

# STRUCTURAL EXPERIMENTATION TO DISTINGUISH BETWEEN MODELS OF RISK SHARING WITH FRICTIONS

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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 the sorts of impediments to trade restricting villagers' ability to share. We rule out full insurance, hidden investment alone, and limited commitment alone in favor of an environment with both hidden investment and limited commitment.

JEL codes: C93, D85, D86, and O17.

## 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 trade exist in rural Paraguay.

Previous papers which look at risk-sharing within villages as a whole include Townsend (1994) and Jalan and Ravallion (1999), while Grimard (1997) looks at risk-sharing within the same ethnic group. As researchers gain access to more detailed data sets, they have begun to document the importance of risk-sharing within social networks. Angelucci et al. (2009) find evidence that the shock of receiving a conditional cash transfer from Progreso in Mexico is shared only within the extended family. Udry (1994), Fafchamps and Lund (2003), and De Weerd and Dercon (2006) look at transfers between specific households and find that risk sharing occurs at the level of the network rather than the level of the village. These papers tend to find that negative income

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Preliminary and incomplete. Guaranteed to contain at least one mistake.

shocks experienced by someone a respondent is linked with increase the gift giving and informal lending of that respondent.

Our basic strategy is to visit villages and offer 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. From the decisions they make in the experiment we can determine which impediments to trade may exist.

Our arrival in the village 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 place a value on the social network. However, as it happens, subjects in our experiments tended not to respond 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’s full risk sharing, it will matter how *much* one invests, but it shouldn’t matter 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’s *not* full risk-sharing, the identity of the beneficiary matters. Making such investments might be a simple way for the subject to repay past debts, or to curry favor with selected members of her social network.

In Section 2 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; turn to an alternative model which has full commitment but private information; and finally describe a model featuring both limited commitment and private information. In Section 3 we show how to incorporate the random event of our experiment into the dynamic program facing the villagers. The data is 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. 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 we later explain the experimental treatments within the village, 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—we will show that the predictions of some of the models we describe are inconsistent with outcomes observed 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. Two models which have previously been used to try to explain deviations from full risk sharing are models with hidden information and limited commitment. Adding hidden information will help us to explain how much dictators in our experiment send and adding limited commitment helps us to explain to whom the dictators choose to send money.

Consider a set of individuals in a village; index these individuals by  $i = 1, 2, \dots, n$ . Each individual lives for some indeterminate number of periods. In each period, some state of nature  $s \in \mathcal{S} = \{1, 2, \dots, S\}$  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  $\pi_{sr}^i \geq 0$ .

At the beginning of the period, each individual  $i$  has some non-negative quantity  $x_i^m$  of assets indexed by  $m = 1, \dots, M$ . 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  $k_{ii}^m$  in asset  $m$  on her own behalf. Individual  $i$  can also make a non-negative contribution to the assets held by someone else—a contribution by person  $i$  of asset  $m$  held by person  $j$  is written  $k_{ij}^m$ , so that, as a consequence, the total investment for person  $i$  and asset  $m$  is  $k_i^m = \sum_{j=1}^n k_{ji}^m$ , while the portfolio of investments held by  $i$  is  $\mathbf{k}_i = [k_i^1 \dots k_i^M]$ . The  $n \times M$  matrix of person  $i$ 's investments (whether made on her own behalf or on others') is written  $\mathbf{k}_i$ , which is assumed to be drawn from a

convex, compact set  $\Theta_s^i(\mathbf{X})$  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  $\mathbf{K} = \sum_{j=1}^n \mathbf{k}_j$ . It will sometimes be convenient to consider the sum of all investments *except* for  $i$ 's. We write this as  $\mathbf{K}^{-i} = \sum_{j \neq i} \mathbf{k}_j$ .

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 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  $U_r^i$ , then  $i$ 's discounted, expected utility in state  $s$  can be computed by using the recursion

$$U_s^i = u_s^i + \delta_i \sum_{r \in \mathcal{S}} \pi_{sr}^i U_r^i$$

for all  $s$ .

The values of the  $\{U_s^i\}$  which satisfy the above recursion depend on the more primitive momentary utilities  $\{u_s^i\}$ . These, in turn, must be feasible given the resources  $\mathbf{X}$  brought into the period and the resources  $\mathbf{K}$  taken out. Note that these momentary utilities are flexible enough to include benevolence as well as directed altruism. 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  $\mathbf{u}$ .

