. We doubled the money sent by the dictator to his anonymous partner. While only those individuals who were invited to and showed up for the experiment could act as dictators, any household in the village could be a recipient.

The games are distinguished along two dimensions (Table 1); first, by whether the sending dictator's identity was kept "Anonymous" or was "Revealed" *ex post*; second, by whether the recipient's selection was "Random" or they were "Chosen" by the dictator. Thus, the first of the experimental games was the traditional dictator game which we call the Anonymous-Random game. In this experiment partners were randomly assigned and remained anonymous. We call the second game Revealed-Random; it is similar to the first, except that players were told that when the game was over we would reveal the identities of both the dictator and recipient.

We called the third and fourth experimental games Anonymous-Chosen and Revealed-Chosen respectively. In these Chosen games, the dictator could choose which household would receive the proceeds of any investment he made in the game. In these two games the identity of the sending dictator was revealed only in the Revealed-Chosen game.

We took three steps to preserve the anonymity of the dictator in the anonymous games. First, although the dictator chose the recipient in both the Revealed-Chosen and Anonymous-Chosen games, we implemented the payoffs from only one of these (determined by a coin flip). Second, in all four games, we added a randomly determined sum to the (doubled) investment chosen by the dictator (determined by the roll of a six-sided die). We explained this additional stochastic component to both dictators and receivers, and the distribution of the random addition was also made public. We call the amount received from investments by a particular dictator in a particular game "returns to investments in the game asset." Note that these distributions are identical across each of the four games, except for the random implementation in the Chosen games. Note also that the distribution of returns when the dictator invested k in the game asset was stochastically dominated by the distribution when the dictator invested $k' > k$. Third, payoffs to the recipients were pooled, both across games and across dictators. Thus, recipients had no certain information about who had sent what in the Anonymous games.

The players received no feedback about the outcome in each experimental game until all four sets of decisions had been made. The order of the four versions was randomly decided for each participant. Dictators were not allowed to send money to their own household (either by choice or lottery). The dictators were asked to allocate 14 KGs (a bit less than $3US) in each version of the dictator game. A day's wages for agricultural labor at the time was approximately 15 to 20 KGs. The average winnings for the players[6] was 41 KGs with a standard deviation of 22. The games took approximately three hours from start to finish. The maximum won by a player was 205 KGs and the minimum was 0. The dictators earned payoffs for three of the four games in which they acted as dictator (Anonymous-Random, Revealed-Random, and one of Anonymous-Chosen or Revealed-Chosen, depending on which of these last two was implemented). Dictators also had the possibility of earning payoffs as recipients. In addition to the payments earned by players, many households throughout the village received additional payments as recipients.[7]

Because we wanted to collect more information about all households chosen as recipients by dictators, we conducted a 'short survey' with all households chosen by a dictator who were not also themselves dictators. In this short survey we asked how they would have played if

[6]Players were also offered 1 KG extra for arriving on time. We used our vehicle to pick up participants who were not able to get to the game using their own means of transport. In this case they were offered 1 KG if they were ready when the vehicle arrived at their residence.

[7]If we consider the sample we have in each village as representative of the village as a whole, we can estimate total village annual income. In this case, the total amount distributed in a village ranged from 0.01% to 0.4% of annual village income.

they had been invited to participate in the economic experiments; to save time we simplified these "hypothetical" games by not incorporating the coin flips and roll of the die used in the main experiment. This means that the expected amount received by the dictator's partner is less in the hypothetical questions than in the actual games.

We can incorporate these games into the models from Section 3 by partitioning the state space $\mathcal{S} = \mathcal{S}_1 \cup \mathcal{S}_2$ and letting $\mathcal{S}_2$ be the set of states in which games are run in the village. Since researchers had played games in these villages before (Schechter, 2007), we do not believe the villagers would have regarded our experiment as being outside the realm of possibility. Let person i's assessment of the probabilities of transiting between $\mathcal{S}_1$ and $\mathcal{S}_2$ be given by

$$p = \begin{bmatrix} p^i_{11} & p^i_{12} \\ p^i_{21} & p^i_{22} \end{bmatrix}.$$

Note that these don't depend on the particular state within a partition.

Let Σ index the set of possible states within the context of the experiment. In the experiment, we confront the villagers with a randomly determined state $\sigma \in \Sigma$ (e.g., person 1 is randomly selected to be a dictator, persons 2 and 20 are randomly selected as recipients, a sequence of dice rolls comes up $(1, 5, 2)$, and a coin flip comes up heads). The experiments we conduct augment the set of states which would otherwise have occurred. Thus, in a period in which the experiment occurs, the state space is $\mathcal{S}_2 = \mathcal{S}_1 \times \Sigma$. The probabilities of different states within the experiment are independent of the 'external' state s_1. Let the probability of experimental state σ be given by ρ_σ. Any experimental protocol can be described by the pair (Σ, ρ).

Our experiment was designed to manipulate the incentives that subjects had to make risky investments in a game "asset" g on others' behalf. A participant can make investments on behalf of any individual j in the village. Returns to investing in (g, j) are independent of returns to any other asset by construction (returns are determined by flipping coins and rolling dice); further, returns to any asset $m \neq g$ are independent of investments in g.

The independence of returns is crucial to our ability to test the predictions of our different models. A second crucial feature is that returns to investments in the game asset must be high enough to guarantee that it's efficient to invest in these assets, regardless of risk attitudes.

Assumption 2. The distribution of returns to investments in the game asset g second-order stochastically dominates returns to all other assets.

The assumption of second-order stochastic dominance implies (Rothschild and Stiglitz, 1970) that any risk-averse individual would invest the maximum amount possible in the game asset provided she was able to reap the returns herself. We note that in our setting it would be extremely surprising if Assumption 2 did not hold, since the returns to the game asset exceed a 100 percent return overnight in every state of the experiment $\sigma \in \Sigma$, and since investment affects only the location and scale of the distribution.

For each of the models we've previously described, we next discuss the predictions we'd make about behavior in our games, conditional on each model being a correct description of the actual environment within a particular village.

5.1. **Predicted effects of experiment with full insurance.** Our predictions in this case are straightforward, but rely on the fact that the distribution of returns to (g, j) don't vary with the recipient j.

Proposition 4. *If Assumption 2 is satisfied then in the full risk-sharing model described by Problem 1, any dictator i in any state will invest the maximum possible amount in the game asset g in every one of our experimental games and will be indifferent as to the recipient j so long as $j \neq i$.*

Proof. In this model the utility of any dictator i depends only on a fixed weight λ^i and on the distribution of aggregate resources $\mathbf{X}$. Returns to the game asset are independent of returns to any other asset, so the only question is whether there's some alternative investment with a better distribution of returns, and this is ruled out by assumption so long as $j \neq i$. □

It's worth noticing before we move to more complicated models that as a formal matter both the limited commitment models and hidden investment models nest the full risk sharing model, and that if we fail to reject the hypothesis of Proposition 4 this could simply be because some of our experimental treatments were either too small (limited commitment) or insufficiently informative (hidden investment) to induce significant movements away from a full insurance optima.

5.2. **Predicted effects of experiment in limited commitment model.** What behavior would we predict from participants in our experiment if the environment they inhabit is characterized by limited commitment? To explore this, set aside issues related to differences in discounting or beliefs, and consider a particular state r in which payoffs to the game investment are maximal. Then the updating rule in the limited commitment case for a dictator i (10) simplifies to

$$\lambda_r^j = \left(\frac{1+\phi_r^j}{1+\phi_r^i}\right)\lambda_s^j \qquad \text{for all } j = 1, \dots, n \text{ and all states } r \in \mathcal{S}. \tag{19}$$

To illustrate, suppose that in addition to i there are two people 1 and 2, and that i knows that given a distribution of investments across people $\mathbf{K}$ that person 1 will not be constrained in the subsequent period, while person 2 will be constrained should state r be realized. Then

$\phi_r^2 > 0$, while $\phi^1 = 0$. We'd expect that larger received investments in asset g strictly improve 2's autarkic payoffs (so that $\partial A^j / \partial k_{\cdot 2}^m > 0$). Then by reducing k_{i2}^m by some $\epsilon > 0$ while increasing k_{i1}^m by the same ϵ leads to strict improvement in expected utility for the dictator i.

