American Economic Journal: Applied Economics 2012, 4(2): 134–167
http://dx.doi.org/10.1257/app.4.2.134

Risk Pooling, Risk Preferences, and Social Networks†

By Orazio Attanasio, Abigail Barr, Juan Camilo Cardenas, Garance Genicot, and Costas Meghir*

Using data from an experiment conducted in 70 Colombian communities, we investigate who pools risk with whom when trust is crucial for enforcing risk pooling arrangements. We explore the roles played by risk attitudes and social networks. Both empirically and theoretically, we find that close friends and relatives group assortatively on risk attitudes and are more likely to join the same risk pooling group, while unfamiliar participants group less and rarely assort. These findings indicate that where there are advantages to grouping assortatively on risk attitudes those advantages may be inaccessible when trust is absent or low. (*JEL* C93, O12, O18, Z13)

The aim of this paper is to study group formation when risk sharing is the objective and enforcement is scarce. In particular, we study the effects of pre-existing social networks, individual attitudes toward risk, and their interaction on group formation and matching patterns in a risk pooling experiment. Both empirically and theoretically, we find that close friends and relatives group assortatively on risk attitudes and are more likely to join the same risk pooling group, while unfamiliar participants group less and rarely assort.

We use a unique database containing information on the behavior of over 2,000 participants in a version of the risk-pooling game (Barr and Genicot 2008; Barr, Dekker, and Fafchamps 2012) in 70 Colombian communities. Our experiment has a number of advantages. First, it can be directly linked to a household survey that provides very rich data on the experimental participants, the households to which they belong, and the communities in which they live. Second, it can also be linked to data on the social ties that exist between all of the participants. Third, the experiment

* Attanasio: University College London, Gower Street, London, WC1E 6BT, UK (e-mail: o.attanasio@ucl.ac.uk); Barr: University of Nottingham, School of Economics, University Park, Nottingham, NG 2DR, UK (e-mail: abigail.barr@nottingham.ac.uk); Cardenas: Universidad de los Andes, Calle 19A No. 1-37 Este W-803, Bogotá, Colombia (e-mail: jccarden@uniandes.edu.co); Genicot: Georgetown University, IIC 570, Washington, DC 20057 (e-mail: gg58@georgetown.edu); Meghir: Yale University, 37 Hillhouse Ave, PO Box 208268, New Haven, CT 06520-8268 (e-mail: c.meghir@yale.edu). The field experiment upon which this analysis is based was funded by the Economics and Social Research Council. The survey to which it was linked was funded by the Colombian government, the World Bank, and the Inter-American Development Bank. Attanasio's research was partly funded by ESRC Professorial Fellowship RES-051-27-0135 and by ERC AdG grant 249612 (IHKDC). Genicot thanks the World Bank's Development Research Group for their warm hospitality while the article was revised. We are grateful to our team of field researchers for their dedication, our experimental participants for their patience, and the anonymous referees for their useful comments.

† To comment on this article in the online discussion forum, or to view additional materials, visit the article page at http://dx.doi.org/10.1257/app.4.2.134.

was designed to generate data not only on who chooses to share risk with whom, but also on individual risk attitudes. Fourth, the experimental protocol was designed to ensure that the participants were embedded within rather than isolated from their usual social environment when making their choices. And fifth, it is one of the largest (in terms of numbers of participants) experiments to have been undertaken.

The risk-pooling game involves two rounds. In the first round, participants independently play a version of Binswanger's (1980) gamble choice game. Behavior in this game provides information about individual attitudes toward risk. In the second round, participants play the game again but have the opportunity, prior to playing, to form risk-sharing groups in which the proceeds of all members' second round gambles are divided equally. However, the group forming agreements are not enforced, and group members can secretly defect from the agreement to share after finding out the outcome of their own second round gambles. Thus, group formation depends on trust. As we mention above, we have information on the network ties that exist between the experimental participants.

Applying a dyadic regression approach to the data from our risk-pooling game, we find the following. Dyads who share a close bond of friendship or kinship are more than three times as likely to group together. Among close friends and family members, individuals who choose the same gamble in the first round, and therefore have similar risk attitudes, have a 10 percent higher likelihood of grouping together than individuals with the average difference between their first round gamble choice. No such assortative matching was found among unfamiliar dyads. Finally, as an individual's close friends and family options increase, they are increasingly less likely to group with unfamiliar others.

To interpret these results, we build a theoretical model in which individuals are heterogenous in terms of their risk aversion and trustworthiness and are variably embedded in a trust-supporting social network. We show that individuals prefer to group with close friends and relatives with similar risk attitudes. When grouping with individuals outside their social network, untrustworthy individuals are opportunistic, defaulting on risk-sharing arrangements when it pays to do so and lying about their type, i.e., both their trustworthiness and their level of risk aversion, in order to convince others to group with them. Within this context of limited trust, individuals may prefer to group with others whose risk attitudes differ from their own and therefore have an incentive to misrepresent their risk attitudes. In this case, the assorting process is perturbed and group formation discouraged among unfamiliar individuals.

Our paper contributes to the recent literature on the importance of networks, interpersonal links, and group memberships in accessing credit and coping with risk.

A number of papers show that informal risk sharing groups or networks rarely, if ever, encompass entire communities,[1] and that these groups or networks are not

[1] See for instance Murgai et al. (2002), Fafchamps and Lund (2003), De Weerdt and Dercon (2006), and Dercon et al. (2006) for empirical evidence and Genicot and Ray (2003); Bloch, Genicot, and Ray (2008); Bramoullé and Kranton (2007), and Ambru, Mobius, and Szeidl (2010) for theoretical reasons why this is to be expected.

randomly formed, but correlate strongly with networks of kinship, caste, friendship, and geographic proximity.[2]

Group formation and membership have also been analyzed in the context of microcredit. With joint liability, Ghatak (1999, 2000) and Besley and Coate (1995) present models where socially connected groups of borrowers display higher repayment rates. Chowdhury (2007) shows that when group lending is sequential and renewal is contingent, while moral hazard is lower in groups of socially connected individuals, whether socially connected individuals choose to group together depends on the discount factor. Giné et al. (2010), in a lab-type experiment in Peru designed to simulate group lending with joint liability, found strong evidence for the positive role of social networks in the group formation process.

There is some work on the role of risk and risk attitudes in the formation of microcredit groups. Ghatak (1999, 2000) shows theoretically that risk neutral people group assortatively with respect to the riskiness of their portfolios, and Ahlin (2009) finds support for this hypothesis in a Thai microcredit program. However, when interpersonal insurance is allowed within groups, Sadoulet (2000) predicts and Carpenter and Sadoulet (2000) find evidence of grouping that is heterogeneous with respect to risk attitudes. Of course, portfolio riskiness is likely to correspond, in part, to investors' attitudes toward risk and this brings us to Giné et al. (2010) who observed a subsample of their participants grouping assortatively with respect to their risk attitudes.

The studies cited above highlight three determining factors in group formation: individual preferences and attitudes toward risk, pre-existing social networks, and the function that the groups are to perform conditional on their context. However, in contrast to our paper, they provide few, if any, insights relating to how these factors interact.

The paper is organized as follows. Section I describes the experimental design. In Section II, we introduce the empirical specification. Results are then discussed in Section III. We present a theoretical framework consistent with our result in Section IV. Section V concludes.

I. Experimental Design

A. *The Subjects*

The experiment was conducted by a team of professional field researchers in 70 Colombian municipalities during the first quarter of 2006. The experimental subjects were all participants in a survey designed to evaluate the government of Colombia's conditional cash transfer program, Familias en Acción (FeA).[3] The 70 municipalities in which the experiment was conducted were drawn from the full sample of 122 municipalities included in the FeA evaluation. The sample of 122

[2] See Dekker (2004); Dercon et al. (2006); Fafchamps and Gubert (2007); Mazzocco and Saini (2008); Munshi and Rosenzweig (2009); and Barr, Dekker, and Fafchamps (2012).

[3] The FeA program makes cash transfers to households conditional on a pledge from them that all of their children will complete primary school and that the senior woman will attend some nutrition workshops.

is made up of two random stratified samples, one of 57 municipalities selected for treatment under FeA and a control sample of 65 municipalities. The stratification of the evaluation sample reflected the focus of FeAs first expansion. The funding for the experiment reported here was sufficient to cover only 70 municipalities and was secured only after the survey round into which the experiment was embedded had already started. As a result, the 70 municipalities in which the experiment was conducted were the last in each of the routes that the 14 teams of evaluating interviewers followed. So, while the sample of 70 municipalities is not strictly random, it is unlikely to be systematically different from the remaining 52 in terms of social networks and group forming tendencies. This notwithstanding, we control for community fixed effects in all of our regression analyses.

Within each municipality, the FeA evaluation focuses on a random sample of approximately 100 households drawn from those in the poorest sixth of the national population.[4] Of these, a random sample of 60 households was invited to send a participant to the experimental workshop being held in their municipality. We anticipated a show-up rate of around 65 percent and observed a show-up rate of just under 60 percent, and we so need to give some consideration as to the selection processes that might have come into play. Each household was invited to send a participant during the private evaluation interview that took place in their home only a day or two before the workshop, thereby minimizing the likelihood of social selection processes. A comparison of those households that sent participants and those that did not indicates that the former had marginally higher consumption and were more remotely located. However, by far the strongest predictors of household participation were the identities of the interviewer who invited the household to send a participant and of the senior member of the field research team, known as the "critic," whose time was divided, at their own discretion, between conducting data quality checks and facilitating the smooth running of the research activities. We account for selection on the level of household consumption by including household consumption as a control variable in our analysis. The geographical distribution of our within-municipality samples is explicitly taken into account in our analysis. The possible effects of critics are accounted for via the inclusion of municipality fixed effects in the analysis. We do not account for the possible effect of interviewers as this would require the inclusion of a large number of additional dummy variables and because interviewers were not systematically assigned to households.

Finally, the FeA evaluation, like the FeA intervention, focuses on women within the sampled households, and, so, it is women who would have taken receipt of the invitation to the experimental workshop. The invitation did not explicitly indicate that the direct recipient needed to participate in the experiments. However, the effect of this recruitment strategy is evident in our data; 87 percent of the participants were female. We control for the gender of the participant in our analysis. However, we do not have the data required to establish whether and to what extent the participants' social networks and group formation tendencies correlate with the networks and

[4] Every household in Colombia is assigned to a category within the Sistema de Selección de Beneficiarios de Programas Sociales (System for Selecting Beneficiaries of Social Programs). FeA is targeted at the poorest of the six categories, and this is reflected in the sample of households included in the evaluation.

Table 1—Experimental Subjects

	Full sample			Sample analyzed		
	Obs.	Mean/Prop	SD	Obs.	Mean/Prop	SD
Female	2,420	0.88		2,321	0.87	
Age (years)	2,396	41.78	11.39	2,321	41.72	11.37
Education (years)	2,397	3.70	3.12	2,321	3.70	3.13
Household head	2,423	0.29		2,321	0.29	
Married	2,420	0.77		2,321	0.78	
Lives in municipal center	2,478	0.34		2,321	0.34	
Household consumption ('000 pesos/month)	2,478	433.64	254.90	2,321	427.29	249.91
Log household consumption per month	2,478	12.82	0.58	2,321	12.81	0.58
Household size	2,452	7.34	3.19	2,321	7.27	3.13
Number of kin recognized in session	2,506	0.32	0.66	2,321	0.32	0.67
Number of friends recognized in session	2,506	2.39	2.57	2,321	2.42	2.57

group formation tendencies of others in their households, and this needs to be born in mind when reviewing our findings.

A total of 2,512 individuals took part in the experiment. Our data on ties of kinship and friendship were collected during the experimental workshops, and all of the other data we use in our analysis is drawn from the FeA evaluation survey.

Table 1 presents some descriptive statistics for our experimental subjects. In this table, the first and second columns contain the proportions, means, and corresponding standard errors for as many of the 2,512 subjects as we can match to the survey data in the case of each variable, and the third and fourth columns present the same statistics but for the sample upon which the dyadic regression analysis was ultimately performed.[5] Eighty-seven percent were female, 77 percent were married, 29 percent were heads of households. Their average age was 42 years old and, on average, they had 3.7 years of education. Thirty-four percent lived in municipal centers, i.e., the small towns or villages in which the municipal administrations are situated and the experimental sessions were conducted, while the remaining 66 percent lived in the surrounding rural clusters. The average monthly household consumption (including consumption of own farm outputs) for this sample at the time of the experiments was 430,000 Colombian pesos (approximately US$190). This is low and reflects the fact that only households in the poorest of six income categories defined by the Colombian government are eligible for the FeA.