**Assumption 1.** For any  $s \in \mathcal{S}$  the correspondence  $\Gamma_s$  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  $\mathbf{X} \in \mathcal{X}$ .

So, 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  $g_s : \mathbb{R}^n \rightarrow \mathbb{R}$  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  $g_s(\mathbf{u}; \mathbf{X} - \mathbf{K}) = 0$ .

**2.1. 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

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

subject to the promise-keeping constraints

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

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

$$(3) \quad g_s(u_s^1, \dots, u_s^n; \mathbf{X} - \mathbf{K}) \geq 0,$$

and that each individual's investments are feasible,

$$(4) \quad \mathbf{k}_j \in \Theta_s^j \quad \text{for all } j = 1, \dots, n.$$

We associate Kuhn-Tucker multipliers  $(\underline{\eta}_{ij}^m, \bar{\eta}_{ij}^m)$  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 satisfies*

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

$$(6) \quad \lambda_r^j = \frac{\delta_j \pi_{sr}^j}{\delta_i \pi_{sr}^i} \lambda_s^j,$$

and

$$(7) \quad \frac{\partial g_s}{\partial x_j^m} = \delta_i \sum_{r \in \mathcal{S}} \pi_{sr}^i \frac{\partial g_r}{\partial x_j^m} \frac{\partial \mathbf{f}_r}{\partial k_{ij}^m} + \sum_{l=1}^n (\bar{\eta}_{lj}^m - \underline{\eta}_{lj}^m)$$

for some non-negative numbers  $\{\lambda_s^j, (\lambda_r^j)_{r \in \mathcal{S}}, \left( (\bar{\eta}_{ij}^m, \underline{\eta}_{ij}^m)_{i=1}^n \right)_{m=1}^M\}$ .

*Proof.* The payoffs  $u_s^i$  are bounded, the discount factor  $\delta_i$  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).  $\square$

**2.2. Hidden Investments.** Let us now add a particular sort of friction to the problem described in Section 2.1. We allow some of the villagers to make *unobserved* investments, introducing an element of private information into the environment. These unobserved investments can result in unobserved holdings of assets at the beginning of the subsequent period, so there is in effect both a hidden information problem at the beginning of each period, as well as a hidden investment problem during the course of the period.

We imagine that only the first  $\bar{n} < n$  agents may have the opportunity to make hidden investments or to conceal their assets, so that for any  $j \leq \bar{n}$ , agent  $j$  chooses a matrix of investments  $\mathbf{k}_j \in \Theta_{s_1}^j$ . Note that we assume that the  $n$ th agent (and possibly others) do *not* make hidden investments—though  $n$  may make investments  $\mathbf{k}_n$ , 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).

The addition of private information we’ve described requires some modification to the model described above, along lines explored by Cole and Kocherlakota (2001); Doepke and Townsend (2006); Fernandes and Phelan (2000) and Árpád Ábrahám and Pavoni (2005, 2008). Here we formulate our model as a special case of the model explored by Doepke and Townsend (2006),<sup>1</sup> as expressed in their Program 1. Casting our model into their framework involves two important changes. First, 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, given that they’ve truthfully reported their initial assets at the beginning of each period, and to make truthful initial reports regarding their assets, even if future deviation investments are possible. Doepke and Townsend prove a version of the revelation principle for their environment, so that we can assert that there’s no loss of generality in requiring truth telling and obedience. Second, to induce agents to report their (stochastic) asset balance truthfully, our dynamic program

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<sup>1</sup>Our model is more general than that of Doepke and Townsend in some dimensions—for example, they allow only a single agent and assume a risk-neutral principal. However, the extension of their model to accommodate ours as a special case is trivial.

requires us to keep track of a large (but finite) collection of  $n - 1$  vectors of promised utilities, one corresponding to each possible asset realization. Accordingly, instead of keeping track of a vector of promised utilities  $\mathbf{U}^{-n}$ , as before, we now keep track of a vector of functions, where each function can take a finite number of values  $\mathcal{U}^{-n}(\mathbf{X})$ .

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

We now turn our attention to the problem facing individual  $n$  when there's no problem with commitment, but when agents  $j \leq \bar{n}$  can make (or fail to make) a hidden investment which affects the probability distribution of assets in the next period. Individual  $n$ , acting as an uninformed principal, can recommend to  $j$  that she make some particular investment  $k_j$ . In addition,  $j$ 's portfolio of assets  $\mathbf{x}_j$  may be private.