The same logic extends. Let $\alpha_r^j = \partial A^j / \partial k_{\cdot j}^g$ denote the marginal increase in autarkic utility for individual j in state r when that person has a larger investment in the game asset g. We then have the following result:

Proposition 5. *In the limited commitment model described by Problem 2, given state s, a dictator i who sends investments in the game asset g to some individual $j \neq i$ will prefer the individual j having the smallest value of*

$$\sum_{r \in \mathcal{S}} \alpha_r^j \lambda_s^j \delta_j \pi_{sr}^j \phi_r^j.$$

Proof. Consider the set of constraints given by Equation (7). In a Karesh-Kuhn-Tucker formulation of Problem 2 these constraints appear as the sum

$$\sum_{j \neq i} \sum_{r \in \mathcal{S}} \left(U_r^j - A_r^j(\mathbf{k}_{\cdot j}) \right) \lambda_s^j \delta_j \pi_{sr}^j \phi_r^j = 0,$$

where the equality is a consequence of complementary slackness.

Now, assuming that $i > 2$, without loss of generality consider just a pair of individuals 1 and 2, and write their autarkic pay-offs so as to depend explicitly on investments in the game asset g, or as $A_r^j((\mathbf{k}_{\cdot j}^{-g}, k_{\cdot j}^g))$. Their contribution to the sum is

$$\sum_{r \in \mathcal{S}} \left(U_r^1 - A_r^1((\mathbf{k}_{\cdot 1}^{-g}, k_{\cdot 1}^g)) \right) \lambda_s^1 \delta_1 \pi_{sr}^1 \phi_r^1 + \sum_{r \in \mathcal{S}} \left(U_r^2 - A_r^2((\mathbf{k}_{\cdot 2}^{-g}, k_{\cdot 2}^g)) \right) \lambda_s^2 \delta_2 \pi_{sr}^2 \phi_r^2.$$

Now suppose that i considers transferring some of the investment in g from one person to the other; because returns to the game asset don't depend on the person holding the asset and because returns are independent from returns to all other assets such a transfer will affect no other part of Problem 2. Thus, we can think of i as choosing a perturbation ϵ to solve

$$\max_{\epsilon} \sum_{r \in \mathcal{S}} \left(U_r^1 - A_r^1((\mathbf{k}_{\cdot 1}^{-g}, k_{\cdot 1}^g - \epsilon)) \right) \lambda_s^1 \delta_1 \pi_{sr}^1 \phi_r^1 + \sum_{r \in \mathcal{S}} \left(U_r^2 - A_r^2((\mathbf{k}_{\cdot 2}^{-g}, k_{\cdot 2}^g + \epsilon)) \right) \lambda_s^2 \delta_2 \pi_{sr}^2 \phi_r^2.$$

The first order conditions of this problem imply that i will choose ϵ to equate $\sum_{r \in \mathcal{S}} \alpha_r^1 \lambda_s^1 \delta_1 \pi_{sr}^1 \phi_r^1 = \sum_{r \in \mathcal{S}} \alpha_r^2 \lambda_s^2 \delta_2 \pi_{sr}^2 \phi_r^2$. Applying similar logic across all other individuals and using the fact that α_r^j is non-increasing in ϵ yields the result. □

Roughly speaking, the import of this proposition is that if the environment is characterized by limited commitment we predict that a dictator in our game will direct any investments to someone unlikely to be constrained should that investment result in a large return. The features which govern "unlikely to be constrained" may depend on a variety of factors, including wealth, risk aversion, beliefs, and of course the marginal effect of the investment on autarkic utility.

Thinking now of our experimental conditions: In two of the four games dictators played, they were able to choose the recipient. Proposition 5 implies that in these games we can expect the dictator to send more than they would in the games in which the recipient was randomly selected. Nothing in the limited commitment model hinges on the identity of the dictator, and so we would also predict that revealing the dictator's identity would have no effect on the amounts sent.

5.3. **Predicted effects of experiment in hidden investment model.** We next consider the behavior we'd expect from people in our experiment if the environment is characterized by the hidden investment model. Observational outcomes depend heavily on aspects of the environment which may be difficult to measure, such as the covariance of returns to different investments. But the returns to such investments in our experimental asset are independent of the returns to other assets, independent of the recipient, and identically distributed across people. We will provide two predictions, but need some additional regularity conditions on the distribution of returns to the game assets.

Assumption 3. The objects $\phi^g_{ji}(\mathbf{X}|\mathbf{K})$ which appear in (16) and correspond to the distribution of returns to investments in our game asset g can (i) be interpreted as likelihood ratios; and (ii) the support of $\mathbf{X}$ does not depend on k^g_{ij} for any (i, j).

Note that these additional regularity conditions impose additional structure only on investments and returns related to the game asset, and are standard. Further, Proposition 3 has already established that the existence of a density with compact support invariant to $\mathbf{K}$ is sufficient for both parts (i) and (ii) of Assumption 3. But though standard, one might ask whether they hold in our experimental setting. In the first place, investments must in fact be discrete; in the second place the mechanism we use in our experiment has bounded support, and investments can change the location of that support. We dismiss the first problem, on the grounds that the increments in value of the discrete investments we allowed were rather small. For the second point, note that so long as participants in the game believe that there's a continuous probability distribution governing things like variation in the timing of payment or some other random events which might effect the value of returns to the games, then both differentiability and invariant support may be reasonable.

Exploiting these assumptions and the independence described above, we have the following proposition:

Proposition 6. *In the investment model described by Problem 2 given state s, a dictator i who sends investments in the game asset g to some other individual will have payoffs which vary with game returns only via likelihood ratios $\phi^g_{ij}(\mathbf{X}'|\mathbf{K})$, and each of these will depend only on a single investment, taking the form*

$$\phi^g_{ij}(\mathbf{X}'|\mathbf{K}) = \begin{cases} \phi^g(x^g_j|k^g_{ij}) & \text{for } i \neq j \\ \varphi^g(x^g_i|k^g_{ii}) & \text{for } i = j; \end{cases}$$

further, the dictator will be indifferent as to which other person j receives the investment.

Proof. Note that any change in payoffs is indexed by $\lambda^i_r(\mathbf{X})$. For any observable state s, person i, and set of possible returns $\mathbf{A}$ the distribution F^i_s which appears in Problem 3 takes the form

$$\begin{aligned} F^i_s(\mathbf{A}|\mathbf{K}) &= \Pr(\mathbf{X}_t \in \mathbf{A}|s_t = s, \mathbf{K}) \\ &= \Pr(\mathbf{X}^{-g}_t \in \mathbf{A}^{-g}|s_t = s, \mathbf{K}^{-g})\Pr(X^g_t = x^g|s_t = s, K^g) \\ &= \Pr(\mathbf{X}^{-g}_t \in \mathbf{A}^{-g}|s_t = s, \mathbf{K}^{-g})\Pr(X^g_t = x^g|K^g) \\ &= \Pr(\mathbf{X}^{-g}_t \in \mathbf{A}^{-g}|s_t = s, \mathbf{K}^{-g}) \prod_j \Pr(x^g_j|k^g_{\cdot j}). \end{aligned}$$

where $\mathbf{K}^{-g}$ indicates investments in all assets for all people except for investments in asset g, and similarly for $\mathbf{X}^{-g}$ and $\mathbf{A}^{-g}$; and where X^g_t is a vector of the returns to and K^g the vector of investments in the asset g across all people. The penultimate equality relies on the independence of returns to asset g from the observable state s, while the final line uses the independence of returns across people.

Using this final line, the likelihood ratios which govern how informative investments in asset g are and which feature in Proposition 3 can be seen to take the form

$$\phi^g_{ij}(\mathbf{X}'|\mathbf{K}) = \frac{\partial \Pr(x^g_j|k^g_{\cdot j})/\partial k^g_{ij}}{\Pr(x^g_j|k^g_{\cdot j})}.$$

Using the fact that the distribution of returns in the game is not only independent but also identical across people, it follows that the distribution of x^g_j is the convolution of the distribution of returns to the single game investment, taken across all investors. Then the relevant likelihood ratios take the form:

$$\phi^g_{ij}(\mathbf{X}'|\mathbf{K}) = \begin{cases} \phi^g(x^g_j|k^g_{ij}) & \text{for } i \neq j \\ \varphi^g(x^g_i|k^g_{ii}) & \text{for } i = j. \end{cases}$$

Using this fact to re-write the key updating equation (16) for the hidden investment case yields

$$(20)\quad \lambda_r^i(\mathbf{X}') = \frac{\delta_i}{\delta_n}\frac{\pi_{sr}^i}{\pi_{sr}^n}\lambda_s^i(\mathbf{X})\left[1 + \sum_{j=1}^{n}\sum_{m\neq g}^{M}\mu_{ij}^m\phi_{ji}^m\left(\mathbf{X}^{-g}|\mathbf{K}^{-g}\right)\right.$$
$$\left. + \sum_{j\neq i}^{n}\mu_{ij}^g\phi^g\left(x_j^g|k_{ij}^g\right) + \mu_{ii}^g\varphi^g\left(x_i^g|k_{ii}^g\right).\right]$$

The result then follows from the fact that this expression does not depend on j. □

The final line of the expression (20) is what is of interest; this describes the information about hidden investments in the game that can be gleaned by observing returns across different people. The key point is that this expression does not depend on the identity of the recipient j, but only on the identity of the dictator i. Thus, while we could expect the provision of incentives to encourage investments in the high-return game asset, we should not expect to see any differential incentives to direct these investments toward one person rather than another, as the informativeness of the return signal doesn't vary by recipient.