The data on friendships and kinships between experimental subjects was collected during the experimental sessions. Following registration, the field researchers constructed a complete list of all those present in the session. Then, each participant was asked whether they were related to or friends with each of the other people named on the list. Approximately one quarter recognized kin among their fellow participants. One recognized as many as five. As shown in Table 1, the average participant recognized 0.3. Friendship was more commonplace. Approximately three

[5] One hundred twenty-eight individuals had to be dropped from the analysis owing to mismatches between the experimental and survey data and to missing data points in the survey. A further 58 were effectively dropped during the estimation because they related to either the one municipality in which all the participants formed a single risk-sharing group or the one municipality in which none of the participants formed risk-sharing groups.

Table 2—Gamble Choices

Gamble choice	Low payoff (yellow)	High payoff (blue)	Expected value	Standard deviation	Risk aversion class	CRRA range
Gamble 1	3,000	3,000	3,000	0	Extreme	Infinity to 7.49
Gamble 2	2,700	5,700	4,200	2,121	Severe	7.49 to 1.73
Gamble 3	2,400	7,200	4,800	3,394	Intermediate	1.73 to 0.81
Gamble 4	1,800	9,000	5,400	5,091	Moderate	0.81 to 0.46
Gamble 5	1,000	11,000	6,000	7,071	Slight-neutral	0.46 to 0.00
Gamble 6	0	12,000	6,000	8,485	Neutral-negative	0 to −ve infinity

quarters recognized friends among their fellow participants, with 2 recognizing as many as 16. The average participant recognized 2.4.

B. *The Gamble Choice Game*

The experiment was based on a version of the risk-pooling game (Barr 2003; Barr and Genicot 2008; Barr, Dekker, and Fafchamps 2012). This game is divided into two rounds each involving a *gamble choice game*.

According to our experimental design, each subject i is called to a private meeting with a field researcher and asked to choose one gamble ℓ_i out of six gambles offered $\mathcal{L} \equiv \{1, 2, \ldots, 6\}$, ranked from the least to the most risky. Every gamble $\ell \in \mathcal{L}$ yields either a high payoff $\overline{y}_\ell$ or low payoff $\underline{y}_\ell$, each with probability 0.5. Once the gamble is chosen, the payoff is determined by playing a game that involves guessing which of the researcher's hands contains a blue rather than a yellow counter. We denote as $y_i(\ell_i)$ i's realized gamble gain. If the subject finds the blue counter, she receives the high payoff associated with the gamble of her choice, $\overline{y}_{\ell_i}$. If she finds the yellow counter, she receives the low payoff associated with that gamble, $\underline{y}_{\ell_i}$.

The six gambles are reported in Table 2. The visual aid used to explain the gambles to the participants, many of whom had very little formal education or were even illiterate, is presented in Figure A1 in the Appendix. The six gambles are similar but not identical to those used by Binswanger (1980). They have been adjusted to accord with the Colombian currency. On the visual aid, each gamble $\ell \in \{1, 2, \ldots, 6\}$ is depicted as two piles of money: the high payoff $(\overline{y}_\ell)$ on a *blue* background (dark gray in the printed Figure A1) and the low payoff $(\underline{y}_\ell)$ on a *yellow* background (light gray in the printed Figure A1). Table 2 presents the expected returns on each gamble, which vary from 3,000 to 6,000 Colombian pesos, their standard deviations, which lie between 0 and 8,458 Columbian pesos, and the ranges of CRRA associated with each gamble choice.[6]

Surprisingly, we discovered a bias in the likelihood of winning in our data. The frequency of high (blue) payoffs was higher than 50 percent, especially for those choosing riskier lotteries. Our investigations indicate that this bias is owing to a form of altruism on the part of the field researchers, and that the participants were unaware of the bias in the probabilities. Multiple tests indicate that none of the

[6] The average earnings during the experiment were 5,841 and 6,126 Columbian pesos in Rounds 1 and 2, respectively. At the time, the official exchange rate was around 2,284 Colombian pesos per US dollar.

results presented below were driven by this bias. All of this is documented in a file that we are happy to share with anyone interested.

During the first round of the experiment, the gamble choice was introduced and explained to the subjects in their private one-on-one meetings, where their comprehension was also tested. Once they had made their decisions and had played out the gamble of their choice, they were given a voucher for the value of their winnings and asked to sit separately from those who had not yet played to await further instructions. Their first round gamble choices provide a measure of their individual risk attitudes.

C. *The Risk-Pooling Game*

Once everyone had played Round 1, Round 2 of the experiment was explained.

In Round 2, the participants were told that they would play the *gamble choice game* again, that is they would be called separately, one by one and offered the same choice of gambles. However, this time, before going to their meetings, the participants could choose to form "sharing groups." Within sharing groups, second round winnings would be pooled and shared equally. However, in their private meetings, *after* seeing the outcome of their gambles, each participant would be given the option to withdraw from their sharing group, taking their own winnings with them, but forfeiting their share of the other members' winnings.[7]

All of this was explained to the participants prior to forming and registering their groups, and it was also made clear that all decisions made during private meetings between individual participants and researchers would be treated as confidential by the researchers. So, members of sharing groups could secretly leave their groups (but without knowing the choice or outcome of others' gambles), taking their own second round gamble winnings with them, but forfeiting their share of the winnings of others. If one or more members withdrew from a group, the rest of the gains within the group were pooled and divided equally between the remaining group members. Following the explanations and the presentation of a number of examples designed to demonstrate the effects of grouping and of group members subsequently withdrawing on both their own and fellow group members' winnings, the participants were invited to a luncheon and given 1–1½ hours to form their groups.

Denote as $\mathbf{y} \equiv y_1, \ldots, y_n$ the vector of gamble outcomes for all participants. Their second round earnings can be represented as follows. For all subjects $i = 1, \ldots, n$, let d_i be an indicator that takes the value 1 if i stays in the group she joined and 0 if she defects. The payoff of subject i in group S is

$$(1) \qquad e_i = \begin{cases} \dfrac{\sum_{j \in S} y_j(\ell_j) d_j}{\sum_{j \in S} d_j} & \text{if } d_i = 1 \\ y_i(\ell_i) & \text{if } d_i = 0 \end{cases}.$$

[7] If someone opts out of a group, the remaining members could potentially draw some inferences about defections from their own shared winnings, but they could never have been certain that someone had opted out and, in groups of three or more, about whom to suspect of foul play. Moreover, other community members would not know anything about the defection and neither would other group members who also defect. So punishments would be hard to design and to enforce and, as a consequence, extrinsic commitment is very limited.

II. Empirical Strategy

A. *Empirical Specifications*

Our objective is to study the formation of risk-sharing groups and, in particular, the role of risk attitudes and pre-existing networks and their interaction, in this process. The interaction is important as, if social networks capture trust, there are reasons to expect different patterns of matching among close family and friends as compared to among unfamiliar individuals. This is shown formally in Section IV, where we present a simplified model of the experiment to interpret our results.

To study group formation, we combine the data from the experiment with the network data on friendship and kinship and survey data on the individuals' characteristics and apply the dyadic analysis techniques developed in Fafchamps and Gubert (2007) and Arcand and Fafchamps (2011).

In dyadic analyses, each possible pair or dyad of individuals in a dataset is treated as an observation. Thus, in the current context, a dyadic approach allows us to investigate who chooses to group with whom during the second round of the experiment and how those choices are affected by both any pre-existing relationships between dyad members and their individual preferences and characteristics.

Let $m_{ij} = 1$ if individual i forms a risk pooling group with individual j, and 0 otherwise. The network matrix $\mathbf{M} \equiv [m_{ij}]$ is symmetrical since $m_{ij} = m_{ji}$ by construction, and, as noted by Fafchamps and Gubert (2007), this implies that the explanatory variables must enter the regression model in symmetric form. So, to test our first two predictions, we start by estimating the following model:

$$(2) \quad m_{ij} = \beta_0 + \beta_1 f_{ij} + \beta_2 |l_i^1 - l_j^1| + \beta_3 (f_{ij} \times |l_i^1 - l_j^1|) + \mathbf{s}_{ij} + u_{ij},$$

where f_{ij} indicates that i and j are close family or friends, l_i^1 denotes the gamble chosen by individual i in the first round, our proxy for their risk preferences; $\mathbf{s}_{ij}$ is a vector of session (and municipality) fixed effects; u_{ij} is the error term; and β_1 to β_3 are the coefficients to be estimated.

A significantly positive coefficient β_1 can be taken as evidence that close family and friends are more likely to group together. The regressor $|l_i^1 - l_j^1|$ is the difference in gamble choices in Round 1, our proxy for differences in risk attitudes. A significantly negative coefficient β_2 can be taken as evidence of assortative grouping based on risk attitudes among unfamiliar dyads. A significantly negative coefficient β_3 can be taken as evidence that close family and friends assort more strongly with respect to risk attitudes than those who are unfamiliar to one another. Finally, the magnitude and significance of the sum of β_2 and β_3 tells us whether this assorting is an important determinant of grouping decisions among close family and friends.

Of course, differences in risk attitudes and social networks are unlikely to be the only determinants of group formation. Other individual and dyadic characteristics and environmental factors may also affect the group formation process and, only when these are controlled for in the model can we be sure that the observed results are not owing to omitted variable bias. Therefore, to test the robustness of any results obtained by estimating (2), we expand it to include a number of additional controls and more information regarding the nature of the relationships of friendship and kinship:

$$(3) \qquad m_{ij} = \beta_0 + \beta_{11} f_{1ij} + \beta_{21} f_{2ij} + \cdots + \beta_{h1} f_{hij} + \beta_2 |l_i^1 - l_j^1| + \beta_3 (f_{ij} \times |l_i^1 - l_j^1|) + \beta_4 |\mathbf{z}_i - \mathbf{z}_j| + \beta_5 (\mathbf{z}_i + \mathbf{z}_j) + \beta_6 (l_i^1 + l_j^1) + \mathbf{s}_{ij} + u_{ij},$$

where $\mathbf{z}_i$ is a vector of other potentially relevant characteristics of individual i, and f_{1ij} to f_{hij} are refinements of the family and friends variable indicating whether a friendship or a kinship was recognized and whether the tie was reciprocally identified.

Among the refinements to the family and friends indicator variable, we expect those identifying reciprocally recognized ties to bear larger, positive coefficients. Further, and more importantly, if similarities in risk preferences are associated with genetic or social closeness, the inclusion of these controls could reduce or eliminate the significance of the interaction term. Put another way, apparent assorting on risk attitudes among close family and friends could be owing to similarities in risk preferences being associated with the degree of closeness, and it is only by controlling for that closeness that we can isolate the pure assorting effect.

Significantly negative elements in β_4 can be taken as evidence of assorting on individual characteristics other than risk attitudes, i.e., the tendency for more similar individuals to group (Jackson 2008, and Currarini, Jackson, and Pin 2009). Significant elements in β_5 identify individual characteristics that are associated with an increased likelihood of group formation and the formation of larger groups. To see why, suppose that individuals with a large value of z form larger groups. This implies that $E[m_{ij}]$ is an increasing function of $\mathbf{z}_i + \mathbf{z}_j$, and hence that β_5 is positive. And, by the same logic, a significantly negative β_6 can be taken as evidence that less risk averse individuals are less likely to enter into risk sharing groups.

The dyadic models are estimated using a logit. When estimating the models it is essential to correct the standard errors for nonindependence across observations. Nonindependence arises in part because residuals from dyadic observations involving the same individual i are correlated, negatively or positively, with each other. Standard errors can be corrected for this type of nonindependence by clustering either by dyad as proposed by Fafchamps and Gubert (2007), or by municipality (and, hence, experimental session). The second approach corrects for possible nonindependence not only within dyadic pairs sharing a common element but also across all the dyads participating in the same experimental session. Because we have data from 70 municipal sessions, we are able to apply the second, more conservative approach. In addition, we include municipality fixed effects to control for all municipality-level unobservables, including possible variations in the level of background or generalized trust.