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 is some  $\mathbf{X} - (\mathbf{K}^{-j}, \hat{k}_j)$ . Finally, others must receive the momentary utility they expected given obedience. Thus, let  $d_s^j(\mathbf{u}_s, \mathbf{X} - \mathbf{K}, \mathbf{X} - (\mathbf{K}^{-j}, \hat{k}_j))$  be the largest momentary deviation utility available to individual  $j$  in state  $s$  given utility promises  $\mathbf{u}_s$  and her embezzlement  $k_j - \hat{k}_j$ .

We now formulate our problem in the recursive form of Program 1 of Doepke and Townsend (2006), yielding

**Problem 2.** Individual  $n$  solves

$$(8) \quad V_s^n(\mathcal{U}^{-n}, \mathbf{X}) = \max_{\{\{\mathcal{U}_r^{-n}(\tilde{\mathbf{X}})\}_{r \in \mathcal{S}, \mathbf{u}_s^{-n}}, \mathbf{K}\}_{\tilde{\mathbf{X}} \in \mathcal{X}}} u_s^n + \delta_n \sum_{r \in \mathcal{S}} \pi_{sr}^n V_r^n(\mathcal{U}_r^{-n}, \mathbf{f}_r(\mathbf{K}))$$

subject to the promise-keeping constraints

$$(9) \quad u_s^j + \delta_j \sum_{r \in \mathcal{S}} \pi_{sr}^j \mathcal{U}_r^j(f_r(\mathbf{K})) = \mathcal{U}^j(\mathbf{X})$$

for all  $j \neq n$ . We associate the multipliers  $\lambda_s^j$  with these constraints. As before, allocations must be feasible, so we require

$$\mathbf{u}_s \in \Gamma_s(\mathbf{X}).$$

We also require that each individual's investments are feasible, given the actual asset stocks  $\mathbf{X}$ , or that

$$(10) \quad \mathbf{k}_j \in \Theta_s^j(\mathbf{X}) \quad \text{for all } j = 1, \dots, n.$$

We associate Kuhn-Tucker multipliers  $(\underline{\eta}_{ij}^m, \bar{\eta}_{ij}^m)$  with the choice variable  $k_{ji}^m$  in (10).

Individual  $n$  will recommend investments  $k_j$  to  $j$ . But since these investments may be unobservable, the recommendation must be incentive compatible. This amounts to requiring that

$$(11) \quad \mathcal{U}^j(\mathbf{X}) \geq d_s^j(\mathbf{u}_s, \mathbf{X} - \mathbf{K}, \mathbf{X} - (\mathbf{K}^{-j}, \hat{k}_j)) + \delta_j \sum_{r \in \mathcal{S}} \pi_{sr}^j \mathcal{U}_r^j(f_r((\mathbf{K}, \hat{k}_j)))$$

for all  $j \leq \bar{n}$  and all  $\hat{k}_j \in \Theta_s^j(\mathbf{X})$ .

In addition to the obedience called for by (11),  $n$ 's problem must also induce truth-telling regarding each agent's hidden assets. As in Doepke and Townsend (2006), we accomplish this by requiring that no agent can benefit via a joint deviation of mis-representing their assets and subsequently disobeying the principal's investment recommendation. Thus, we require that if  $j$  really has assets  $\tilde{x}_j$  rather than  $x_j$  that she obtain a higher utility by truthfully reporting that fact than by lying and disobeying, or that

$$(12) \quad d_s^j(\mathbf{u}_s, \mathbf{X} - \mathbf{K}, (\mathbf{X}^{-j}, \tilde{x}_j) - (\mathbf{K}^{-j}, \hat{k}_j)) + \delta_j \sum_{r \in \mathcal{S}} \pi_{sr}^j \mathcal{U}_r^j(f_r((\mathbf{K}, \hat{k}_j))) \leq \mathcal{U}^j((\mathbf{X}^{-j}, \tilde{x}_j))$$

for all  $j \leq \bar{n}$ , all  $\tilde{x}_j \in \mathcal{X}$ , and all  $\hat{k}_j \in \mathcal{K}$ .

When we add hidden investment, agent  $j$  may have an incentive to invest less than the efficient amount. 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. Although this friction does give the agent a reason to send less than the efficient amount, she still does not care who receives the investment, since all resources will be divided according to a predetermined sharing rule.