This result hinges on the independence of returns for our game asset, and would not hold for observational data from a hidden investment environment if we didn't know the covariance structure of returns. This may seem surprising—if returns are public information, why should the recipient matter? But while it's true that the identity of the recipient doesn't matter *per se*, it does matter if sending the investment to one person is more revealing than sending it to another person would be. In general we might think these differences might exist because an investment in one asset may affect returns to the overall portfolio. The claim that the recipient doesn't matter works for the asset in our experiment, however, since our randomization of the returns to that asset are independent of everything else in the environment by construction.

Our second prediction about behavior in our experiment if the hidden investment model characterizes investment is not about "to whom," but rather about "how much."

Proposition 7. *If Assumption 2 and Assumption 3 are satisfied and the likelihood ratios $\phi^g(x_j^g|k_{ij}^g)$ are twice continuously differentiable functions of k_{ij}^g, then in the hidden investment model described by Problem 3, a dictator i who sends investments in the game asset g to some other individual j will send more when the identities of the pair (i,j) are public knowledge.*

Proof. The independence of returns across people and different games greatly simplifies the first order conditions characterizing the investments, and allows us to treat these as independent decisions, each a single action in a standard principal-agent model, in which person i is the sole agent, and person n the principal. We can thus condition on investments made in other games, and contrast two different versions of the model. In the first conditional model we consider only the action of sending an investment in the game asset k_{ij} when the pair (i, j) is made public (Note that Proposition 6 predicts in the hidden investment model that behavior will not differ across the Random and Chosen versions of the Revealed games.)

Without loss of generality, suppose that person i is revealed to have sent to person 1. In this case the only game-related likelihood ratio that will effect payoffs is the likelihood governing observed realizations of the game asset x_1^g given an investment k. Call this likelihood ratio $L_R = \phi^g(x_1|k)$, and note that by construction these likelihood ratios possess the monotone likelihood property.

Next, consider the case in which there's a positive probability that more than one person might be the recipient (as in the Random games); here the likelihood ratio that matters depends on the entire vector of realizations $(x_l^g)_{l \in G}$ over the set of people who might have received the transfer, G. Using the conditional independence of each of these returns given k, the likelihood ratio in this case is $L_A = \sum_{l \in G} \phi^g(x_l|k)$.

Since L_R is one of the terms in the sum of random variables defining L_A, and since each of the terms in this sum is conditionally independent, it follows that the distribution of L_R is a mean-preserving spread of the distribution of L_A. Using our assumption that the likelihood ratios $\phi^g(x|k)$ are twice differentiable with a support that is independent of k, then Proposition 1 of Kim (1995) implies that i will make a weakly more efficient action in the revealed games than in the anonymous games; the monotone likelihood property of these distributions then implies that the efficient action must be to send larger investments in the game asset g. □

Summing up the relevant predictions of the hidden investment model for behavior in our experiment: (i) Proposition 6 tells us that the dictator in our games will be indifferent as to who receives the investments, so we would expect behavior not to differ across the Random and Chosen games; and (ii) Proposition 7 tells us that when it's known that i sent to j that i will send more, so we should expect investments to be larger in the Revealed than the Anonymous games.

6. Estimation

In order to clarify our thinking, it is useful to lay out how large transfers will be in each version of the dictator game under the three different models of the background environment. In the basic full insurance model there is a fixed sharing rule. We will expect to see transfers since it is socially efficient, but there would not be any variation in the transfers across the four games.

Our second model is one of limited commitment but full information. In these models, who has what matters, because it will affect the value of outside options. The dictator will send her investments to whomever is least likely to have his bargaining position strengthened by the transfer. Conversely, the dictator will be tempted to invest less than the efficient amount only if the stakes are large enough to improve her own bargaining position so that she can claim a larger share of village resources, both now and later. Whether or not the dictator is revealed is unimportant in this environment. Transfers will be equal under the Anonymous-Random and Revealed-Random games. Transfers will be larger under both the Anonymous-Chosen and Revealed-Chosen games, but won't differ across these two.

If, instead, the reality is a world full commitment but hidden investments, then the private information that we induce via the experiment may tempt the dictator to send less and misrepresent the size of her investments sent to others. In the two private information games (the Anonymous-Random and Anonymous-Chosen games) one cannot infer how much the dictator actually sent. In the two revealed versions of the game (the Revealed-Random game and the Revealed-Chosen game) received returns are much more informative. Accordingly, we would expect the dictator to send more, provided the village has existing mechanisms to address problems caused by private information.

Keep in mind that in the case with commitment the received returns don't necessarily benefit any specific recipient, as any returns received can be re-allocated. Thus, we would not expect there to be any difference in the amount sent between the two Anonymous games, or between the two Revealed games. In a world of hidden investments, the dictator does not care which specific person receives her transfer, she only cares whether the recipient knows who sent the transfer, because the distribution of receipts depends on her private choices, but not on who the recipient is.

So: our limited commitment model predicts that *who* receives transfers is important, but not who sent it or how much; our hidden investment model predicts that who sent *how much* is important, but not who the recipient is. These predictions are summarized in Table 2. We can imagine a more complicated model in which both mattered, and even write it down; perhaps in a model with both hidden information and limited commitment the amount sent would differ in all four games. But we don't have a characterization of this more complicated model and developing it is well beyond the scope of this paper.

We speculate that in a model which combined both hidden investment and limited commitment both revelation of identity and choice might increase transfers, but refrain from claiming that this would be a prediction of such a model, as we don't have a good understanding of how these constraints might interact. In a model with both sorts of frictions Broer et al. (2017) obtain a characterization of limiting distributions of consumption in a

Table 2. Relative size of transfers. Comparisons should be made only within rows, with $\tau_1 < \tau_2 \leq \tau_3$.

	Anonymous-Random	Revealed-Random	Anonymous-Chosen	Revealed-Chosen
Full Insurance	τ_3	τ_3	τ_3	τ_3
Limited Comm.	τ_1	τ_1	τ_2	τ_2
Hidden Inv.	τ_1	τ_2	τ_1	τ_2

calibration exercise, but as we don't have consumption data for people or households in these villages these comparisons are unavailable to us.

Our testing is somewhat unusual, because although the null under full insurance is that all four amounts sent are equal (we construct a Wald statistic to test this hypothesis), the other three cases involve joint tests of equalities and inequalities. We tackle this hypothesis testing problem using a technique described by Kodde and Palm (1986) to simultaneously test for inequality and equality constraints. The null under hidden investment is that the amounts sent in the two Anonymous games equal one another, and in the two revealed games equal one another, but the amount sent in the Anonymous games is less than that sent in the Revealed games. The null under limited commitment is that the amounts sent in the two Chosen games equal one another, and in the two Random games equal one another, but more is sent when Chosen compared to when Random. When there is only one inequality constraint as in these cases, Kodde and Palm (1986) give the exact critical values for the relevant test. In the case with more than one inequality constraint, Kodde and Palm (1986) give upper and lower bounds for the critical values of the test statistic.

7. Results

Our main results are given in Table 3, which shows the average amount sent and its standard deviation in each game. We find that none of the models with a single friction we consider can explain outcomes across all villages. The alternatives are either (i) we need a different model, perhaps one with both limited commitment and hidden investment; or (ii) different frictions are important in different villages.

First, consider the possibility that we need a different model. The limited commitment model predicts that we'll see larger investments when the recipient is chosen. And this is true, on average: consulting the first row of Table 3, we see that the average amount sent in the "Real" games is significantly greater in the Anonymous-Chosen game than the corresponding Anonymous-Random game (t-statistic 2.66) while the average amount sent in the Revealed-Chosen game is significantly greater than the amount sent in the corresponding Revealed-Random game (t-statistic 3.83).