Finally, we want to investigate whether the probability that two unfamiliar individuals belonging to the same group depend negatively on the number of family and friends each member of the dyad has available. For this, we restrict the sample to unfamiliar dyads and introduce the number of family and friends available to the dyad as the additional variable of interest in the estimation.

Table 3—Experimental Data

		Full sample		Sample analyzed	
		Mean/Prop	SD	Mean/Prop	SD
Gamble choice 1st round (in percent)	Gamble 1 (safe)	8.74		8.75	
	Gamble 2	17.76		17.66	
	Gamble 3	18.20		18.31	
	Gamble 4	29.29		29.17	
	Gamble 5	11.25		11.12	
	Gamble 6 (riskiest)	14.76		14.99	
Won gamble in 1st round (percent)		54.71		54.55	
Winnings 1st round ('000 pesos)		5.84	3.83	5.84	3.84
Joined a group (percent)		86.23		86.90	
Number of co-group members		4.13	5.76	3.62	3.86
Gamble choice 2nd round (in percent)	Gamble 1 (safe)	6.03		5.99	
	Gamble 2	12.85		12.76	
	Gamble 3	17.68		17.76	
	Gamble 4	28.94		28.75	
	Gamble 5	17.21		17.33	
	Gamble 6 (riskiest)	17.29		17.41	
Won gamble in 2nd round (percent)		57.73		57.72	
Defected having won gamble (percent)		6.26		6.42	
Defected having lost gamble (percent)		1.76		1.77	
Winnings 2nd round ('000 pesos)		6.134	4.05	6.13	4.05
Observations		2,506		2,321	

B. *Identifying Close Family and Friends*

Before we can estimate models 2 and 3, we need to decide which dyads are made up of close family or friends. As we will discuss at further length in Section IV, we expect trust to be important in an environment with limited enforcement. As a result, we want to identify pairs who have reasonable information about each other and are likely to be able to trust one another. Hence, we treat dyads in which one or both members indicated a tie of friendship or kinship and the members' dwellings are geographically proximate as close family and friends, the idea being that only geographically proximate family and friends have sufficient information about one another to know each other's levels of trustworthiness.[8]

III. Results

A. *Experimental Data*

The data generated by the experiment are presented in Table 3. In this table, the first and second columns contain the proportions, means, and corresponding standard errors for all 2,512 participants. The third and fourth columns present the

[8] Definitions of close family and friends that did not account for geographical proximity returned qualitatively similar but less robust results.

same statistics, but for the sample upon which the dyadic regression analysis was ultimately performed.

The modal gamble choice, Gamble 4, was chosen by 29 percent of the participants in both rounds of the experiment. However, there is evidence of a shift toward more risk-taking in the second round: 36 percent chose either Gamble 5 or 6 in the second round as compared to 26 percent in the first round. Eighty-six percent of the experimental participants chose to join a risk-sharing group and the average participant chose four co-group members. The mode of two co-group members was selected by 19 percent of the sample, with one co-group member, i.e., groups of two, being almost as prevalent (18 percent).

Eight percent of the participants subsequently defected, 6 percent after finding out that they had won their gambles and 2 percent after finding out that they had lost their gambles. Note that, since individuals do not know their co-group members' gamble realizations before deciding whether to stay in or defect, it can be rational for some people to leave having lost their own gamble. Indeed, an individual who is very risk averse at low levels of consumption—for instance because of subsistence constraints—but not at higher levels of consumption, may be happy to form a group with a trustworthy, risk loving person and leave the group when losing. If he were to stay in the group upon losing his gamble, he would run the risk of having to share his already small gain with his partner. We illustrate this with an example in Appendix A.

B. *Dyadic Characteristics*

We report the proportions, means, and standard deviations for the dyadic variables in Table 4. Here, we focus on the sample of 86,518 within-session dyads upon which the dyadic analysis is ultimately performed.[9]

Thus, we see that 9 percent of all the possible within-municipality dyads grouped together. This proportion is low despite the large proportion of individuals joining groups because average group size was small. So, the dependent variable m_{ij} in (2) and (3) equals 1 in 9 percent of cases and 0 in 91 percent of cases.

The average difference in gamble choices was two. This difference corresponds to, for example, one member of the dyad choosing the modal Gamble 4 and the other choosing either Gamble 2 or Gamble 6. In 9 percent of dyads the difference in gamble choices was 4 or 5, indicating that either one of the dyad members chose Gamble 1 and the other Gamble 5 or 6, or one chose Gamble 6 and the other Gamble 1 or 2.

In 10 percent of the dyads one or both of the members recognized that they shared a tie of kinship or friendship. However, kinship between dyads is extremely rare, with a kinship tie being recognized by both individuals in less than half a percent of dyads and being recognized by one individual in an additional three-quarters of a percent of dyads. Friendships are less rare, being mutually recognized in over 2 percent of dyads and by 1 individual in a further 7 percent of dyads. It is worth

[9]The experiment involved between 11 and 90 individuals per municipality or session. Thus, there are between 110 and 8,010 dyads per municipality. Inter-municipality dyads could not group together because they were not present in the same session. So, they are not included in the sample.

TABLE 4—DYADIC VARIABLES, MEANS, PROPORTIONS, AND STANDARD DEVIATIONS

	All dyads		Close family and friends	Other dyads
Dyadic variable	Mean/Prop	SD	Mean/Prop	Mean/Prop
Joined same group in round 2 (percent)	9.21		29.47	8.11
Difference in gamble choice (round 1)	1.64	1.26	1.68	1.64
Sum of gamble choices (round 1)	7.18	2.12	7.06	7.19
Friends and family: one or both recognized friendship or kinship (percent)	10.49		100.00	5.62
Both recognized friendship (percent)	2.43		29.02	0.98
Both recognized kinship (percent)	0.45		5.46	0.18
One recognized friendship, other kinship (percent)	0.18		2.02	0.08
One recognized friendship (percent)	6.90		57.77	4.13
One recognized kinship (percent)	0.53		5.73	0.25
Strangers (percent)	89.51		—	100.00
Close, i.e., geographically proximate, friends and family (percent)	5.16		100.00	—
One lives in the municipal center, one not (percent)	30.95		—	32.64
Different genders (percent)	20.54		16.57	20.75
Difference in age (years)	12.40	9.68	11.48	12.45
Difference in education (years)	3.23	2.77	2.63	3.27
Difference in marital status (percent)	34.68		30.72	34.90
Difference in household consumption ('000s pesos/month)	232.84	227.24	226.58	233.18
Difference in log household consumption per month	0.59	0.49	0.58	0.59
Difference in household size	3.11	2.91	2.80	3.13
Difference in round 1 winnings ('000 pesos)	4.18	3.21	4.08	4.19
Number who live in the municipal center	0.71	0.78	1.16	0.69
Number of females	1.75	0.48	1.77	1.75
Sum of ages (years)	83.67	16.01	84.46	83.63
Sum of education (years)	7.35	4.51	6.71	7.39
Number married	1.55	0.59	1.60	1.55
Sum of household consumption ('000s pesos/month)	850.19	359.94	850.36	850.18
Sum of log household consumption per month	25.62	0.85	25.60	25.62
Sum of household sizes	14.57	4.53	14.11	14.59
Sum of round 1 winnings ('000s pesos)	11.71	5.48	11.52	11.72
Observations	86,518		4,466	82,052

noting that, while these proportions are very small, because of the size of our dyadic sample, they relate to large numbers of observations: kinships were mutually recognized by 396 dyads and by 1 member of a further 626 dyads; and friendships were mutually recognized by 2,132 dyads and by one member of a further 6,170 dyads.[10]

We do not have data on the precise location of the dwelling of each of the experimental subjects. However, we do know whether they live in the small town or village in which the municipal government is located and the experimental session was conducted or in the surrounding rural hinterland. Further, because the sample was clustered and the clustering was captured in the data, we know which of those living in the rural hinterland are geographically proximate to one another and which are not. In the following analysis, we treat dyads in which both live in the municipal center

[10] In social network data, it is not unusual for only one member of a dyad to recognize a tie.

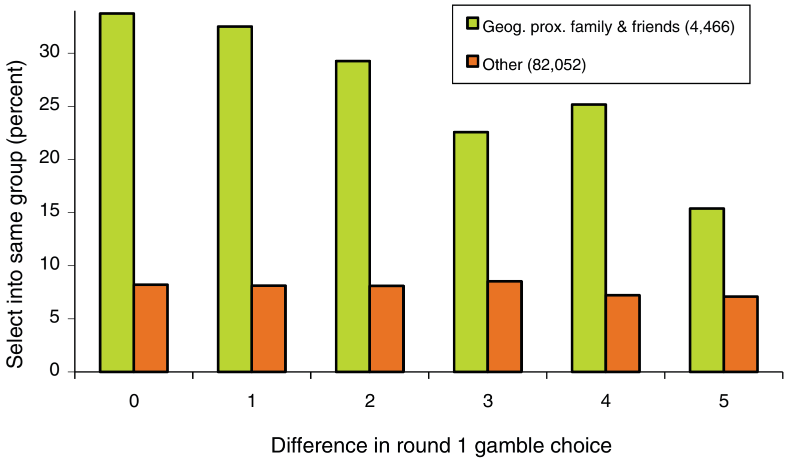

Figure 1. Assortative Match with Respect to Risk Attitudes by Different Types of Dyad

and dyads in which both live in the same rural cluster as geographically proximate. Approximately half of the dyads in which one or both members recognized a tie of kinship or friendship are geographically proximate. So, 5 percent of the full sample of dyads accord with our definition of close family and friends. Table 4 also presents the average differences in and sums of individual characteristics for the dyads.[11]

C. *Graphical Analysis*

Before moving to the regression analysis, it is useful to investigate graphically the pattern of matching among close friends and family and among others. Figure 1 shows how the proportion of dyads choosing to group together varies with the difference in their first round gamble choices and depending on whether they are close family and friends or not. The graph shows that approximately 8 percent of the dyads who are not close family and friends $(f_{ij} = 0)$ end up in the same group and that this does not vary depending on how similar or dissimilar the dyad members are with respect to their first round gamble choices. Close family and friends $(f_{ij} = 1)$ are twice as likely to end up in the same risk-sharing group when one picked the safe option and the other the riskiest option in the first round of the gamble choice game, and are over four times as likely to end up in the same risk-sharing group when both picked the same option in the first round of the gamble choice game. Close friends and family are more likely to group together and assort on risk attitudes, while others do not.

[11] We do not report the difference in household headship and the number of household heads, and neither do we use these variables in the dyadic regressions as headship and gender are highly correlated in our sample (Chi-squared statistic = 401).

Table 5—Dyadic Analysis of Assortative Matching on Risk Attitudes

	All dyads		Close friends and family	Other dyads	
	(1)	(2)	(3)	(4)	(5)
Difference in gamble choice (round 1)	−0.001	$4.45e^{-4}$	−0.021***	$-4.63e^{-5}$	−0.001
	(0.001)	(0.001)	(0.008)	(0.001)	(0.001)
Close friends and family	0.295***	0.048***			
	(0.049)	(0.019)			
Diff. in gamble choice 1 × close friends and family	−0.012***	−0.011***			
	(0.004)	(0.003)			
Both recognized friendship		0.362***	0.298***	0.358***	0.002
		(0.034)	(0.065)	(0.042)	(0.003)
Both recognized kinship		0.259***	0.302***	0.180***	0.359***
		(0.047)	(0.095)	(0.055)	(0.042)
One recognized friendship, other kinship		0.254***	0.211*	0.257***	0.181***
		(0.066)	(0.112)	(0.095)	(0.056)
One recognized friendship		0.087***	0.019	0.084***	0.260***
		(0.015)	(0.059)	(0.015)	(0.095)
One recognized kinship		0.090***		0.051	0.086***
		(0.034)		(0.038)	(0.015)
Max no. of close friends and family options					−0.006*
					(0.003)
Diff. in gamble choice × max no. close friends and family options					$3.2\ e^{-4}$
					$(4.2e^{-4})$
Other control variables included[b]	No	Yes	Yes	Yes	Yes
Municipality dummy variables included	Yes	Yes	Yes	Yes	Yes
Observations	86,518	86,518	4,440[a]	82,052	82,052
Pseudo R^2	0.131	0.160	0.183	0.139	0.140

Notes: Marginal effects reported. Corresponding standard errors (in parentheses) adjusted to account for non-independence within municipalities by clustering.