**Proposition 2** (Folk Theorem).

**2.3. Limited Commitment.** Now, suppose that after any state  $s$  any individual  $j$  can deviate from the existing agreement. The value of the deviation depends on his portfolio of assets  $\mathbf{k}_j$ , and is given by

$A_s^j(\mathbf{k}_j)$ . Then for any arrangement to be respected, after any state  $s$  the continuation utilities received by  $j$  must satisfy

$$(13) \quad U_r^j \geq A_r^j(\mathbf{k}_j),$$

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

$$(14) \quad V_r^i(U_r^{-i}, \mathbf{f}_r(\mathbf{K})) \geq A_r^i(\mathbf{k}_i)$$

for all  $r$ . This arrangement assumes that the investment decision  $k_{ji}^m$  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 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 3.** Individual  $i$  solves (1) subject to (2), (3), (4), and the limited commitment constraints (13) (with multipliers  $\phi^j$ ) and (14) (with multipliers  $\phi^i$ ).

This is essentially the model of Ligon et al. (2000), and similar results follow.

**Proposition 3.** *A solution to Problem 3 exists, and satisfies*

$$(15) \quad \lambda_s^j = \frac{\partial g_s / \partial w^j}{\partial g_s / \partial u^i},$$

$$(16) \quad \lambda_r^j = \frac{\delta_j \pi_{sr}^j}{\delta_i \pi_{sr}^i} \left( \frac{1 + \phi_r^j}{1 + \phi_r^i} \right) \lambda_s^j,$$

and

$$(17) \quad \frac{\partial g_s}{\partial x_j^m} = \delta_i \sum_{r \in \mathcal{S}} \pi_{sr}^i \frac{\partial g_r}{\partial x_j^m} \frac{\partial \mathbf{f}_r}{\partial k_{ij}^m} + \sum_{l=1}^n (\bar{\eta}_{lj}^m - \underline{\eta}_{lj}^m) - \delta_j \frac{\lambda_s^j}{\mu_s} \sum_{r \in \mathcal{S}} \pi_{sr}^i \phi_r^j \frac{\partial A_r^j}{\partial k_{ij}^m}.$$

When an adequate commitment technology is available, Proposition 1 tells us that the ‘planning weights’  $\lambda_r^j$  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  $\lambda_r^j$  will satisfy a law of motion given by (16). 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, leading to a modified Euler equation given by (17).

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 renege.

**2.4. Hidden Transfers with Limited Commitment.** By combining both hidden investments and limited commitment, we can construct a model which yields predictions both about *how much* and *to whom* dictators will send. This turns into a complicated model since the two frictions may interact.

### 3. EXAMPLE

In each of the villages we're considering, one day in the summer of 2007 a *gringa* rolled unexpected into town. The villagers didn't know she was coming. However, they must have known of the possibility that she'd come—they'd seen this *gringa loca* before (Schechter, 2007).

In this section we show how to model the event of *la gringa's* arrival from the viewpoint of the villagers, and how to deal with the probability distribution over different possible future states induced by the experiments conducted by *la gringa loca*.

Partition the state space  $\mathcal{S} = \mathcal{S}_1 \cup \mathcal{S}_2$ , letting  $\mathcal{S}_2$  be the set of states in which *la gringa loca* runs an experiment in the village. Let person  $i$ 's assessment of the probabilities of transiting between  $\mathcal{S}_1$  and  $\mathcal{S}_2$  be given by

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

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

Let  $\Sigma$  index the set of possible states within the context of the experiment. In the experiment, we confront the villagers with a randomly chosen state  $\sigma \in \Sigma$  (e.g. person  $i$  is randomly selected to a particular treatment, and within this treatment a random die roll comes up 1). 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  $\sigma$  be given by  $\rho_\sigma$ . Any experimental protocol can be described by the pair  $(\Sigma, \rho)$ .

Our experiment was designed to manipulate the incentives that subjects had to make risky investments on others' behalf. The experimental state space  $\Sigma$  includes all possible combinations of three different elements:

- The identity of the 30 households randomly selected to participate in each village;
- The assignment of each household head to one of several possible treatments; and
- The outcomes of a coin flip and several rolls of a die (to determine payoffs from investments  $f_r(\mathbf{K})$ ).

#### 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 300 rural Paraguayan households in sixteen villages in three departments (comparable to states) across the country. Fifteen of the villages were randomly selected, and the households were stratified by land-holdings and chosen randomly. The sixteenth village was of Japanese heritage and was chosen purposefully due to the large farm size in that village. The original survey was followed up by subsequent rounds of data collection in 1994, 1999, 2002, and, most recently, 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.<sup>2</sup>

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 one small 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

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<sup>2</sup>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.