In contrast, the hidden investment model predicts that the size of transfers will be larger when the identities are revealed. This is also true, on average: transfers in the Revealed-Random game exceed those in the Anonymous-Random game, and transfers in the Revealed-Chosen game exceed those in the Anonymous-Chosen game (with t-statistics of 3.11 and 4.65, respectively).

The fact that both revealing identities and allowing choice among recipients increases transfers on average across our entire sample leads us to reject all three of our models as a characterization of our entire sample—no single one of our models successfully explains outcomes across all villages. Examine the final four columns of Table 3. The full insurance model predicts that we should see no change in transfers when we add choice or revelation, and for the pooled sample this hypothesis is strongly rejected. The limited commitment predicts that allowing choice should affect transfers, but that revealing identities should not—for the pooled it gets one of these two predictions wrong. And finally, the hidden investment model predicts that revelation should matter, but choice should not, also achieving only half-marks for the pooled sample. If we had a model which predicted increased transfers for *both* revelation and for choice we would not be able to reject it (the final column), but we do not really have such a model, only speculation.

Second, let us consider the possibility that different frictions are important in different villages; it might be the case that the average behavior is masking an underlying heterogeneity which is in fact consistent with one or more of our models. We look village by village in the subsequent rows of Table 3 (combining the real games with the hypothetical questions).

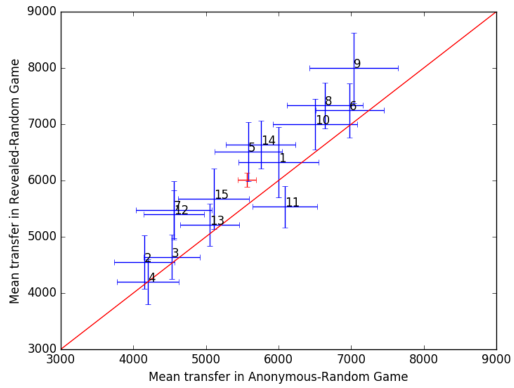
Here we certainly do find evidence of heterogeneity. Of our fifteen villages, we can reject the full insurance model in ten; reject the limited commitment model in nine; and reject the hidden investment model in two. There is overlap in these rejections: in the two villages where we reject hidden investment we also reject the other two models. We do not have a well-specified model to explain the transfers observed in these two villages. But for the remaining thirteen we do not reject all models, and we can infer, for example, that villages 1, 4, 6, 9, and 15 have transfers consistent with full insurance; that villages 1, 6, 7, 9, 10, and 15 have transfers consistent with limited commitment; and that all but villages 2 and 3 have transfers consistent with hidden investment. In only one village (village 11) are we able to reject the speculative model with both hidden investment and limited commitment.[8] On this basis, were we forced to choose a single model which best explained observed transfers we would choose the hidden investment model, but we would insist that there's considerable variation across villages, and that the hidden investment model doesn't seem to explain outcomes in all villages.

[8]In this case we had to calculate the critical values of the test statistic according to Kodde and Palm (1986) because the test statistic was between the upper and lower bound.

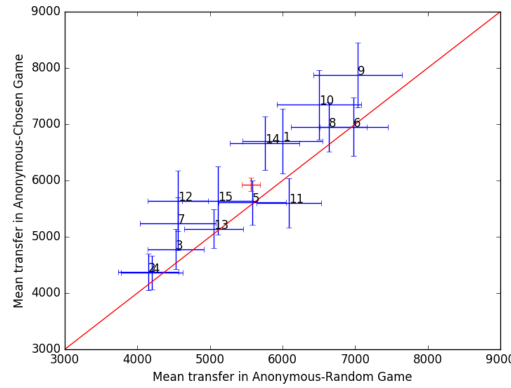
Table 3. Averages Sent and Tests of the Background Environment

Setting (Obs.)	Anonymous-Random (1)	Revealed-Random (2)	Anonymous-Chosen (3)	Revealed-Chosen (4)	Full Insurance	Limited Commitment	Hidden Investment	HI & LC Both?
Real Games	5084	5466	5394	5927	44.18***	31.80***	19.81***	0.00
(371)	(2695)	(2687)	(2679)	(2840)				
Hypothetical	6601	7173	7075	8098	39.16***	28.84***	17.84***	0.00
(173)	(3445)	(3359)	(3224)	(3295)				
Village 1	6000	6324	6706	6765	1.99	0.51	2.58	0.00
(34)	(3200)	(3674)	(3353)	(3774)				
Village 2	4150	4550	4375	5775	12.86***	11.69***	9.43**	0.00
(40)	(2646)	(3038)	(2047)	(3182)				
Village 3	4528	4639	4778	5667	10.07**	7.30**	7.70**	0.00
(36)	(2334)	(2355)	(2143)	(2644)				
Village 4	4200	4200	4367	5367	5.72	6.19*	4.71	0.00
(30)	(2310)	(2203)	(1650)	(3189)				
Village 5	5585	6512	5610	6927	17.44***	17.30***	1.79	0.00
(41)	(2958)	(3377)	(2519)	(2715)				
Village 6	6978	7244	6956	7622	4.23	4.23	2.20	0.01
(45)	(3151)	(3248)	(3470)	(3339)				
Village 7	4559	5471	5235	5853	8.16**	5.34	5.39	0.00
(34)	(3027)	(3028)	(2742)	(3500)				
Village 8	6641	7333	6949	7923	6.99*	6.15*	2.86	0.00
(39)	(3256)	(2548)	(2733)	(3012)				
Village 9	7031	8000	7875	7656	3.49	3.50	3.23	0.66
(32)	(3450)	(3501)	(3260)	(3442)				
Village 10	6500	7000	7344	7438	6.63*	1.37	5.03	0.00
(32)	(3282)	(2553)	(3488)	(2782)				
Village 11	6089	5533	5600	6444	6.65*	6.65*	5.50	2.16*
(45)	(2999)	(2473)	(2911)	(2841)				
Village 12	4560	5400	5640	6120	17.18***	10.46**	4.67	0.00
(25)	(2083)	(2121)	(2675)	(3180)				
Village 13	5048	5214	5143	6167	8.84**	8.23**	4.86	0.00
(42)	(2641)	(2435)	(2193)	(2938)				
Village 14	5756	6634	6659	7390	17.22***	9.92**	4.69	0.00
(41)	(3064)	(2727)	(3030)	(3024)				
Village 15	5107	5679	5643	5393	2.14	2.14	2.73	0.71
(28)	(2587)	(2855)	(3234)	(2529)				

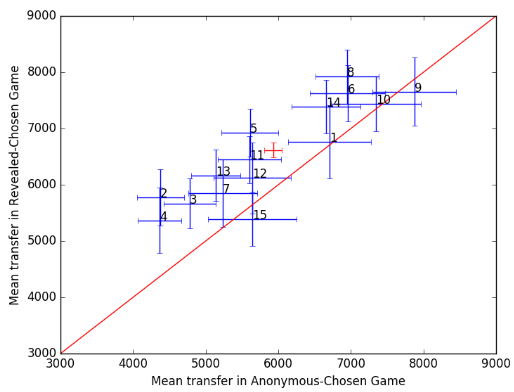
Numbers in parentheses are standard deviations. The null in the full insurance column is (1)=(2)=(3)=(4). The null in the hidden investment column is (1)=(3), (2)=(4), and (1) $\leq$ (2). The null in the limited commitment column is (1)=(2), (3)=(4), and (1) $\leq$ (3). The null in HI & LC column is (1) $\leq$ (2) and (3) $\leq$ (4) if (2) $\leq$ (3), or (1) $\leq$ (3) and (2) $\leq$ (4) if (3) $\leq$ (2). 99% (***), 95% (**), and 90% (*) cutoffs in first test column are 11.35, 7.82, and 6.25. Cutoffs in second and third test columns are 10.50, 7.05, and 5.53. Upper and lower bounds on cutoffs in the fourth test column are 8.27-5.41, 5.14-2.71, 3.81-1.64. The p-value for village 11 in the fourth column is 0.0895.