[a] Four additional municipalities were dropped from this regression because, in one, all of the dyads joined the same group and, in three, none of the dyads joined the same group.

[b] Controls included: one lives in municipal center, one not, different genders, difference in age, difference in years of schooling, difference in marital status, difference in log household consumption, difference in household size, difference in round 1 winnings, sum of gamble choices, number who live in municipal center, number of females, sum of ages, sum of years of schooling, number who are married (not to each other), sum log household consumption, sum of household sizes, sum of round 1 winnings.

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

D. *Dyadic Logit Analysis*

The significance and robustness of the patterns identified in Figure 1 can be investigated more formally by estimating the dyadic models described in Section II. Table 5 presents the results we obtain when estimating equations (2) and (3). Municipality fixed effects are included in all specifications, and reported standard errors have been adjusted by clustering at the municipality level. Rather than the coefficients of the logit models, we report marginal effects. Therefore, each number describes by how much the probability that a dyad groups together changes when changing the corresponding explanatory variable by one unit.

Column 1 of Table 5 presents the estimates corresponding to equation (2). Being close family and friends ($f_{ij} = 1$) is associated with a significantly higher likelihood of grouping together. A dyad is 30 percent more likely to be part of the same risk-sharing group if it is comprised of close family or friends who chose the same gamble in the first round. This effect is similar in magnitude to the effect observed in the graphical analysis.

Furthermore, the significant negative marginal effect of the interaction term indicates that group formation is more assortative with respect to risk attitudes among close family and friends as compared to less familiar dyads. The insignificant marginal effect of the difference in gamble choice uninteracted indicates that among less familiar dyads assorting on risk attitudes is not observed, while, according to an F-test, the sum of the marginal effect of the difference in gamble choice and the interaction term is significantly negative at the 0.1 percent level, indicating that among close family and friends group formation is assortative on risk attitudes. According to these estimates, a close friends and family dyad choosing Gambles 1 and 6 is 6 percent less likely to group together as compared to one who chooses the same gamble.[12]

Column 2 of Table 5 investigates the robustness of these findings to the inclusion of other controls and the disaggregated family and friends indicators in accordance with specification (3).[13] The additional controls lead to a significant reduction in the size of the marginal effect of "close friends and family." While still positive and significant, the marginal effect is less than one-fifth of its former size. This, of course, is because the "close friends and family" variable is strongly correlated with the other friends and family variables: reciprocated friendship ties have a large positive marginal effect; the marginal effects of reciprocated kinship ties and ties viewed as friendships by one party and kinships by the other are also positive and large; and unreciprocated ties have smaller but nevertheless highly significant positive marginal effects.[14] However, the interaction between the "close friends and family" variable and the "difference in gamble choice" variable has an almost unchanged significant, negative marginal effect.

In column 3, we present an estimated model for the subsample of dyads that are close family and friends. In this model, the marginal effect of the "difference in gamble choice" variable is negative and highly significant, and we see that, among close family and friends, reciprocated friendship ties and reciprocated ties that are

[12] Replacing "difference in gamble choice (round 1)" with a variable that equals 1 if that difference is greater than 3, and 0 otherwise, returns a small significant negative marginal effect. However, this finding is not robust.

[13] The disaggregated family and friends indicators control for the possibility that dyads sharing ties of close friendship or kinship may be more alike with respect to risk attitudes. Another way of exploring this possibility is to regress the dyadic difference in first round gamble choice on our indicator of close family and friends and on the disaggregated friends and family indicators. Doing this, we find that close family and friends are not significantly more similar with respect to risk attitudes. Dyads in which both members recognized a friendship tie were significantly more similar. However, excluding such dyads from the analysis presented in Table 5 does not significantly alter any of the results.

[14] To check whether these findings are driven purely by who chooses to group with anyone rather than who chooses to group with whom, we reran all of the estimates in Table 5 on the subsample of dyads in which both members chose to group with at least one other person, though not necessarily the other member of that dyad. The results were almost indistinguishable indicating that the findings reported in Table 5 are not driven by the decision to group irrespective of with whom.

recognized as a friendship by one and kinship by the other are particularly strongly associated with grouping. The assortative matching effect is large. A difference of 1.6 in first round gamble choice (the mean difference in our sample) as opposed to 0 reduces the likelihood of friends and family grouping by approximately one-tenth.

In column 4, we present an estimated model for the subsample of dyads that do not accord with our definition of close family and friends, i.e., geographically distant family and friends and unrelated dyads. Here, the marginal effect of the "difference in gamble choice" variable is insignificant, while we see that ties of friendship and kinship remain important even when they are not also backed up by geographic proximity.

Table 5 does not report the marginal effects and significance levels for the control variables added in columns 2–4. However, it is worth noting that grouping is assortative on gender and household consumption among geographically distant family and friends and unrelated dyads, but not among close family and friends. Also, among geographically distant family and friends and unrelated dyads, municipal center dwellers and rural hinterland dwellers tend not to group with each other, while the latter tend to engage in more grouping than the former, and those who received high winnings in the first round were less likely to group. In both subsamples those who received high and low winnings in the first round were less likely to group together.

Finally, we investigate whether unfamiliar dyads are less likely to group together the more close family and friends are available. This is of interest because strategic individuals may be less inclined to feel guilt when they defect from a group of unfamiliar individuals as compared to when they defect from a group of close family or friends, or close family and friends might be better informed about each others' trustworthiness. And, under these circumstances, an individual with available close family and friends who wants to group with unfamiliar individuals should be deemed more likely to renege and, hence, unsuitable as a co-group member. We test this idea (formalized in Section IV) in column 5 of Table 5. To do so, we re-estimate the model for the subsample of geographically distant family and friends and unrelated dyads, while introducing three additional variables: the number of close friends and family options that the member of the dyad with the greatest number of such options had when choosing whether and how to group; the interaction between this and the "difference in gamble choice" variable; and, as a control, the difference in the number of close friends and family options that the members of the dyad had. The "max. number of geographically proximate family and friends options" has a significant negative marginal effect as predicted.[15] However, while the marginal effect of the interaction between this variable and the difference in gamble choice variable is negative, it is insignificant.

[15] This variable also has a significant negative marginal effect when included in the estimation on the subsample of dyads who are close family and friends. However, it is less significant. This is consistent with more options implying a reduced likelihood of grouping with any particular one.

IV. Model

In this section, we present a theoretical model of the experiment that generates predictions that are consistent with the empirical results presented above.

A. *Premise of the Model*

Our model captures an environment that is as similar as possible to the game played in the field. However, we make three simplifying assumptions for analytical tractability. First, we assume that individuals choose from a continuum of lotteries. Second, we assume that individuals can only form groups of size one, i.e., stay as singletons, or two. And third, we make some specific assumptions about the utility function. In addition, we assume that subjects do not make additional transfers to each other during or after and as a result of the games. We will discuss these assumptions in more detail below.

Lotteries.—When taking part in the *gamble choice game*, individuals choose one out of six gambles with different expected payoffs and risk (see Table 2). For the model, we can view the gamble choice as a choice of $\sigma \geq 0$, where σ represents a lottery that earns $\overline{y}(\sigma) = b + h(\sigma)$ with a probability ½, $\underline{y}(\sigma) = b - \sigma$ with a probability ½, and h is strictly increasing.

Groups.—Consider a community I with n subjects. To participate in the second round of the experiment, subjects *partition* themselves into "sharing groups" $S_1, \dots, S_m$.[16] For tractability, we assume that these groups can be of size 1 or 2 only.

Let y_i be individual i's lottery gain, and 1_i be an indicator that takes value 1 if i stayed in the group she joined, and 0 if she defected. A subject i in group S earns a payoff as in equation (1).

Preferences.—In our risk pooling experiment, commitment is limited since individuals can secretly opt out of their sharing groups. We assume that punishments are not possible, and the consequences for individuals who opt out of their risk-sharing groups stem only from their intrinsic motivations, i.e., from feelings of guilt. We shall assume that individuals are heterogenous in terms of both their attitude toward risk and their intrinsic motivations.

We make the simplifying assumption that individuals have either low or high constant absolute risk aversion $u_i(c) = (-1/a_i)\exp(-a_i c)$. So their attitude toward risk is captured by one parameter a_i that is either low $\underline{a}$ or high $\overline{a}$, $0 < \underline{a} < \overline{a}$, with probability π and $1 - \pi$, respectively.

Individuals also differ in terms of their trustworthiness t_i that is either low $\underline{t}$ or high $\overline{t}$. A proportion $\overline{\gamma}$ of individuals are trustworthy. The guilt that an individual i feels from opting out of a group with j or lying to that person, g_{ij}, is likely to depend not only on i's trustworthiness but also on the nature of the relationship between i and j. Among

[16]These groups are exhaustive and mutually exclusive $\cup_{j=1,\dots,m} S_j = I$ and $S_j \cap S_k = 0$ for $k \neq j$.

close family and friends, we expect guilt to be higher. To capture this we make the following assumptions. If i and j are *close friends or family* (FF), g_{ij} is high enough that i would never defect from or lie to j irrespective of t_i. However, if i and j are relatively *unfamiliar* with each other, then i's type matters. *Trustworthy* individuals have a level of guilt high enough that they would not defect from or lie to a someone who is unfamiliar. In contrast, *untrustworthy* individuals would feel no guilt from lying to or defecting from someone who is unfamiliar ($g_{ij} = 0$ if j is unfamiliar and $t_i = \underline{t}$).

The distributions of risk attitudes, trustworthiness, and ties of close kinship and friendship are assumed to be independent. Let $\theta_i \equiv (a_i, t_i)$ be the type of individual i. Unfamiliar individuals do not know each other's type and only know the distribution of types in the population. Let r_{ij} denote the nature of the relation between two individuals i and j, $r_{ij} = F$ if they are close family and friends, and $r_{ij} = U$ if they are unfamiliar. We assume that everybody knows whether i and j are close friends or family.

Before exploring grouping behavior, we need to understand the incentives that individuals face and the choices that they make in a given group. To this end, the next section looks at how individuals' expected utility and choices are affected by group membership.

B. *Utilities from Groups*

Once the population is partitioned into groups, individuals choose gambles that maximize their expected utilities. This generates the expected utility of being in a specific group. The choice of lottery and resulting utilities are described in detail in Appendix B, but here is the essence.

Autarchy.—An individual i who stays as a singleton chooses a lottery that maximizes her utility given her risk preference a_i. We denote her resulting expected utility as $\nu^o(a_i)$.

Close Family and Friends.—If j and k are close friends or family and group, they would neither lie nor defect from each other.[17] They know each other's risk aversion and, taking as given the lottery choice of their partner, maximize their own utility. The resulting pair of lottery choices is (σ_j^*, σ_k^*). Let ν_{jk}^* be j's expected utility evaluated at this equilibrium.

Unfamiliar Individuals.—Consider individuals j and k who are unfamiliar with each other. Recall that people who are unfamiliar know neither each other's risk preferences nor their trustworthiness. Instead, they make *announcements* to each other about their risk aversion and form beliefs about each other's types. Every individual has an *announcement policy* $\alpha_i \in [0, 1]$ that specifies the probability that she will declare herself to be highly risk averse, $\hat{a}_i = \overline{a}$, to someone unfamiliar. An

[17] The data indicates that close friends and family members are less likely to default. In groups of two, close friends and family never default, while in 11 percent of groups comprising of two unfamiliar individuals, one individual defaults, and in 1 percent both default. In larger groups there are fewer defaults the higher the density of the close friends and family network, although the effect declines with group size. See Appendix Table A1.

individual's announcement policy is assumed to depend only on her type, so that $\alpha_i = \alpha(\theta_i)$. Since trustworthy individuals do not lie, $\alpha(\overline{t}, \overline{a}) = 1$ and $\alpha(\overline{t}, \underline{a}) = 0$. Individuals' *beliefs* then depend on their own and the others announcements $(\hat{a}_j, \hat{a}_k)$, their number of "available" friends and family members (m_j, m_k) (more on this below), and their willingness to group with each other.