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, 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. 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. The games were held in a central location such as a church, a school, or a social hall. Of 449 households, 371 (83 per cent) participated in the games. This share is quite similar to the 188 out of 223 (or 84 per cent) 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 B for the full game protocol.

We designed four experiments which are each variants of the dictator game and, together, can be used to distinguish between the different frictions that villagers may face. The first of the experiments we conduct is the traditional dictator game which we call the ‘Random Anonymous’ game. In this game a dictator is given a sum of money and must decide how to divide it between himself and an anonymous partner. In the four experiments we conducted, we doubled the money sent by the dictator to his anonymous partner. While only those individuals who showed up for the experiment could act as dictators, any household in the village could be a recipient. In the first experiment partners were randomly assigned and remained anonymous.

The ‘Random Revealed’ game was basically the same, but players were warned that when the game was over we would reveal to them who their partner had been. The person receiving the money would also find out the rules of the game and who sent the money. In the ‘Chosen Anonymous’ and ‘Chosen Revealed’ versions of the game, the dictator could choose to which household he would like to send money. In the third version the recipient was not told who sent him the money and in the fourth version he was told.

Although the dictator chooses the recipient in both the chosen revealed and non-revealed games, only one of the two versions is randomly chosen to affect actual payoffs. This step was taken to aid in anonymity in the non-revealed version. In addition, in all four versions, we used a probability distribution to relate the amount of money sent to the amount of money received. For each of the four versions and for each of the dictators we rolled a die. The dictator knew that we were going to roll a die. In the non-revealed versions he did not see the result of the roll. On a roll of one, the recipient received an extra 2 thousand Guaranies (KGs; at the time the experiments were conducted, one thousand Guaranies was worth approximately 20 US cents); a roll of two meant an extra 4 KGs; a roll of three meant an extra 6 KGs; a roll of four meant an extra 8 KGs; and a roll of five meant an extra 10 KGs; finally, a roll of six meant that no extra money was added. Thus, the more money a dictator sent, the more money a recipient would receive on average, but the exact amount received had a random component. This was another step taken to ensure that in the chosen (non-revealed) game the dictator couldn't prove to the recipient that he had chosen him. Lastly, the recipients received all their winnings together. If they were not told, then they would not know if they were receiving money because they were chosen by one of their village mates or because they were randomly chosen by our lottery. Given that they might be receiving multiple winnings at the same time, if they were not told, they could not be sure how much came from each Dictator.

In a short survey we asked all recipients who were chosen by a dictator and who were not also themselves originally dictators how they would have played if they had been invited to participate in the economic experiments. In this case we did not worry about whether the recipient could find out the money was sent by the respondent since all decisions were hypothetical. So, in order to simplify the explanation of the game for the respondents and ease in understanding we did not incorporate the roll of the die and the additional random component received in these questions. This means that the expected amount received by the dictator's partner is 5 KGs less in the hypothetical questions than in the actual games.

The game took approximately three hours from start to finish and players were 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.

The players received no feedback about the outcome in each version until all four sets of decisions had been made. The order of the

four versions was randomly decided for each participant. Players may become more or less generous with experience, and this could bias estimation of the value of the network. With four experiments there are twenty-four possible orderings for the experiments. But, we only implemented the twelve orderings which kept the chosen revealed and chosen non-revealed games together. This is because we asked players to which household they wished to send money. Then we asked the two questions (in random order) regarding how much they would send if the recipient would find out their identity and how much they would send if the recipient would not find out. We might ask the revealed version first or the non-revealed version first, but we would never ask the chosen revealed, then ask one of the non-chosen games, and then go back to ask about the chosen non-revealed game.

Dictators were not allowed to choose to send money to their own household, nor could their own household be randomly chosen to receive money from themselves. The dictators were given 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 (not including the 1 KG received if the player showed up or was ready on time) was 40.93 KGs with a standard deviation of 21.71. 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, and had the possibility of earning payoffs as recipients as well. In addition to the winnings earned by players, many recipients throughout the village also received money.<sup>3</sup>

## 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 four different models of the background environment. In the basic full insurance model there is a fixed sharing rule. In this case people may be benevolent or altruistic, and there may be social sanctions imposed by the village collectively or by individuals in the social network for failing to make a socially efficient investment. But, transfers in all four games will be the same and we won't be able to distinguish between these four motives. We will expect to see transfers since it is socially

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<sup>3</sup>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.

efficient, but there would not be any variation in the transfers across the four games.