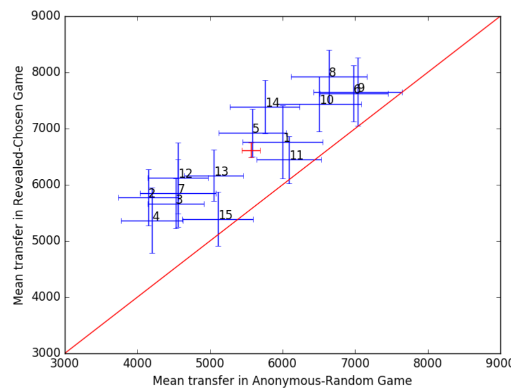
(A) (HI)



(B) (LC)



(C) (HI)



(D) (HI,LC)

FIGURE 1. Mean transfers across villages in different games, with bars indicating 95% confidence intervals. Numbers identify villages; the unnumbered "cross" indicates the global mean. Captions for each panel indicate which model(s) (HI: Hidden investment; LC: Limited commitment) predict investments should lie above 45 degree line.

Some of this variation across villages is on display in Figure 1. This figure has four panels, each using intersecting confidence intervals to indicate the means of transfers in different games for different villages. The top two panels show mean transfers in the Anonymous-Random game versus mean transfers in the Revealed-Random game (left) and the Anonymous-Chosen game (right).

Broadly, our models tell us that if the villages have mechanisms for providing incentives to deal with hidden investments, then the Revealed games ought to lead to higher transfers relative to the Anonymous games. This prediction is informally tested in three of the four panels of the Figure (A, C, D), and seems to be generally borne out in most villages.

In contrast, if incentives related to limited commitment are present, then people may care about who the recipient of the transfer is, leading to higher transfers in the Chosen games relative again to the Random games. This prediction can be tested in the right-most panels of the Figure (B,D), both overall and for most villages individually, and again this prediction is consistent with the evidence in the figure for most villages.

The panels which allow us to distinguish between models are (A) and (C); in both of these panels any limited commitment villages should like along the 45 degree line, while any hidden investment villages should lie above it. In both of these panels most villages lie above the 45 degree line, with some conspicuous exceptions.

Finally, the Southeast panel (D) combines both revelation of identity and choice of recipient; this leads to even larger mean transfers relative to the Anonymous-Random case, significantly so for all but two villages. This evidence strongly reinforces the results shown in Table 3 that on average both information and commitment are issues in this setting, but that there's variation in what is more important across different villages.

7.1. **Partner Choice.** We seek further validation of the idea that recipients matter (as they would in the model with limited commitment) by turning to an exploration of dictators' choices of recipients. Recall that each dictator is asked to choose one other household in the village with whom to share in the two Chosen games. Importantly, though the dictator can choose to share different amounts in these two games, the chosen recipient is the same in both games. We also explore whether the determinants of partner choice differ according to whether the village faces hidden investment or limited commitment, as predicted by the theory.

In the basic regression, we look at determinants of dyad-level partner choice. The dependent variable p_{ijv} takes a value of 1 if household i chose to send money to household j in village v. It takes a value of 0 if household i was a dictator in the games but did not choose to send money to j. There are observations for every dictator i, potentially linking with every j in the village (other than household i itself, since players could not send money to their own household). The basic regression equation is

$$p_{ijv} = \alpha + \beta X_{ijv} + \psi_v + u_{ijv} \tag{21}$$

As predictors, we include characteristics X_{ijv} of the relationship between i and j as stated by i, for example, whether i claims to have given gifts to j.[9] Because every player i chooses exactly one recipient, we do not include individual characteristics of player i as regressors. Because we do not have information on all household j's, we do not include individual characteristics of player j. These regressions include over 90,000 observations; 544 players

[9]We only know for those households j in our survey whether j corroborates i's claim, and so can only include characteristics of the relationship as stated by i. We do find, as have others before us, that many more people report giving gifts and lending money than report receiving gifts or borrowing money (Comola and Fafchamps, 2017).

participated in the games as dictators, and they could choose to send money to one of any 30 to 600 other households in their village, depending on the size of the village. Because of these differences in village size, and the fact that each player can only choose one partner, we include village fixed effects ψ_v.

The explanatory variables include indicator variables for whether i claims to be directly related to j (sibling, child, or parent only), whether i claims to have given money to help with health expenses, given gifts, lent money, or lent land to j and whether she claims to have received or borrowed any of the previous items from j. They also include whether i and j are compadres (godparents of each other's children), whether i claims she would go to j if she needed 20,000 Gs, and whether i claims j would come to her if he needed 20,000 Gs. Finally, they include an indicator variable for whether the potential recipient j participated in the actual games, and an indicator for whether j chose i to be his partner. Summary statistics for all variables can be found in Appendix B in Table B-1. Note that while there are over 94,000 observations, the share of pairs for which the explanatory variables equal 1 (e.g., the share of pairs for which one household lent money to the other household) is rather low.

The standard errors of such a regression must take into account that dyadic observations are not independent due to individual-specific factors common to all observations involving the same individual. We adapt the dyadic standard errors suggested by Fafchamps and Gubert (2007). They assume that $\mathrm{E}[u_{ij}u_{ik}] \neq 0$, $\mathrm{E}[u_{ij}u_{kj}] \neq 0$, $\mathrm{E}[u_{ij}u_{jk}] \neq 0$, and $\mathrm{E}[u_{ij}u_{ki}] \neq 0$. In other words, the errors for dyads which share a person in common are allowed to be correlated. Fafchamps and Gubert (2007) extend the method that Conley (1999) developed to deal with spatial correlation. We adapt the formula they suggest to the logit case, yielding an expression for the asymptotic covariance matrix

$$\frac{D}{D-K}\mathbf{H}^{-1}\left(\sum_{v=1}^{V}\left(\sum_{i=1}^{N_v}\sum_{j=1}^{N_v}\sum_{k=1}^{N_v}\sum_{l=1}^{N_v} m_{ijkl}^{v} X_{ij}^{v'} u_{ij}^{v} u_{kl}^{v} X_{kl}^{v}\right)\right)\mathbf{H}^{-1},$$

where $m_{ijkl} = 1$ if $i = k$, $j = l$, $i = l$, or $j = k$, and 0 otherwise, and where $\mathbf{H}$ is an estimate of the Hessian for the logit model. There are K regressors and D dyadic observations on pairs of households.[10] There are N_v households observed in each village v. All observations where $i = j$ or $k = l$ are omitted. This formulation allows us to account for both heteroscedasticity and cross-observation correlation.

In addition to looking at the basic regression, we also ask if the determinants of partner choice differ across hidden investment and limited commitment villages. We do so by running

[10] We would have $D = N^2 - N$ observations if households could choose partners in other villages, but this was not allowed.

the following regression:

$$p_{ijv} = \alpha + \beta X_{ijv} + \gamma X_{ijv} H_v + \theta X_{ijv} L_v + \psi_v + u_{ijv} \tag{22}$$

where H_v is a measure of hidden investment in the village and L_v is a measure of limited commitment in the village. We create one set of binary measures of village type and one set of continuous measures, both based off of the results in Table 3.

For the binary measure, we consider a village to be of hidden investment type if we can not reject hidden investment at the 10% significance level. Thus, from Table 3 one can see that according to the binary measure all villages other than 2 and 3 are considered to be hidden investment. Similarly, villages 1, 6, 7, 9, 10, and 15 are considered to be limited commitment. For the continuous measure we take into account that the test statistic shown in Table 3 measures how far from the prototypical hidden investment setting the village is. We create a continuous village-level measure which is larger for villages closer to the prototype: $(20 - \text{test statistic})/20$.

The first column of Table 4 shows the results from equation (21) while the next three columns show the results from equation (22) with the binary measures of hidden investment and limited commitment. The first column of Table 5 reproduces the first column of Table 4 for comparison, and then shows the results for equation (22) using the continuous village-level measures of hidden investment and limited commitment in the subsequent three columns.

In column (1), we find that the coefficients on many of the dyad characteristics are positive and significant, especially those which signify i had made transfers in the past to j. By far the two variables with the largest coefficients are the variable stating the two households are directly related, and the variable stating i helped j out with health expenses. Players are also more likely to choose a recipient who would come to them if the recipient needed money, to whom they would go if they needed money, or a recipient to whom they gave agricultural gifts in the past year.

The fact that coefficients on variables representing transfers out are larger and more often significant than coefficients on variables representing transfers in could suggest that dictators prefer to choose recipients in the game to whom they make transfers in their daily lives, or could be due to larger measurement error in data on receipts of help compared to the error in the giving of help. We interpret the fact that a dictator is likely to choose the same people to send to in the games as in 'real life' as evidence in favor of limited commitment constraints. Dictators will prefer to choose recipients whose limited commitment constraints will not bind as a result of the transfer.