Given their beliefs and their type, individuals then choose a lottery that maximizes their utility and whether to stay or not once they learn the realization of that lottery. Untrustworthy individuals choose to leave upon winning their lotteries and stay upon losing. An *equilibrium* is a vector of lotteries describing a lottery choice for every possible type of individual in the match.[18]

For a given set of beliefs, these choices generate expected utility $\nu^u_{j,k}(\mathbf{m}, \hat{\mathbf{a}})$ for j when grouping with k given js and ks announcements and numbers of available friends and family members.

Consistent Beliefs.—Naturally, we want the beliefs that individuals hold when grouped with the unfamiliar to satisfy some consistency.

Consider a partition of the population into groups Q and an announcement vector $\hat{\mathbf{a}} = \{\hat{a}_1, \hat{a}_2, \ldots\}$. An individual is said to be "available" if he is not already matched with a close friend or relative in Q. Let m_i be the number of available close friends or relatives of i in Q. We denote as $I_{m,m',\hat{a},\hat{a}'}$ the set of individuals i with $m_i = m$ and $\hat{a}_i = \hat{a}$ who are grouped with someone with m' available friends or relatives and announcement $\hat{a}'$.

Beliefs $\mathbf{p}$ and announcement policies $\boldsymbol{\alpha} = \{\alpha_1, \alpha_2, \ldots\}$ are said to be *consistent* with a vector of announcements $\hat{\mathbf{a}}$ and a partition Q if the following conditions hold:

(1) if $\hat{a}_i = \overline{a}$ then $\alpha_i > 0$ and if $\hat{a}_i = \underline{a}$ then $\alpha_i < 1$;

(2) $p_{\overline{a},\overline{t}}(m, m', \underline{a}, \hat{a}') = p_{\underline{a},\overline{t}}(m, m', \overline{a}, \hat{a}') = 0$;

(3) if $I_{m,m',\hat{a},\hat{a}'} \neq \emptyset$ then $p_\theta(m, m', \hat{a}, \hat{a}') = [\Sigma_{i \in I_{m,m',\hat{a},\hat{a}'} | \theta_i = \theta} 1]/[\Sigma_{i \in I_{m,m',\hat{a},\hat{a}'}} 1]$.

Condition (1) requires consistency between announcement policies and actual announcements. Only announcements that have a positive probability of being made according to one's announcement policy can be observed. Condition (2) states that trustworthy individuals are not believed to lie. Finally, (3) requires that one's beliefs regarding the type of an unfamiliar person who agrees to form a specific group corresponds to the actual proportion of individuals of this type in similar groups. That is, the probability with which a person with m available close friends or relatives and an announcement $\hat{a}$, who wants to group with someone with m' close friends or relatives and an announcement $\hat{a}'$ is thought to be of type θ, must correspond to the proportion of individuals of type θ in $I_{m,m',\hat{a},\hat{a}'}$ (individuals who are in similar groups). If some groupings $(m, m', \hat{a}, \hat{a}')$ are not observed in a partition, consistency does not restrict the beliefs for this hypothetical grouping.

[18] In case of multiplicity of equilibrium lotteries, we select the equilibrium favored by the trustworthy risk averse agent with the least number of available friends.

Why do an individual *i*'s beliefs regarding a potential partner *j* depend not only on *j*'s announcement and situation but also on *i*'s own announcement and situation? This is because *j*'s willingness to form a group with *i* can tell *i* something about *j*'s type (see Chade 2006). For instance, consider a setting in which a trustworthy individual with high risk aversion would under no circumstance want to group with an unfamiliar person announcing low risk aversion. If *i* announces low risk aversion and *j* announces high risk aversion, and then *j* wants to group, *i* should infer that *j* is untrustworthy.

We are now in a position to study group formation.

C. *Grouping*

Stable Groups.—We are interested in partitions of individuals into risk-sharing groups that are *stable*. Our concept of stability requires beliefs to be consistent and individuals not to want to change their current group membership and/or announcements.[19] Individuals should prefer their current group to both autarchy, if they are in a group, and forming a group with a different willing individual. Note that when a pair of individuals *i* and *j*, who are not together in the initial partition Q, consider forming a group, we assume that in the resulting partition, denoted as $Q_{+\{ij\}}$, the people they were in groups with (if they were in groups) remain alone.

Consider a partition of the population into sharing groups of size 1 or 2, $Q \equiv \{S_1, \ldots, S_m\}$. As described in Section IVB, this partition, along with a vector of announcements $\hat{\mathbf{a}}$ and a set of beliefs $\mathbf{p} = \{p_\theta(m, \hat{a})\}_{\forall m, \theta, \hat{a}}$, generates a vector of utility $\boldsymbol{\nu} = (\nu_1, \ldots, \nu_n)$, where $\nu_i = \nu^o(a_i)$ if i is alone ($\{i\} \in Q$), $\nu_i = \nu^u_{i,j}(\hat{a}_i, \hat{a}_j, m_i, m_j)$ if i and j are unfamiliar and in a group ($\{ij\} \in Q$ and $r_{ij} = U$), and $\nu_i = \nu^*_{ij}$ if i and j are close friends or relatives in a group ($\{ij\} \in Q$ and $r_{ij} = F$).

The partition Q and announcements $\hat{\mathbf{a}}$ are deemed *stable* if:

- there are announcement policies $\boldsymbol{\alpha}$ so that $\boldsymbol{\alpha}$ and the beliefs $\mathbf{p}$ generating $\boldsymbol{\nu}$ are consistent with $\hat{a}$ and Q;
- there is no individual i so that $\nu^o(a_i) > \nu_i$;
- there is no pair of individuals j and k and announcements $(\hat{a}'_j, \hat{a}'_k)$ so that $\nu'_{jk} > \nu_j$ and $\nu'_{kj} \geq \nu_k$, where $\nu'_{i-i} = v^*_{i-i}$ for $i, -i \in \{j, k\}$ if j and k are close friends or family ($r_{jk} = F$), and $\nu'_{i-i} = v^u(\hat{a}'_i, \hat{a}'_{-i}, m'_i, m'_{-i})$ if they are unfamiliar ($r_{j,k} = U$) in which case m'_i is the number of available close friends and relatives for $i, -i \in \{j, k\}$ in $Q_{+\{jk\}}$.

Having defined stability, we are ready to study individuals' preferences over group partners and their incentives to misrepresent their types.

Preferences over Partners.—

PROPOSITION 1: *Trustworthy individuals strictly prefer being in a group with a close friend or family member who has the same risk preference.*

[19] This is a natural extension of the concept of a stable match to a setting in which information is asymmetric.

The intuition behind this result is simple (all proofs are in Appendix C). When co-group members can fully trust each other and know it, they expect to share all gains. One's lottery choice then has exactly the same effect on both group members' payoff. So close friends or family members with the same preferences will choose the very lottery that they would want each other to choose. Hence, neither defection nor moral hazard is an issue, and individuals strictly prefer being in a group to being alone.

Furthermore, along with our consistency requirement, this consideration implies that people who have friends and family available to group with, but who nevertheless seek to group with unfamiliar individuals, are highly likely to be and to be believed to be untrustworthy. This is because untrustworthy individuals are relatively more tempted to group with an unfamiliar individual and thereby have the option of defecting guiltlessly than trustworthy individuals.

Suppose that trustworthy individuals always prefer to match with friends or relatives, even of different risk preference, rather than remaining alone. Then, a set of consistent beliefs would hold that someone with available friends and relatives to group with ($m > 0$), who, nevertheless, considers grouping with an unfamiliar person, is untrustworthy with probability 1. On the other hand if, for some risk preference, being alone is preferred to grouping with a friend or relative of different risk preferences, then there is a positive probability that someone unfamiliar with $m > 0$ is a trustworthy individual whose available friends and relatives have different risk aversion to them. However, this probability is still going to be smaller than for an unfamiliar person with the same announcement and fewer available friends or relatives.

With these beliefs, what happens if the assortative matching among close friends and family leaves pairs of friends or relatives with different risk attitudes? If forming a group with anyone is preferable to remaining alone, then they would do so since they would not be trusted by unknown individuals. If remaining alone is preferred by one of them, they would most likely both stay alone. This is because they would be trusted less than individuals without available close friends or family and, therefore, would only be able to group with someone else in a similar situation who is likely to be untrustworthy.

Incentives for Truth Telling and Preferences over Unfamiliar Partners.—Suppose that truth telling prevails, that is individuals announce their actual risk aversion. Would trustworthy people prefer unfamiliar individuals with the same risk preference as themselves? It is not clear. Assume that a trustworthy person with risk aversion a could choose her co-group member's lottery as well as her own. On the one hand, if he's untrustworthy she would like him to make as safe a choice as possible. This effect favors individuals who are *more* risk averse than her. On the other hand if he's trustworthy, she would like him to choose a more risky choice than he would choose if he has risk preference a, as he would want to "protect" himself against the possibility that she is not trustworthy. This makes individuals that are *less* risk averse than her attractive as co-group members. Overall, among unfamiliar others, individuals would not necessarily prefer people with the same risk preferences as themselves.

To be sure, this does not rule out assortative matching. In most cases, when a low risk aversion person would rather group with a high risk aversion person, in general, a high risk aversion person would too. Similarly, when a high risk aversion person would rather group with a low risk aversion person, in general, a low risk aversion person would too. Hence, assortative matching would arise owing to common preferences.

However, when individuals prefer partners of different risk aversion from themselves among unfamiliar individuals, this gives untrustworthy individuals incentives to misreport their risk preferences, and truth-telling would *not* be stable. As a result, grouping among unfamiliar individuals is less attractive and grouping is *mixed* in terms of risk preferences. The following section illustrates these effects.

D. *Examples of Stable Partitions*

This section presents two numerical examples of stable partitions that illustrate our reasoning above. In both examples, we consider the 6 lotteries used in the actual experiment and assume that half the population has low risk aversion $\underline{a} = 0.02$ and the other half has high risk aversion $\overline{a} = 0.05$, so that in autarchy, they would choose Gamble 3 and 2, respectively. In both examples, grouping with a close friend or relative of any risk preference is always preferred to autarchy. Hence, individuals with available close friends or relatives who seek to group with unfamiliar people are believed to be untrustworthy. It follows that in a stable partition, there will be no individual with *available* close friends or family members grouping with unfamiliar individuals. Note that close friends and relatives who are already in groups with other close friends and relatives are counted as available. Whenever possible, close friends and family with the same risk aversion group with each other, and if they have low (high) risk aversion select Gamble 5 (3). What happens among unfamiliar individuals depends on the proportion of untrustworthy people in the population and differs across the examples.

The proportion of trustworthy individuals, $\overline{\gamma}$, is assumed to be 85 percent in Example 1, while in Example 2, we set $\overline{\gamma} = 50$ percent.

EXAMPLE 1:

Consider a stable partition with truth-telling about risk preferences. In this case, all individuals with high risk aversion $\overline{a}$ (whether trustworthy or untrustworthy) in a group select Gamble 3, while trustworthy individuals with low risk aversion $\underline{a}$ grouping with unfamiliar individuals select Gamble 4 and untrustworthy individuals with low risk aversion $\underline{a}$ grouping with unfamiliar individuals select Gamble 5.

Since the probability of an untrustworthy partner is only 15 percent, this has little impact on who individuals choose to group with, and individuals prefer grouping with unfamiliar individuals to autarchy. Trustworthy individuals of all risk preferences prefer to group assortatively and untrustworthy individuals have no incentive to lie.

Hence, assortative matching among both family and friends and unfamiliar and truth-telling are stable in this example.

EXAMPLE 2:

This second example is identical to the first except that the proportion of untrustworthy individuals is much larger; they constitute half the population. Let's assume truth-telling about risk preferences to start with. In all groups of unfamiliar individuals, low risk aversion individuals would select Gamble 4 and high risk aversion individuals would select Gamble 3. Now, trustworthy individuals with low risk aversion would prefer grouping with individuals with high risk aversion. Since individuals with high risk aversion prefer each other to people with low risk aversion, this would not be an option. With assortative matching among unfamiliar individuals, individuals with high risk aversion would form groups while individuals with low risk aversion would choose autarchy. Would this be a stable partition?