If, instead, the reality is a world of hidden investments, then the private information that we induce via the experiment may tempt the dictator to send less and misrepresent the size of his transfers. In the two private information games (the Random Anonymous and Chosen Anonymous games) one can never infer exactly how much the dictator actually sent. In the two full information versions of the game (the Random Revealed game and the Chosen Revealed game) outcomes are more informative and so we would expect the dictator to send more.

Keep in mind that since the amounts received are assumed to be public information, they won't particularly benefit any specific recipient. Thus, we would not expect there to be any difference in the amount sent between the two private information games, or between the two full information games. The dictator does not care who receives his transfer.

Our third model is one of limited commitment but no private information. In this case the Dictator will send his 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 his own bargaining position so that he 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 and Revealed games. Transfers will be (weakly) larger under both the Chosen and Chosen Revealed games, but won't differ across these two.

It's only with both hidden information and limited commitment that we'd expect the amount sent to differ in all four games. We'd expect the Random Anonymous game to feature the lowest transfers. Transfers in the Random Revealed game should be larger than in the Random Anonymous game. Transfers in the Chosen Anonymous will probably be larger than in the Anonymous game. It's not possible to say whether transfers in the Chosen Anonymous game will be larger than in the Random Revealed game or not. Transfers should be largest in the Chosen Revealed game. This can be summarized in Table 1.

## 7. RESULTS

Table 2 shows the average amount sent and its standard deviation in each game. We find that the data fit the pattern in Table 1 characterizing the case of a model with both limited commitment and hidden

TABLE 1. Relative size of transfers

	Random Anonymous	Random Revealed	Chosen Anonymous	Chosen Revealed
Basic Model	$\tau$	$\tau$	$\tau$	$\tau$
Hidden Inv.	$\tau_1$	$\tau_2$	$\tau_1$	$\tau_2$
Limited Comm.	$\tau_1$	$\tau_1$	$\tau_2$	$\tau_2$
LC. & HI	$\tau_1$	$\tau_{2 3}$	$\tau_{3 2}$	$\tau_4$

$\tau_j < \tau_{j+1}$  and comparisons should only be made across rows.

information. The null under full insurance is that all four amounts sent are equal and we use a Wald test to test this hypothesis. The other three cases involve inequalities and so we use a technique laid out 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 non-revealed games equal one another, and in the two revealed games equal one another, but the amount sent in the non-revealed games is less than 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 non-chosen games equal one another, but more is sent when chosen rather than non-chosen. When there is only one inequality constraint as in these cases, Kodde and Palm (1986) give the exact critical values for the relevant test.

The null under both hidden investment and limited commitment is that the least is sent in the anonymous game, the most is sent in the chosen revealed game, and the amounts sent in the other two games are more than in the anonymous game but less than in the chosen revealed game. 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. In both the real games and the hypothetical answers we are able to reject all models other than the one with both hidden investment and limited commitment.

It might be the case that the average behavior is masking the fact that different villages are in different regimes and so we also look village by village (combining the real games with the hypothetical questions). Due to the smaller sample sizes, fewer of the differences are significant. On the whole, the patterns look similar to the overall result resembling a world with both limited commitment and hidden information. In only one village (11) are we able to reject that there are both hidden investment and limited commitment. In this case we had to calculate the

TABLE 2. Averages Sent and Tests of the Background Environment

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

Numbers in parentheses are standard deviations.

Null in full insurance column is  $(1)=(2)=(3)=(4)$ . Null in hidden investment column is  $(1)=(3)$ ,  $(2)=(4)$ , and  $(1) \leq (2)$ . Null in limited commitment column is  $(1)=(2)$ ,  $(3)=(4)$ , and  $(1) \leq (3)$ . 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 is 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 91.05%.

critical values of the test statistic according to Kodde and Palm (1986) because the test statistic was between the upper and lower bound.

**7.1. Partner Choice.** We now turn to an exploration of dictators' choice of recipients. Recall that each dictator is asked to choose some 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.