One might worry that this correlation is instead due to dictators getting warm glow utility from giving to certain individuals. We can not test for this directly, but we have two measures which may be proxies for warm glow—being a close relative, and being a compadre. Dictators

Table 4. Determinants of Household A's Choice of Partner (Household B) - Interactions with Binary Village Type Indicators

	Uninteracted	Interacted Regression Interaction		
		None	HI	LC
	(1)	(2)	(3)	(4)
HHA and HHB Participated in Real Games	0.672**	0.380	0.366	−0.051
	(0.261)	(0.518)	(0.709)	(0.652)
HHA in Hypothetical and HHB in Real Games	0.315*	−0.089	0.238	0.336
	(0.186)	(0.385)	(0.480)	(0.431)
HHB is Close Relative	2.203***	2.566***	−0.592	0.328
	(0.217)	(0.513)	(0.619)	(0.464)
Would go to HHB if Needed Money	0.706***	0.273	0.561	−0.061
	(0.229)	(0.414)	(0.545)	(0.512)
HHB Would go to them if Needed Money	1.026***	1.859**	−0.986	0.086
	(0.308)	(0.801)	(0.941)	(0.651)
Chose HHB as Compadre	0.316	0.200	0.356	−0.442
	(0.307)	(1.897)	(1.962)	(0.637)
HHB Chose Them as Compadre	0.550	0.178	0.296	0.245
	(0.409)	(1.108)	(1.216)	(0.752)
Gave to HHB for Health in Past Year	2.619***	−0.111	3.084***	−0.356
	(0.207)	(0.481)	(0.585)	(0.461)
Gave Ag Gift to HHB	1.116***	1.096	0.019	0.091
	(0.271)	(0.792)	(0.882)	(0.600)
Received Ag Gift from HHB	0.511	0.646	−0.166	0.048
	(0.325)	(1.275)	(1.360)	(0.687)
Lent Money to HHB in Past Year	0.368	−1.708	2.168	0.171
	(0.354)	(1.864)	(1.913)	(0.708)
Borrowed Money from HHB in Past Year	0.673	−1.263	1.949	0.411
	(0.539)	(1.083)	(1.210)	(1.391)
Lent Land to HHB in Past Year	0.170	0.517	0.309	−1.658
	(0.523)	(1.571)	(1.752)	(1.098)
Borrowed Land from HHB in Past Year	−0.224	−0.532	−0.107	0.814
	(0.340)	(0.822)	(0.981)	(0.727)
HHB Chose Them in the Real Games	1.631***	2.544***	−0.887***	−0.406
	(0.255)	(0.391)	(0.343)	(0.373)
Obs.	94,404	94,404		

Correlates of partner choice using logit with village fixed effects. Regression in column (1) has no village-type interactions. The single regression in columns (2)–(4) includes village-type interactions. Column (2) shows the coefficient on the variable, column (3) shows the coefficient on the listed variable interacted with Hidden Investment (HI) village, and column (4) shows the coefficient on the listed variable interacted with Limited Commitment (LC) village. Dyadic standard errors in parentheses. *-10%, **-5%, and ***-1% significant.

Table 5. Determinants of Household A's Choice of Partner (Household B) - Interactions with Continuous Village Type Measures

	Uninteracted	Interacted Regression		
		Interaction		
		None	HI	LC
	(1)	(2)	(3)	(4)
HHA and HHB Participated in Real Games	0.672**	0.147	0.052	0.711
	(0.261)	(1.614)	(2.049)	(1.109)
HHA in Hypothetical and HHB in Real Games	0.315*	−0.466	1.050	0.038
	(0.186)	(1.268)	(1.717)	(1.056)
HHB is Close Relative	2.203***	3.574**	−1.612	−0.179
	(0.217)	(1.398)	(1.824)	(1.077)
Would go to HHB if Needed Money	0.706***	0.816	0.660	−0.975
	(0.229)	(1.428)	(2.071)	(1.348)
HHB Would go to them if Needed Money	1.026***	3.287	−3.572	0.803
	(0.308)	(2.275)	(2.942)	(1.619)
Chose HHB as Compadre	0.316	1.909	−1.767	−0.241
	(0.307)	(2.836)	(3.318)	(1.676)
HHB Chose Them as Compadre	0.550	1.619	−1.089	−0.164
	(0.409)	(3.232)	(3.524)	(1.383)
Gave to HHB for Health in Past Year	2.619***	0.255	2.851	0.203
	(0.207)	(1.439)	(1.956)	(1.195)
Gave Ag Gift to HHB	1.116***	0.726	0.474	0.023
	(0.271)	(2.504)	(3.167)	(1.331)
Received Ag Gift from HHB	0.511	−0.137	0.151	0.792
	(0.325)	(2.462)	(3.096)	(1.502)
Lent Money to HHB in Past Year	0.368	−3.329	4.150	0.676
	(0.354)	(3.377)	(4.111)	(1.910)
Borrowed Money from HHB in Past Year	0.673	−4.523	5.603	1.279
	(0.539)	(3.687)	(4.829)	(3.413)
Lent Land to HHB in Past Year	0.170	−1.122	5.109	−4.228
	(0.523)	(3.775)	(7.384)	(4.482)
Borrowed Land from HHB in Past Year	−0.224	−1.567	−1.475	3.607*
	(0.340)	(2.354)	(3.343)	(2.009)
HHB Chose Them in the Real Games	1.631***	4.442***	−4.648***	1.089
	(0.255)	(0.907)	(0.326)	(1.327)
Obs.	94,404	94,404		

Correlates of partner choice using logit with village fixed effects. Regression in column (1) has no village-type interactions. The single regression in columns (2)–(4) includes village-type interactions. Column (2) shows the coefficient on the variable, column (3) shows the coefficient on the listed variable interacted with Hidden Investment (HI) village, and column (4) shows the coefficient on the listed variable interacted with Limited Commitment (LC) village. Dyadic standard errors in parentheses. *-10%, **-5%, and ***-1% significant.

are much more likely to choose to give to a recipient with whom they are related, but no more likely to choose a recipient with whom they are compadres. After controlling for both of those characteristics, variables measuring economic interactions such as whether the dictator would go to the recipient if he needed money and whether the recipient would go to the dictator if he needed money are still significantly correlated with partner choice. This is suggestive, though not conclusive, evidence that the determinants of partner choice are due to a friction such as limited commitment rather than warm glow.

In the first row we see that households participating in the actual games are more likely to choose another participant as a recipient than a non-participating household. This may be due to the power of suggestion; when choosing a recipient, the individuals who are participating in the same games may come to mind first.

The last row explores whether households are more likely to choose the household which chose them in the real games. For the real games, everyone decided at the same time at the same event, making coordination unlikely. No communication about the games was permitted and in our monitoring we did not see individuals coordinating with one another beforehand. For the hypothetical games we did not tell recipients who chose them until after they answered the questionnaire (in the case in which we revealed the dictator's identity). Though it is conceivable that the dictator might have forewarned the recipient that we would be giving them money from her we do not believe that this occurred in practice—recipients generally seemed genuinely surprised to be receiving the money. We find households are more likely to choose the household that chose them which suggests that they are involved in reciprocal relationships, consistent again with the notion of commitment being limited.

Columns (2)–(4) of Table 4 show the results for the regression with village-type interactions. Here village type is decided by the outcome of the hypothesis tests in Table 3; we classify villages according to whether we can reject the null of no hidden investment, whether we can reject the null of no limited commitment, and whether neither null is rejected. Note that for some villages we reject both hypotheses, so that these are treated as both hidden investment and limited commitment villages for the purposes of Table 4. The standard errors are quite a bit larger in these columns due to the fact that some of the relationships described by the explanatory variables are infrequently observed in some villages. Column (2) shows that in all villages players are more likely to choose partners who are close relatives and who would go to them if they needed help.

Column (3) shows that it is only in hidden investment villages that players are more likely to choose recipients to whom they gave money for health expenses in the past year. One explanation for this is that in the hidden investment case there is no strategic reason to choose any particular individual. In that case, it is most direct to give the money to the person who needs it most, which is the person who has faced a bad health shock in the past year. Column (3) also shows that in hidden investment villages players are less likely to choose partners who had also chosen them than they are in other villages. This may be due to the fact that in villages with more hidden information, players are less likely to know or be able to back out who chose them, and so they do not or can not take that into account when choosing their partner.