No. Untrustworthy individuals with low risk aversion would have an incentive to pretend to be highly risk averse in order to match with a high risk aversion person. Hence, a stable partition will involve some misrepresentation of risk preferences.

A stable partition in this example consists of unfamiliar individuals announcing high risk aversion grouping with each other while others remain alone, and 10.36 percent of the untrustworthy with low risk aversion pretending to have high risk aversion. Hence, groups of unfamiliar individuals with different levels of risk aversion form while we have assortative matching among close friends and family members.

E. *Predictions of the Model*

The theoretical model and the examples discussed above support the following predictions that are consistent with our empirical findings:

- Grouping is more likely among close family and friends than the unfamiliar. This is so, not only because trustworthy individuals prefer close friends and family with similar preferences, but also because individuals with available friends and family who consider grouping with unfamiliars nevertheless will be suspected of being untrustworthy.
- Among close family and friends, grouping is strongly assortative with respect to risk attitudes. Among unfamiliar individuals, grouping may or may not be assortative with respect to risk attitudes. The lack of trust among unfamiliar individuals perturbs preference orderings across different types of co-group members leading to some preferring to group with individuals exhibiting risk preferences that are different from their own. In this case, untrustworthy individuals have an incentive to lie about their risk attitudes and this prevents assortative matching among unfamiliars.
- The likelihood that an individual will group with someone who is unfamiliar to them declines as the number of close family and friends present increases. This is because, the likelihood of finding close family and friends with similar risk attitudes rises with the number of close family and friends present and, so, individuals who choose not to group with close family and friends are more likely to be and be believed to be untrustworthy by others.

The model above provides an intuitively attractive explanation for the empirical findings presented in the preceding section, in particular for the different patterns of matching between close friends and relatives and unfamiliars. Before concluding, it is worth briefly discussing some assumptions underlying the theory and points at which the theory and the experiment diverge.

A key assumption in the model is that subjects do not make any additional transfers to each other outside of the experiment. As Sadoulet (2000), Legros and Newman (2007), and Chiappori and Reny (2004) have shown, additional transfers could result in negative assortative matching among close friends and family members. However, there was no evidence that post game transfers were made by the subjects: none were observed in the experimental venue, and there is no correlation between individuals' first gamble choice and the number of close friends and family that they have (something that we would expect in the presence of post play transfers).

In the model, only groups of one or two were allowed, while groups could be of any size in the experiment. Restricting the experimental subjects to groups of two might have introduced an element of artificiality that would have distracted the subjects from the underlying nature of the choices they were being asked to make.[20] Allowing for groups of any size in the theoretical model would require us to make many more assumptions on the group formation process and is beyond the scope of this paper. However, we believe that the intuition would carry through as long as people have a limited number of close friends and family with whom to group.

Finally, we have assumed that the higher trust among close friends and relatives stems from intrinsic motivations (guilt), but it could alternatively be the result of higher enforcement. Close friends and family could use some defection-revealing mechanism[21] and punish each other during future interactions (something that individuals with no other interactions would not be in a position to do). There was no evidence of individuals engaging in such a scheme within the session but close friends and family could presumably do so later on.

V. Conclusion

Our objective in this paper was to investigate the effects of risk attitudes and social networks on group formation in a risk pooling experiment.

Using a dyadic analysis based on experimental data on risk attitudes and risk pooling group formation, social network data, and data from a survey, we find the following. Among close family and friends, grouping is relatively commonplace and strongly assortative with respect to risk attitudes. Among unfamiliar individuals, grouping is much less common and is not assortative with respect to risk attitudes. Individuals are less likely to group with someone who is unfamiliar the more close family and friends are available.

[20] In Zimbabwe, subjects playing a version of the game in which people could form groups of at most two likened (in post play discussions) the game to a dance or being required to walk in pairs when at school, whereas they likened the current game to the forming of funeral societies and various types of cooperatives.

[21] This mechanism would require all group members to announce their winnings simultaneously. More likely than not, a defector would be unable to answer the question correctly.

These findings are consistent with a simple theoretical model in which individuals are heterogenous in terms of their risk attitudes and trustworthiness and can form pairs to pool risk. Indeed, such a model predicts precisely what we find: that close friends and family are more likely to group together; that among close family and friends, individuals with similar risk attitudes are more likely to group together; and that the more friends and family members one has, the less likely one is to group with an unfamiliar person.

Appendix

A. *Deviations upon Losing One's Gamble*

This Appendix shows that since individuals do not know the other's realization before deciding whether to stay or not, it may be rational for them to leave their group after having lost their lottery. An individual who is very risk averse at low levels of consumption—for instance because of subsistence constraints—but not at higher levels of consumption, may be happy to form a group with a trustworthy risk loving person and leave the group when losing. By taking a fairly safe lottery and leaving in the event of losing, she can be sure that her consumption does not fall below a certain level, but being matched with a risk taker she gets access to the higher expected payoff from more risky lotteries. We illustrate this point with the following example.

Consider individual 1 who has the following utility function. She has linear utility for consumption levels greater or equal to 27 but infinitely negative utility at consumption levels below 27.

$$u(c) = \begin{cases} c \\ -\infty \end{cases} \quad \mathit{if} \quad \begin{matrix} c \geq 27 \\ c < 27 \end{matrix}. \tag{A1}$$

Assume that she groups with 2 who is known to never defect. In this case, in autarchy, 1 would choose lottery 2 (which earns 27 or 57 with probability ½) and get utility $u^a = [27 + 57]/2 = 42$.

Assume that 1 is in a group with 2 who chooses lottery 5 (which earns 10 or 110 with probability ½). In this case, 1 would choose to leave her group upon losing her gamble because she would have a consumption of at most 20 (if she chooses lottery 1 that earns 30 for sure) when they both lose their lottery. However, if she stays with 2 when she wins her lottery and leaves when she loses it, she would choose lottery 2 and get utility

$$\frac{1}{2}u(27) + \frac{1}{4}u\left(\frac{57 + 10}{2}\right) + \frac{1}{4}u\left(\frac{57 + 110}{2}\right) = \frac{1}{4}[54 + 33.5 + 83.5] = 42.75.$$

This is better than autarchy.

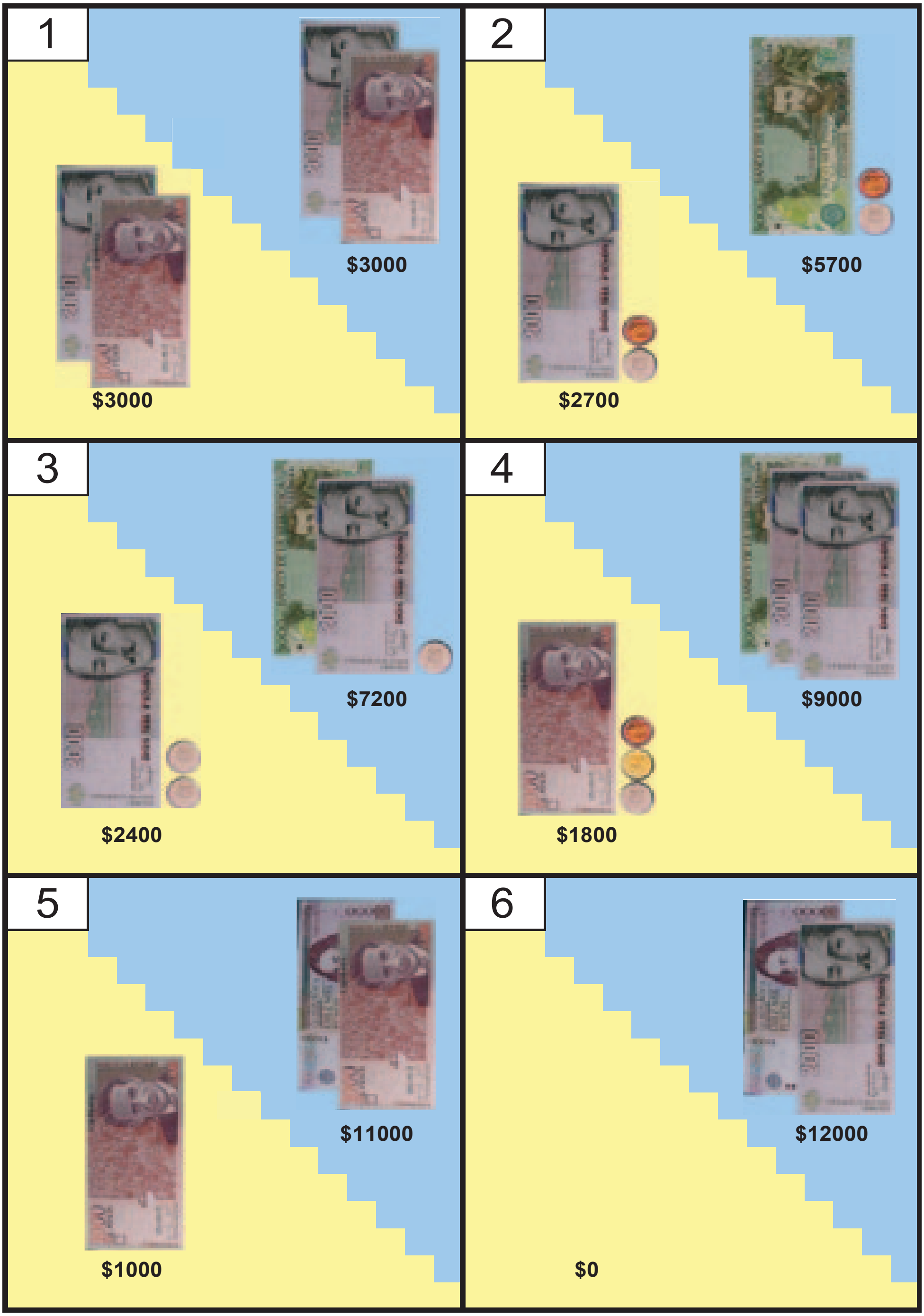

Figure A1. Decision Card for the Gamble Choice Game

B. *Lottery Choices and Expected Utilities*

In this section, we study the choice of lottery and expected utility of individuals who stay alone and who form a group. We denote as ν_i^o the expected utility that individual i has if she stays alone and as ν_{ij}^* her expected utility in a group with j.

Autarchy.—Consider an individual i with risk preference a_i who does not form a group. He will choose the lottery σ that maximizes his utility:

$$\text{(B1)} \qquad v_i^o(\sigma) = \frac{1}{2}\left[u_i(b - \sigma) + u_i(b + h(\sigma))\right].$$

His choice $\sigma_o(a_i)$ is such that

$$h'(\sigma_o)\exp(-a_i h(\sigma_o)) = \exp(a_i \sigma_o),$$

which gives him an expected utility $\nu^o(a_i)$.

Close Family and Friends.—If individuals j and k are close family or friends, they would neither lie to nor defect from each other. Hence, individual $i \in \{j, k\}$ enjoys the following expected utility as a function of her and her partner's lottery choices:

$$\text{(B2)} \quad v_i(\sigma_i, \sigma_{-i}) = \frac{1}{4}\Big[u_i\Big(b - \frac{1}{2}(\sigma_i + \sigma_{-i})\Big) + u_i\Big(b - \frac{1}{2}(\sigma_i - h(\sigma_{-i}))\Big)$$
$$+ u_i\Big(b + \frac{1}{2}(h(\sigma_i) - \sigma_{-i})\Big)$$
$$+ u_i\Big(b + \frac{1}{2}(h(\sigma_i) + h(\sigma_{-i}))\Big)\Big], \; -i \neq i \in \{j, k\}.$$

An equilibrium is a pair of lottery choices (σ_j^*, σ_k^*) such that $\sigma_j^* = \arg\max_\sigma v_j(\sigma, \sigma_k)$ and $\sigma_k^* = \arg\max_\sigma v_k(\sigma, \sigma_j)$. Hence, there is a unique equilibrium (σ_j^*, σ_k^*) where, irrespective of the choice of her partner, individual $i \in \{j, k\}$ with risk aversion a_i chooses lottery $\sigma^*(a_i)$ so that

$$h'(\sigma^*)\exp\Big(-a_i \frac{h(\sigma^*)}{2}\Big) = \exp\Big(a_i \frac{\sigma^*}{2}\Big).$$

Let ν_{ik}^* be the expected utility (B2) evaluated at this equilibrium.