In these regressions, each observation is a dyad. The dependent variable is partner choice, and it takes a value of 1 for a link if household  $i$  played in the games and chose to send money to household  $j$ . It takes a value of 0 if household  $i$  played in the games but did not choose to send money to  $j$ . There are observations for every  $i$  who participated in the games, potentially linking with every  $j$  in the village (other than household  $i$  itself, since players could not send money to their own household). For this reason there are almost 60,000 observations; 371 players participated in the games, 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 every player  $i$  chooses exactly one recipient, we cannot include individual characteristics of player  $i$  as regressors. Because we only have data on a select sample of household  $j$ 's, we cannot include individual characteristics of player  $j$ . We *can* include characteristics of the relationship between  $i$  and  $j$  as stated by  $i$ . We know, for example, whether  $i$  claims to have given gifts to  $j$  and so can use this as a regressor.<sup>4</sup>

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 that individual. We use the dyadic standard errors suggested by Fafchamps and Gubert (2007). They assume that  $E[u_{ij}u_{ik}] \neq 0$ ,  $E[u_{ij}u_{kj}] \neq 0$ ,  $E[u_{ij}, u_{jk}] \neq 0$ , and  $E[u_{ij}u_{ki}] \neq 0$ . This means that the errors between any two dyads having a person in common will not equal 0. 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

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<sup>4</sup>We only know for a select sample if  $j$  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.

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.<sup>5</sup> 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 heteroskedasticity and cross-observation correlation.

The results of these regressions are shown in Table 3. Summary statistics for all variables in these tables can be found in Appendix A in Table A-1. The first column contains everyone who participated in the actual games, and the second column contains everyone who answered the hypothetical questions.<sup>6</sup> Village fixed effects are included in all regressions.

The explanatory variables are all pre-determined before the time we carry out the experiment. They 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  $j$ . It also includes whether  $i$  and  $j$  are compadres (godparents of each other's children) and whether  $i$  claims she would go to  $j$  if he needed 20,000 Gs and whether  $i$  claims  $j$  would come to her if he needed 20,000 Gs. Lastly, it includes an indicator variable for whether the potential recipient  $j$  participated in the actual games.

Although we told the players they could choose any household in the village, due to the power of suggestion, many of them chose another household who was also there participating in the games. The hypothetical questions were only answered by those households who were chosen to be recipients but who did not participate in the actual games, and this took place either the same day as, or the next day after, the actual games. In the hypothetical choice regression we include another

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<sup>5</sup>We would have  $D = N^2 - N$  if all households could have a relationship with all other households except for with themselves. But, households in different villages are assumed not (and in our sample do not) have relationships with one another.

<sup>6</sup>The second column excludes two villages, one in which only one person answered the hypothetical questions and another in which only three people answered the hypothetical questions.

	Real Game	Hypothetical
	Partner	Choice
HHB Participated in Real Games	0.802*** ( 0.152)	0.210 ( 0.298)
HHB is Close Relative	2.288*** ( 0.205)	2.001*** ( 0.323)
Would go to HHB if Needed Money	-0.077 ( 0.308)	1.819*** ( 0.415)
HHB Would go to them if Needed Money	1.258*** ( 0.282)	0.779* ( 0.421)
Chose HHB as Compadre	0.384 ( 0.346)	0.301 ( 0.509)
HHB Chose Them as Compadre	0.108 ( 0.380)	1.693*** ( 0.484)
Gave to HHB for Health in Past Year	2.504*** ( 0.412)	3.100*** ( 0.570)
Received from HHB for Health in Past Year	-0.087 ( 0.828)	
Gave Ag Gift to HHB	1.119*** ( 0.224)	1.438*** ( 0.405)
Received Ag Gift from HHB	0.527 ( 0.360)	0.250 ( 0.541)
Lent Money to HHB in Past Year	0.657* ( 0.372)	-0.572 ( 0.674)
Borrowed Money from HHB in Past Year	0.901** ( 0.444)	0.763 ( 0.558)
Lent Land to HHB in Past Year	1.101* ( 0.629)	-1.160 ( 1.665)
Borrowed Land from HHB in Past Year	0.469 ( 0.659)	-2.284 ( 1.397)
HHB Chose Them in the Real Games	1.738*** ( 0.436)	1.669*** ( 0.391)
Obs.	59065	35190

TABLE 3. Correlates of partner choice using logit with village fixed effects in the actual games alone (left) and the hypothetical games (right). Dyadic standard errors in parenthesis. \*-90%, \*\*-95%, and \*\*\*-99% significant. Giving and receiving of agricultural gifts for participants of actual games is for the past year, while for hypothetical question respondents it is for the past month (with the exception of animal gifts which are for the past year).

explanatory variable which is 1 if the potential recipient  $j$  had chosen to share money with the respondent  $i$  in the actual games.