Column (4) explores differences in limited commitment villages from others and it is somewhat surprising that none of the differences are significant. Partner choice in limited commitment villages is no different on average from that in villages for which we could reject that limited commitment alone holds.

Columns (2)–(4) of Table 5 show a similar regression but using the continuous measures of hidden investment and limited commitment village type. Here the standard errors increase by quite a lot as the power issues become more severe. Still, the same patterns appear as were seen in Table 4.

In sum, Table 3 shows no single one of our models can explain outcomes across all villages. However, when the 15 villages are considered individually, the hidden investment model is consistent with outcomes in all but two villages, while the limited commitment model is consistent with outcomes in six villages. There are two villages for which we can reject both the limited commitment and hidden investment models; at least for these two villages a different or more complicated model seems to be required. Since dictator choice of recipient matters in at least some villages we explore these choices in some detail by examining characteristics of the pair. Overall, dictators are more likely to choose recipients to whom they have made other transfers in the past year. In hidden investment villages they are more likely to make transfers directly to households which experienced health shocks, and they are less likely to choose the person who chose them as recipient. This suggests that in hidden investment villages partner choice is less due to strategic considerations and more due to efficiency considerations.

8. Conclusion

We use the results from four experimental games to determine in which economic environment the Paraguayan villagers live. In most villages we reject full insurance, in almost as many we reject limited commitment alone, and in a third set we reject hidden investment alone. The overall pattern suggests both that different frictions may be important in different villages, and perhaps that our models (with no more than one friction per model) are not sufficiently rich to completely describe the behavior we observe. Possibly a model with both limited commitment and hidden investment could work, but we do not yet have the tools to adequately characterize the predictions of this sort of hybrid.

Tests of full insurance against environments with different frictions usually require detailed panel data. This type of data is costly to collect and is hard to come by. Using the experimental techniques we designed here, researchers can distinguish between different alternatives to full insurance with experimental data collected at one point in time, with modest additional cross-sectional survey data.

One interpretation of our results is that, as in Ligon (1998), we find evidence that different villages may face different frictions. This suggests that the same intervention could have very different impacts in different villages. Suggestive evidence along these lines is provided by Jakiela and Ozier (2016) who show that rates of productive investment and entrepreneurship are lower in villages in which hidden information frictions are strongest, and by Angelucci et al. (2018) who show that the impact of conditional cash transfers in Mexico depends on network structure. More generally, there is a growing body of research which studies sources of similarities and differences in the impacts of interventions across settings (Brune et al., 2017; Meager, 2018; Vivalt, 2016). These studies focus on differential impacts across countries, which may be important. On the other hand, differential impact across villages may also be worthy of further study.

One intriguing direction for future research would be to collect the data necessary to relate observable heterogeneity across villages to the kinds of outcomes we observe. Our sample of 15 villages is simply too small to pursue this, but it should be possible to see whether things like village size and wealth are systematically related to the kinds of experimental outcomes we observe; if not it may be necessary to consider a richer set of models.

Future research should also focus on measuring the ratios of marginal utilities of expenditures that appear so prominently in the theory, perhaps by measuring the consumption expenditures necessary to estimate these using methods proposed by Ligon (2017). These data would allow one to relate outcomes in these experiments to the rich set of predictions regarding the evolution of intertemporal marginal rates of substitution found in much of the literature on risk-sharing and life-cycle behavior, and to test predictions about the magnitudes of some of the key variables that appear in the theory.

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Appendix A. Game Protocol

The experiments were conducted in a central location such as a church, a school, or a social hall. They took approximately three hours to complete, and players were given 1 KG extra for arriving on time. We used our vehicle to pick up participants who were not able to get to the game using their own means of transport. In this case they were given 1 KG if they were ready when the vehicle arrived at their residence.

[*The following instructions were read to the participants.*]

Thank you very much for coming today. Today's games will last two to three hours, so if you think that you will not be able to remain the whole time, let us know now. Before we begin, I want to make some general comments about what we are doing and explain the rules of the games that we are going to play. We will play some games with money. Any money that you win in the games will be yours. [The PI's name] will provide the money. But you must understand that this is not [his/her] money, it is money given to [him/her] by [his/her] university to carry out [his/her] research.

All decisions you take here in these games will be confidential, or, in some cases, also known by your playing partner. This will depend on the game and we will inform you in advance whether or not your partner will know your identity.

Before we continue, I must mention something that is very important. We invited you here without your knowing anything about what we are planning to do today. If you decide at any time that you do not want to participate for any reason, you are free to leave, whether or not we have started the game. If you let me know that you are leaving, I'll pay you for the part of the game that you played before leaving. If you prefer to go without letting me know, that is fine too.

You can not ask questions or talk while in the group. This is very important. Please be sure that you understand this rule. If a person talks about the game while in this group, we can not play this game today and nobody will earn any money. Do not worry if you do not understand the game well while we discuss the examples here. Each of you will have the opportunity to ask questions in private to make sure you understand how to play.

This game is played in pairs. Each pair consists of a Player 1 and a Player 2 household. [The PI's name] will give 14,000 Guaranies to each of you who are Player 1s here today. Player 1 decides how much he wants to keep and how much he wants to send to Player 2. Player 1 can send between 0 and 14,000 Gs to Player 2. Any money sent to Player 2 will be doubled. Player 2 will receive any money Player 1 sent multiplied by two, plus an additional contribution from us. Player 1 takes home whatever he doesn't send to Player 2. Player 1 is the only person who makes a decision. Player 1 decides how to divide the 14,000 Gs and then the game ends.

The additional contribution is determined by the roll of a die. The additional contribution will be the roll of the die multiplied by 2 if it lands on any number between 1 and 5. If it lands on 6, there will be no additional contribution. Thus, if it lands on 1 there will be 2,000 additional for Player 2, if it lands on 2 there will be 4,000 additional for Player 2, if it lands on 3 there will be 6,000 additional for Player 2, if it lands on 4 there will be 8,000 additional for Player 2, and if it lands on 5 there will be 10,000 additional for Player 2. But if it lands on 6 there will not be any additional contribution for Player 2.

Now we will review four examples. [*Demonstrate with the Guarani magnets, pushing Player 1's offer to Player 2 across the magnetic blackboard.*]

(1) Here are the 14,000 Gs. Imagine that Player 1 chooses to send 10,000 Gs to Player 2. Then, Player 2 will receive 20,000 Gs (10,000 Gs multiplied by 2). Player 1 will take home 4,000 Gs (14,000 Gs minus 10,000 Gs). If the die lands on 5 , Player 2 will receive the additional contribution of 10,000 Gs, which means he will receive 30,000 total. If the die lands on 1, Player 2 will receive the additional contribution of 2,000 Gs, which means he will receive 22,000 total.

(2) Here is another example. Imagine that Player 1 chooses to send 4,000 Gs to Player 2. Then, Player 2 will receive 8,000 Gs (4,000 Gs multiplied by 2). Player 1 will take home 10,000 Gs (14,000 Gs minus 10,000 Gs). If the die lands on 3, Player 2 will receive the additional contribution of 6,000 Gs, which means he will receive 14,000 total. If the die lands on 6, Player 2 will not receive any additional contribution, which means he will receive 8,000 total.

(3) Here is another example. Imagine that Player 1 chooses to allocate 0 Gs to Player 2. Then, Player 2 will receive 0 Gs. Player 1 will take home 14,000 Gs (14,000 Gs minus 0 Gs). If the die lands on 2, Player 2 will receive the additional contribution of 4,000 Gs, which means he will receive 4,000 total.

(4) Here is another example. Imagine that Player 1 chooses to allocate 14,000 Gs to Player 2. Then, Player 2 will receive 28,000 Gs (14,000 Gs multiplied by 2). Player 1 will take home 0 Gs (14,000 Gs minus 14,000 Gs). If the die lands on 4, Player 2 will receive the additional contribution of 8,000 Gs, which means he will receive 36,000 total.

That's how simple the game is. We will play four different versions of this game. Player 2 will always be a household in this community.

1.) In one version, Player 2's household will be chosen by a lottery. The same family can be drawn multiple times. It could be someone who is participating in the games here today, or it could be another household in this company. It can not be your own household. You will not know with whom who you are playing. Only [the PI's name] knows who plays with whom, and [he/she] will never tell anyone. They may be happy to receive a lot of money but can not thank you, or they may be sad to receive a little money but they can not get angry with you, because they are never going to know that this money came from you. You will not know the roll of the die in this version of the game.