Unfamiliar Individuals.—People who are unfamiliar know neither each other's risk preferences nor their trustworthiness. Unfamiliar individuals make announcements to each other about their risk aversion. Consider individuals j and k who are unfamiliar with each other, $r_{jk} = U$. Given their announcements $(\hat{a}_j, \hat{a}_k)$, their number of "available" friends and family members (m_j, m_k) (more on this below), and the fact that they are willing to group with each other, they hold beliefs about each other's types. Let $p_\theta(m_i, m_{-i}, \hat{a}_i, \hat{a}_{-i})$ denote the probability with which $i \in \{j, k\}$ is thought of as being of type θ by $-i$ if he expresses a preference to form a group with her. Notice that, since trustworthy individuals do not lie, $p_{\overline{t},a}(m_i, m_{-i}, \hat{a}_i, \hat{a}_{-i}) = 0$

for $a \neq \hat{a}_i$, the probability that a trustworthy individual is of a type, a, other than that which she declares, $\hat{a}_i$, is zero.

Hence, for a given pair of announcements $\hat{\mathbf{a}} = (\hat{a}_i, \hat{a}_{-i})$ and numbers of available close friends and relatives $\mathbf{m} = (m_i, m_{-i})$, an *equilibrium* is a vector of lotteries $\boldsymbol{\sigma}$ whose typical element $\sigma_i(\theta)$ is the lottery chosen by individual $i \in \{j, k\}$ if her type is θ, for $i \in \{j, k\}$.

That is, if i is trustworthy, $t_i = \overline{t}$, $\sigma_i(a_i, \overline{t}_i)$ is the lottery σ that maximizes

$$
\begin{aligned}
\text{(B3)} \quad \hat{v}_i(\sigma, \boldsymbol{\sigma}_{-i}) = \sum_{a \in \{\underline{a}, \overline{a}\}} \frac{p_{\underline{t},a}(\mathbf{m}, \hat{\mathbf{a}})}{4} \Bigg[& u_i\left(b - \frac{\sigma + \sigma_{-i}(a, \underline{t})}{2}\right) \\
& + u_i\left(b + \frac{h(\sigma) - \sigma_{-i}(a, \underline{t}, \hat{a}_i)}{2}\right) + u_i(b - \sigma) \\
& + u_i(b + h(\sigma)) \Bigg] \\
+ \frac{p_{\bar{t},\hat{a}_{-i}}(\mathbf{m}, \hat{\mathbf{a}})}{4} \Bigg[& u_i\left(b - \frac{\sigma + \sigma_{-i}(\hat{a}_{-i}, \bar{t})}{2}\right) \\
& + u_i\left(b + \frac{h(\sigma_{-i}(\hat{a}_{-i}, \bar{t})) - \sigma}{2}\right) \\
& + u_i\left(b + \frac{h(\sigma) - \sigma_{-i}(\hat{a}_{-i}, \bar{t})}{2}\right) \\
& + u_i\left(b + \frac{h(\sigma) + h(\sigma_{-i}(\hat{a}_{-i}, \bar{t}))}{2}\right) \Bigg],
\end{aligned}
$$

where $\boldsymbol{\sigma}_{-i}$ are the equilibrium values. While if i is untrustworthy, $\sigma_i(a_i, \underline{t}_i, \hat{a}_{-i})$ maximizes

$$
\begin{aligned}
\text{(B4)} \quad \tilde{v}_i(\sigma, \boldsymbol{\sigma}_{-i}) = \sum_{a \in \{\underline{a}, \overline{a}\}} \frac{p_{\underline{t},a}(\mathbf{m}, \hat{\mathbf{a}})}{4} \Bigg[& u_i\left(b - \frac{\sigma + \sigma_{-i}(a, \underline{t})}{2}\right) + u_i(b - \sigma) \Bigg] \\
+ \frac{p_{\bar{t},\hat{a}_{-i}}(\mathbf{m}, \hat{\mathbf{a}})}{4} \Bigg[& u_i\left(b - \frac{\sigma + \sigma_{-i}(\hat{a}_{-i}, \bar{t})}{2}\right) \\
& + u_i\left(b + \frac{h(\sigma_{-i}(\hat{a}_{-i}, \bar{t})) - \sigma}{2}\right) \Bigg] \\
+ \frac{1}{2} u_i(b + h(\sigma)).
\end{aligned}
$$

Table A1—Group-Level Analysis of Defections: Dependent Variable = Proportion of Members that Default

	Groups of 2 or 3	All groups	
[1] Density of close friends and family network within group	−0.062*	−0.034	−0.155***
	(0.035)	(0.031)	(0.052)
[2] Number of group members	0.027	0.001	−0.004
	(0.032)	(0.004)	(0.004)
[1] × [2]			0.040**
			(0.016)
Average gamble choice	0.008	0.011	0.011
	(0.015)	(0.009)	(0.009)
Proportion of females	0.116*	0.033	0.032
	(0.068)	(0.039)	(0.039)
Average age	−0.000	−0.000	−0.000
	(0.002)	(0.001)	(0.001)
Proportion living in municipal center	0.042	0.027	0.017
	(0.055)	(0.028)	(0.030)
Average years of education	−0.010*	−0.010**	−0.010***
	(0.006)	(0.004)	(0.004)
Proportion married	0.003	−0.005	−0.008
	(0.061)	(0.038)	(0.038)
Average log household consumption	−0.006	−0.024	−0.023
	(0.040)	(0.029)	(0.029)
Average household size	0.001	0.005	0.005
	(0.007)	(0.005)	(0.005)
Constant	−0.102	0.276	0.287
	(0.456)	(0.329)	(0.330)
Municipality dummies	Yes	Yes	Yes
Observations	251	526	526

Notes: Linear regression coefficients reported. Standard errors (in parentheses) adjusted to account for non-independence within municipalities by clustering.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

It is implicitly assumed in the expressions in equations (B3) and (B4) that untrustworthy individuals (without guilt) would choose to leave upon winning their lotteries and stay upon losing. That this would indeed be their preferred behavior is proved in Observations 1 and 2 in Appendix C.

There may be more than one equilibrium. In case of multiplicity, we shall select the equilibrium preferred by the more risk averse trustworthy type.[22] The utility $\nu^{u}_{i,-i}(\mathbf{m}, \hat{\mathbf{a}})$ that i expects from forming a group with $-i$ is then given by (B3) if i is trustworthy and (B4) if i is untrustworthy where these expressions are evaluated at the equilibrium.

Some features of individual behavior of agents paired with unfamiliar individuals is noteworthy and useful when characterizing grouping behavior. In particular,

[22] We want to select an equilibrium so that an individual's expected utility in a group is uniquely defined and depends only on the group members' types. The particular selection criterion does not matter. Moreover, no multiplicity was found in simulated exercises.

we note that a trustworthy individual with risk aversion a_i chooses a lottery that is riskier than she would choose in autarchy but safer than she would choose in a match with someone who she knows to be trustworthy, $\sigma_i(a_i, \overline{t}) \in (\sigma_o(a_i), \sigma^*(a_i))$.

We also conjecture that the more risk averse an individual—whether she is trustworthy or not—the safer her choice of lottery tends to be. Theoretically, this effect could be reversed when a trustworthy person expects her partner to choose extremely risky lotteries, but this never occurred in simulations.

C. *Proofs*

OBSERVATION 1: *Untrustworthy individuals in a match with an unfamiliar person prefer leaving to staying upon winning their lottery.*

PROOF:

Assume that individual 1 is without guilt and in a group with an individual 2 who, with a probability λ, selects lottery $\hat{s}_2$ and stays in the sharing group; with probability $(1-\lambda)p$ selects lottery $\tilde{s}_2$ and leaves upon winning; and with probability $(1-\lambda)(1-p)$ selects s_2' and leaves upon winning. If individual 1 finds it optimal to choose lottery s_1 and strictly prefers to stay in the group irrespective of the outcome of her lottery, it must be that at $(s_1, \hat{s}_2, \tilde{s}_2, s_2')$, 1 must prefer her strategy to leaving upon winning her lottery. Therefore, it follows that

$$\text{(C1)} \quad \frac{-1}{2a}\left[\lambda\left[\exp\left(a\frac{\hat{s}_2}{2}\right) + \exp\left(-a\frac{h(\hat{s}_2)}{2}\right)\right]\right.$$
$$\left. + (1-\lambda)\left[p\exp\left(a\frac{\tilde{s}_2}{2}\right) + (1-p)\exp\left(a\frac{s_2'}{2}\right) + \exp\left(-a\frac{h(s_1)}{2}\right)\right]\right]$$
$$> \frac{-1}{a}\exp\left(-a\frac{h(s_1)}{2}\right).$$

Note that for any $z_2 \in \{\tilde{s}_2, s_2'\}$, $u\left(\frac{h(s_1)}{2}\right) - u\left(\frac{-s_1}{2}\right) \geq u\left(\frac{-z_2}{2}\right) - u\left(\frac{-s_1}{2}\right)$ or

$$\left(-\exp\left(-a\frac{h(s_1)}{2}\right)\right) - \left(-\exp\left(a\frac{s_1}{2}\right)\right) \geq \left(-\exp\left(a\frac{z_2}{2}\right)\right) - \left(-\exp\left(a\frac{s_1}{2}\right)\right).$$

Using this in conjunction with inequality (C1) implies that

$$\frac{-1}{2a}\left[\lambda\left[\exp\left(a\frac{\hat{s}_2}{2}\right) + \exp\left(-a\frac{h(\hat{s}_2)}{2}\right)\right] + (1-\lambda)\left[\exp\left(a\frac{s_1}{2}\right) + \exp\left(-a\frac{h(s_1)}{2}\right)\right]\right]$$
$$> \frac{-1}{2a}\left[2\lambda\exp\left(-a\frac{h(s_1)}{2}\right) + (1-\lambda)\left[\exp\left(-a\frac{h(s_1)}{2}\right) + \exp\left(a\frac{s_1}{2}\right)\right]\right],$$

so that

$$\text{(C2)} \qquad \frac{-1}{2a}\left[\exp\left(a\frac{\hat{s}_2}{2}\right) + \exp\left(-a\frac{h(\hat{s}_2)}{2}\right)\right] > \frac{-1}{a}\exp\left(-a\frac{h(s_1)}{2}\right).$$

This inequality requires $\hat{s}_2 > s_1$.

Since $u\left(\frac{h(s_1)}{2}\right) \geq u\left(\frac{h(s_1) - s_1}{2}\right) \geq \frac{1}{2}[u(h(s_1)) + u(- s_1)]$ and $h\left(\frac{\hat{s}_2}{2}\right) \geq \frac{h(\hat{s}_2)}{2}$,

inequality (C2) implies that

$$\text{(C3)} \quad \frac{-1}{2a}\left[\exp\left(-ah\left(\frac{\hat{s}_2}{2}\right)\right) + \exp\left(a\frac{\hat{s}_2}{2}\right)\right] > \frac{-1}{2a}\left[\exp(-ah(s_1)) + \exp(as_1)\right].$$

Moreover, it follows from the concavity of u and h that

$$\frac{1}{2}\left[u\left(\frac{h(\hat{s}_2/2)}{2}\right) + u\left(\frac{\hat{s}_2}{4}\right)\right] \geq \frac{1}{2}\left[u\left(\frac{h(\hat{s}_2)}{2}\right) + u\left(\frac{\hat{s}_2}{2}\right)\right].$$

This inequality, along with (C2), means that

$$\text{(C4)} \quad \frac{-1}{2a}\left[\exp\left(-a\frac{h(\hat{s}_2)/2}{2}\right) + \exp\left(a\frac{\hat{s}_2}{4}\right)\right] > \frac{-1}{2a}\left[\exp\left(-a\frac{h(s_1)}{2}\right) + \exp\left(a\frac{s_1}{2}\right)\right].$$

However, if individual 1 finds it optimal to choose lottery $s1$ rather than himself choosing lottery $\hat{s}_2/2$ given $(\hat{s}_2, \tilde{s}_2, s_2')$, it must be that

$$\frac{-1}{4a}\left[\exp\left(-a\frac{h(s_1)}{2}\right) + \exp\left(a\frac{s_1}{2}\right)\right]\left[\lambda\left[\exp\left(a\frac{\hat{s}_2}{2}\right) + \exp\left(-a\frac{h(\hat{s}_2)}{2}\right)\right]\right.$$
$$\left. + (1-\lambda)\left[p\exp\left(a\frac{\tilde{s}_2}{2}\right) + (1-p)\exp\left(a\frac{s_2'}{2}\right)\right]\right]$$
$$- \frac{1}{4a}\left[\exp(-ah(s_1)) + \exp(as_1)\right]$$
$$\geq -\frac{1}{4a}\left[\exp\left(-ah\left(\frac{\hat{s}_2}{2}\right)\right) + \exp\left(a\frac{\hat{s}_2}{2}\right)\right]$$
$$- \frac{1}{4a}\left[\exp\left(-a\frac{h(\hat{s}_2)/2}{2}\right) + \exp\left(\frac{a\hat{s}_2}{4}\right)\right]$$
$$\times \left[\lambda\left[\exp\left(-a\frac{h(\hat{s}_2)}{2}\right) + \exp\left(a\frac{\hat{s}_2}{2}\right)\right]\right.$$
$$\left. + (1-\lambda)\left[p\exp\left(a\frac{\tilde{s}_2}{2}\right) + (1-p)\exp\left(a\frac{s_2'}{2}\right)\right]\right].$$

This inequality cannot hold given (C3) and (C4) and therefore we have a contradiction.