In this second regression we exclude the variable ‘received for health from HHB’ since there are only 6 non-zero entries out of over 30,000 observations. Although we see that players often choose to send money to people who they claim to have also helped with health expenses, the recipients do not seem to claim to receive much help with their health expenses. This is partly because many people are more willing to admit helping someone than receiving help from someone. It is also because households which experienced a sickness or a mortality often claimed to have received help from the ‘community’ or the ‘local church’ since a pot may have been passed around. There may be too many people who helped them for them to conveniently list each one.

We find that in the actual games many of the dyad characteristics are positive and significant, especially those which signify  $i$  had made transfers in the past to  $j$ . Players are more likely to choose a recipient they are related to. They are also more likely to choose a recipient who would come to them if the recipient needed money, a recipient to whom they gave agricultural gifts in the past year, a recipient to whom they gave money to help with health expenses in the past year, and a recipient to whom they lent land or money in the past year. They are also likely to choose recipients who lent them money 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 be meaningful, or could be due to the larger measurement error in the data on receipts of help.<sup>7</sup> By far the two variables with the largest coefficients are the variable stating the two household are directly related, and the variable stating  $i$  helped  $j$  out with health expenses. A person who has been sick in the past year, and who may still have continuing related health expenses, is a person whose bargaining power is not likely to be much improved by the receipt of money in the game. Thus a limited commitment model would suggest this person would be a good one to choose as recipient.

We also find that the power of suggestion is strong. Households participating in the actual games are more likely to choose another participant as a recipient than some non-participating household. One might worry that this was because the players were able to coordinate

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<sup>7</sup>[COMMENT: In the future, one way to explore this further would be to look at only those households in the actual games which chose to send money to another household in the actual games. For these cases we have both  $i$  and  $j$ 's perception of the relationship and this information could be combined to get more precise results. I could do this if we are going to keep this section in the paper.]

with one another beforehand and agreed to send each other money. We didn't see this happening in practice and no communication was permitted. We do not find that households answering the hypothetical questions are more likely to choose one of the households playing in the actual game.

To explore communication a bit more we look at whether households are more likely to choose the household which chose them in the real games. For the real games, everyone decided simultaneously, although one could imagine households signalling to each other during the instructions. We find households are more likely to choose the household that chose them. In the hypothetical game they are also more likely to choose the household which chose them. Although we did not tell them who chose them until after they answered the questionnaire (in the case in which we revealed the dictator's identity) 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. In addition, these questions were only hypothetical, so it is hard to imagine what kind of incentives it would engender for choosing the same person who chose him. The fact that the coefficient is so similar in both the real and hypothetical games suggests that these people are truly involved in reciprocal relationships rather than coordinating with each other before making their decisions. If such a *quid pro quo* were in fact important, this would bias upward our estimates of the anonymous motive of altruism at the expense of our estimate of the incentive-related motive of reciprocity.

## 8. CONCLUSION

We use the results from four experiments to determine in which economic environment the Paraguayan villagers live. We reject full insurance, limited commitment alone, and hidden investment alone. The patterns we observe in the economic experiments most closely resemble those that would arise in a world with both limited commitment and hidden investment.

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 and minimal cross-sectional survey data.

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

Variable	Real Games Share	Hypothetical Share
HHA Chose to Send Money to HHB	0.61%	0.48%
HHB Participated in Real Games	15.20%	5.71%
HHB is Close Relative	1.62%	1.14%
Would go to HHB if Needed Money	1.49%	1.28%
HHB Would go to them if Needed Money	1.42%	1.00%
Chose HHB as Compadre	0.64%	0.51%
HHB Chose Them as Compadre	0.65%	0.37%
Gave to HHB for Health in Past Year	0.20%	0.11%
Received from HHB for Health in Past Year	0.02%	
Gave Ag Gift to HHB in Past Year	1.12%	0.30%
Received Ag Gift from HHB in Past Year	0.37%	0.24%
Lent Money to HHB in Past Year	0.28%	0.20%
Borrowed Money from HHB in Past Year	0.18%	0.18%
Lent Land to HHB in Past Year	0.05%	0.03%
Borrowed Land from HHB in Past Year	0.08%	0.08%
HHB Chose Them in the Real Games	0.03%	0.54%
Obs.	59065	35190

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 past year).

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#### APPENDIX A. SUMMARY STATISTICS

#### APPENDIX B. GAME PROTOCOL

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 4,000 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 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 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.

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