2.) In another version, Player 2's household will also be chosen by a lottery. The same household can be drawn multiple times. In this version you will discover the identity of Player 2 after all of the games today, and Player 2 will also discover your identity. After the games we'll go to the randomly drawn Player 2's house and we will explain the rules of the game to him and we will explain that John Smith gave so much money and then the die landed in such a way, but that when John Smith was deciding how much to give he did not know who the money was going to. They may be happy to receive a lot of money, and will be able to thank you, or they may get angry with you if they receive little money, because they will know that the money was sent by you.

3 and 4.) In the next two versions, you can choose the identity of Player 2. You can choose any household in this village and we will give the money to someone in that household who is over 18. There will be two versions of this game, only one of which will count for your earnings today. You must choose the same household as recipient in these two games, and you can not choose your own household.

3.) In one version, we will not tell Player 2's household that you chose them and we will make it difficult for them to figure out your identity. That person will never know that you were the one who sent the money. They may be happy to receive a lot of money, or sad to receive little money, but they have no way of figuring out that the money came from you. Even if you go to them afterwards and tell them that you chose them and sent them money, they may not believe you. You will not know the exact amount they received because we add the additional contribution to the amount sent and also because they will receive all their earnings together at the same time as some amount X. They will not know which part of it comes from whom, or if they were chosen by a Player 1, or chosen by the lottery.

4.) In the other version we will tell Player 2's household that you chose him to send money to and you will both know the roll of the die. He can be angry with you if you send little or thank you if you send a lot.

After all of you play all four versions, I will toss a coin. If the coin lands on heads, the Player 2 household you chose will know who chose them. I will go to their house and give them the money, and explain the rules of the game to them, and I will tell them that you chose them and tell them how much money you sent them. If the coin lands on tails, the Player 2 household you chose will not know who sent them the money. We will not tell them that the money came from you, and they will not be able to find out. Remember, you decide how much you want to send when you choose the household and they know that the money comes from you, and how much you want to send when the household won't find out where the money comes from. But in this village only one of these two versions will count for money, depending on the toss of a coin. I will toss the coin in front of you after you have all played.

We now are going to talk personally with each of you one-on-one to play the game. You will play with either [Investigator 1] or [Investigator 2] in private. We will explain the game again and ask you to demonstrate your understanding with a couple of examples. You will play the game with real money. Please do not speak about the game while you are waiting to play. You can talk about soccer, the weather, medicinal herbs, or anything else other than the games. You also have to stay here together; you can not go off in small groups to talk quietly. Remember, if anyone speaks of the game, we will have to stop playing.

Dialogue for the Game

Suppose that Player 1 chooses to send 7,000 Gs to Player 2. In this case, how much would Player 1 take home? [*7,000 Gs*] How much would Player 2 receive? [*14,000 Gs*] What if the die falls on 3, what would the additional contribution be? [*6,000 Gs*] So how much would Player 2 receive in total? [*20,000 Gs*] What if the die falls on 1, what would the additional contribution be? [*2,000 Gs*] So how much would Player 2 receive in total? [*16,000 Gs*]

[*The order of playing these games is randomly chosen for each player.*]

Here I give you four small stacks of 14,000 Gs each, for a total of 56,000 Gs.

- Now we will play the game in which neither you nor Player 2 will know each other's identity. They may be happy to receive a lot of money but they can not thank you, or they may be sad to receive little money but they can not get angry with you. This is because they are never going to know that this money came from you. Take one of the stacks of 14,000 Gs. Please give me the amount you want me to give to Player 2's household, or if you do not want to give anything then don't hand me anything. I will double any money you give me and add the additional contribution to it and give it to a randomly chosen household in your village.
- Now we will play the game in which you and Player 2 will know each other's identity after the end of the games today. They may be happy to receive a lot of money, and will be able to thank you or they can get sad when receiving little money, and will be able to get angry with you. This is because they will know that the money was sent by you. Take one of the stacks of 14,000 Gs. Please give me the amount you want me to give to Player 2's household, or if you do not want to give anything then don't hand me anything. I will double any money you give me and add the additional contribution to it and give it to a randomly chosen household in your village and

inform them of the rules of the game and explain how much you sent and that you sent it without knowing to whom you were sending.

- In the next two games you choose the household to which you want to send money. Now, tell me which household do you want to send money to?
- Now we will play the game in which the recipient household is not going to know that you chose them. Take one of the stacks of 14,000 Gs. Please give me the amount you want me to give to [*name*], or if you do not want to give anything then don't hand me anything. I will double any money you give me and add the additional contribution to it. They are not going to be able to figure out who chose them. They may be happy to receive a lot of money, or sad to receive little money, but they have no way of figuring out that the money came from you. Even if you tell them that you chose them and sent them money, they may not believe you. You will not know the exact amount they received because we add the additional contribution to the amount sent and also because they will receive all their earnings together at the same time as some amount X. They will not know which part of it comes from which person, or if they were chosen by a Player 1, or chosen by the lottery.
- Now we will play the game in which the recipient household will know that you chose them. Take one of the stacks of 14,000 Gs. Please give me the amount you want me to give [*name*], or if you do not want to give anything then don't hand me anything. I will double any money you give me and add the additional contribution to it and give it to Player 2's household and tell them the rules of the game and explain that you chose them and explain how much you sent. They can be angry with you if you send little or thank you if you send a lot.

Now you must wait while the rest of the players make their decisions. Remember that you can not talk about the game while you are waiting to be paid. Please go outside to chat a bit with the enumerator named Ever before exiting.

The End

[*After all participants have made their decisions, talk to them as a group one last time.*] Now I will flip a coin. [*If heads:*] The coin landed heads, which means that the Player 2 household you chose will know who chose them and how much money they sent. [*If tails:*] The coin landed tails, which means that the Player 2 household that you chose will not discover who sent them money. Now I will speak with you one at a time one last time to give you your winnings and to tell you who was drawn in the lottery to receive money from you in the revealed version of the game.

[*Call players in one at a time.*] In the anonymous game you kept [*X Gs*]. In the game in which you will discover who you sent the money to, you kept [*Y Gs*] and [*name*] received [*M*

Gs] since their name was chosen in the lottery. In the game in which you chose your partner and [*if the coin landed heads*] he will know who sent him the money [*or if the coin landed tails*] he will not find out who sent him the money, you kept [*Z Gs*], [*and if the coin landed heads*] so Player 2 received [*M Gs*].

[*If received in anonymous game or chosen game:*] You also received [*G Gs*] from an anonymous Player 1. [*If received in revealed game:*] You also received [*H Gs*] from a Player 1 who did not know he was playing with you and his name is [*name each*] and he sent you this amount [M] which was doubled and then the die landed on [D]. [*If received in chosen revealed game:*] You also received [*J Gs*] in total from a Player 1 who chose you and their name is [*name each*] and he sent you this amount [M] which was doubled and then the die landed on [D].

That means you have won a total of [$X + Y + Z + G + H + J$ *Gs*]. Thank you for playing with us here today. Now the game is over. After we finish handing out the money here, we will go to the households of the appropriate Player 2s to give them their winnings.

Appendix B. Summary Statistics

Table B-1. Summary Statistics for Dyads between Player A and all Other Household B's in the Same Village

Variable	Share or Mean	Std Dev
HHA Chose to Send Money to HHB	0.58%	
HHA and HHB Participated in Real Games	9.36%	
HHA in Hypothetical and HHB in Real Games	2.17%	
HHB is Close Relative	1.46%	
Would go to HHB if Needed Money	1.45%	
HHB Would go to them if Needed Money	1.30%	
Chose HHB as Compadre	0.59%	
HHB Chose Them as Compadre	0.55%	
Gave to HHB for Health in Past Year	0.17%	
Gave Ag Gift to HHB in Past Year	0.83%	
Received Ag Gift from HHB in Past Year	0.34%	
Lent Money to HHB in Past Year	0.25%	
Borrowed Money from HHB in Past Year	0.18%	
Lent Land to HHB in Past Year	0.05%	
Borrowed Land from HHB in Past Year	0.09%	
HHB Chose Them in the Real Games	0.04%	
Binary Measure of Hidden Investment	92.65%	
Binary Measure of Limited Commitment	47.01%	
Continuous Measure of Hidden Investment	0.7867	0.0903
Continuous Measure of Limited Commitment	0.6745	0.2327
Obs.	94,404	

Giving and receiving of agricultural gifts for participants of real games is for past year, while for hypothetical question respondents it is for past month only (with the exception of animal gifts which are for the past year for all respondents).