OBSERVATION 2: *An untrustworthy person would not leave the group upon losing and would not stay upon winning her lottery.*

PROOF:

Consider an individual 1 without guilt and with risk aversion a. Assume that 1 is in a group with an individual 2 who with a probability λ selects lottery $\hat{s}_2$ and stays in the sharing group; with probability $(1-\lambda)p$ selects lottery $\tilde{s}_2$ and leaves upon winning; and with probability $(1-\lambda)(1-p)$ selects s_2' and leaves upon winning. If individual 1 finds it optimal to choose lottery s_1 and leave upon losing her lottery but stay when winning her lottery, the following two inequalities must hold:

(i) at $(s_1, \hat{s}_2, \tilde{s}_2, s_2')$, 1 must prefer her strategy to autarchy (she could only do better in autarchy by choosing σ_1^o):

$$w_1(s_1, \hat{s}_2, \tilde{s}_2, s_2') \equiv \frac{-1}{4a}\Bigg\{\Bigg[\lambda\Big[\exp\Big(a\frac{\hat{s}_2}{2}\Big) + \exp\Big(-a\frac{h(\hat{s}_2)}{2}\Big)\Big] + (1-\lambda)\Big[p\exp\Big(a\frac{\tilde{s}_2}{2}\Big) + (1-p)\exp\Big(a\frac{s_2'}{2}\Big) + \exp\Big(-a\frac{h(s_1)}{2}\Big)\Big]\Bigg]\exp\Big(-a\frac{h(s_1)}{2}\Big) + 2\exp(as_1)\Bigg\} \geq v_1^o(s_1);$$

(ii) she must prefer it to staying in the group (again, she could only do better when staying by re-optimizing her choice of lottery):

$$w_1(s_1, \hat{s}_2, \tilde{s}_2, s_2') > v_1(s_1, \hat{s}_2, \tilde{s}_2, s_2').$$

The first inequality implies that

$$-\frac{1}{2}\Bigg[\lambda\Big[\exp\Big(a\frac{\hat{s}_2}{2}\Big) + \exp\Big(-a\frac{h(\hat{s}_2)}{2}\Big)\Big] + (1-\lambda)\Big[p\exp\Big(a\frac{\tilde{s}_2}{2}\Big) + (1-p)\exp\Big(a\frac{s_2'}{2}\Big) + \exp\Big(-a\frac{h(s_1)}{2}\Big)\Big]\Bigg] \geq -\exp\Big(-a\frac{h(s_1)}{2}\Big),$$

while the second requires that

$$-\frac{1}{2}\Bigg[\lambda\Big[\exp\Big(a\frac{\hat{s}_2}{2}\Big) + \exp\Big(-a\frac{h(\hat{s}_2)}{2}\Big)\Big]$$

$$+ (1-\lambda)\Big[p\exp\Big(a\frac{\tilde{s}_2}{2}\Big) + (1-p)\exp\Big(a\frac{s_2'}{2}\Big) + \exp\Big(-a\frac{h(s_1)}{2}\Big)\Big]\Bigg]$$

$$< -\exp\Big(-a\frac{s_1}{2}\Big).$$

This is a contradiction since $-\exp\Big(-a\frac{h(s_1)}{2}\Big) \geq -\exp\Big(-a\frac{s_1}{2}\Big)$. And since this is the case for any $\hat{s}_2$, $\tilde{s}_2$, s_2', p and λ, it proves our claim.

PROOF OF PROPOSITION 1:

Consider a trustworthy individual i with risk preference a_i grouped with an unfamiliar individual j with announcement $\hat{a}_j$. Let σ_i and $\boldsymbol{\sigma}_j$ be the equilibrium choices of lottery for i and for j's different types, so that i's utility is given by $\hat{v}_i(\sigma_i, \boldsymbol{\sigma}_j)$.

Now, notice that i's utility can only be improved if she could choose her partner's lotteries as well as her own:

(C5) $$\max_{s_i, \mathbf{s}_j} \hat{v}_i(s_i, \mathbf{s}_j) \geq \hat{v}_i(\sigma_i, \boldsymbol{\sigma}_j).$$

i would always prefer the safest lottery possible ($\sigma = 0$) for her partner if he is untrustworthy. Using this in (B3), we can rewrite the left-hand-side of inequality (C5) as

$$\phi(\gamma) \equiv \max_{s_i, s_{-i}} (1-\gamma)w_i(s_i) + \gamma v_i(s_i, s_{-i}),$$

where $w_i(s_i) = \frac{1}{4}\Big[u_i\Big(b - \frac{\sigma}{2}\Big) + u_i\Big(b + \frac{h(\sigma)}{2}\Big) + u_i(b-\sigma) + u_i(b + h(\sigma))\Big]$,

$\gamma = p_{\bar{t}, \hat{a}_j}(j, \hat{a}_j)$ is the probability that j is trustworthy and v_i is the utility that i would have in a group with a close friend or family member as in (B2). Moreover, the inequality in (C5) is strict when $\gamma < 1$ as an untrustworthy j would choose some amount of risk.

Notice that $\phi(\gamma)$ is increasing in γ. Indeed, i can always select $s_{-i} = s_i$ and for any s $v_i(s,s) \geq w_i(s_i)$. Looking at $\gamma = 1$,

$$\phi(1) = \max_{\sigma, \sigma'} v_i(\sigma, \sigma'),$$

it is easy to check that i would choose $\sigma = \sigma' = \tilde{\sigma}(a_i^*)$. This is the same maximization and therefore the same choice of lotteries that a group of friends or family with the same level of risk aversion a_i would select. Since there is a unique equilibrium and $\tilde{\sigma}(a') \neq \tilde{\sigma}(a_i^*)$ for any $a_i'^*$, i's utility is strictly higher when paired with a close friend or family member j with the same risk aversion $a_j = a_i$. Moreover, it follows that i strictly prefers grouping with j than staying alone $\phi(1) = \nu_{ij}^* > \nu^o(a_i)$.

REFERENCES

Ahlin, Christian. 2009. "Matching for Credit: Risk and Diversification in Thai Micro-credit Borrowing Groups." Bureau for Research and Economic Analysis of Development (BREAD) Working Paper 251. http://www.eSocialSciences.com/data/articles/Document12162010150.1994898.pdf.

Ambrus, Attila, Markus Mobius, and Adam Szeidl. 2010. "Consumption Risk-sharing in Social Networks." National Bureau of Economic Research Working Paper 15719.

Arcand Jean-Louis, and Marcel Fafchamps. 2011. "Matching in Community-Based Organizations." http://www.economics.ox.ac.uk/Members/marcel.fafchamps/homepage/cbo.pdf.

Attanasio, Orazio, Abigail Barr, Juan Camilo Cardenas, Garance Genicot, and Costas Meghir. 2012. "Risk Pooling, Risk Preferences, and Social Networks: Dataset." *American Economic Journal: Applied Economics.* http://dx.doi.org/10.1257/app.4.2.134.

Barr, Abigail. 2003. "Risk Pooling, Commitment, and Information: An Experimental Test of Two Fundamental Assumptions." Centre for the Study of African Economies (CSAE) Working Paper WPS/2003-05.

Barr, Abigail, Marleen Dekker, and Marcel Fafchamps. 2012. "Who Shares Risk with Whom under Different Enforcement Mechanisms?" *Economic Development and Cultural Change*. 60 (4)

Barr, Abigail, and Garance Genicot. 2008. "Risk Sharing, Commitment, and Information: An Experimental Analysis." *Journal of the European Economic Association* 6 (6): 1151–85.

Besley, Timothy, and Stephen Coate. 1995. "Group Lending, Repayment Incentives and Social Collateral." *Journal of Development Economics* 46 (1): 1–18.

Binswanger, Hans P. 1980. "Attitudes toward Risk: Experimental Measurement in Rural India." *American Journal of Agricultural Economics* 62 (3): 395–407.

Bloch, Francis, Garance Genicot, and Debraj Ray. 2008. "Informal Insurance in Social Networks." *Journal of Economic Theory* 143 (1): 36–58.

Bramoullé, Yann, and Rachel Kranton. 2007. "Risk-Sharing Networks." *Journal of Economic Behavior and Organization* 64 (3–4): 275–94.

Carpenter, Seth, and Loic Sadoulet. 2000. "Risk-Matching in Credit Groups: Evidence from Guatemala." Econometric Society World Congress 2000 Contributed Papers 1310.

Chade, Hector. 2006. "Matching with Noise and the Acceptance Curse." *Journal of Economic Theory* 129 (1): 81–113.

Chiappori, Pierre-Andre, and Philip J. Reny. 2004. "Matching to Share Risk." http://home.uchicago.edu/ preny/papers/matching-05-05-06.pdf.

Chowdhury, Prabal Roy. 2007. "Group-lending with Sequential Financing, Contingent Renewal and Social Capital." *Journal of Development Economics* 84 (1): 487–506.

Currarini, Sergio, Matthew O. Jackson, and Paolo Pin. 2009. "An Economic Model of Friendship: Homophily, Minorities, and Segregation." *Econometrica* 77 (4): 1003–45.

Dekker, Marleen. 2004. "Risk, Resettlement and Relations: Social Security in Rural Zimbabwe." PhD thesis 331. Tinbergen Institute.

Dercon, Stefan, Joachim De Weerdt, Tessa Bold, and Alula Pankhurst. 2006. "Group-Based Funeral Insurance in Ethiopia and Tanzania." *World Development* 34 (4): 685–703.

De Weerdt, Joachim, and Stefan Dercon. 2006. "Risk-Sharing Networks and Insurance Against Illness." *Journal of Development Economics* 81 (2): 337–56.

Fafchamps, Marcel, and Flore Gubert. 2007. "The Formation of Risk Sharing Networks." *Journal of Development Economics* 83 (2): 326–50.

Fafchamps, Marcel, and Susan Lund. 2003. "Risk-Sharing Networks in Rural Philippines." *Journal of Development Economics* 71 (2): 261–87.

Genicot, Garance, and Debraj Ray. 2003. "Group Formation in Risk-Sharing Arrangements." *Review of Economic Studies* 70 (1): 87–113.

Ghatak, Maitreesh. 1999. "Group Lending, Local Information and Peer Selection." *Journal of Development Economics* 60 (1): 27–50.

Ghatak, Maitreesh. 2000. "Screening by the Company You Keep: Joint Liability Lending and the Peer Selection Effect." *Economic Journal* 110 (465): 601–31.

Giné, Xavier, Pamela Jakiela, Dean Karlan, and Jonathan Morduch. 2010. "Microfinance Games." *American Economic Journal: Applied Economics* 2 (3): 60–95.

Jackson, Matthew O. 2008. *Social and Economic Networks*. Princeton: Princeton University Press.

Legros, Patrick, and Andrew F. Newman. 2007. "Beauty Is a Beast, Frog Is a Prince: Assortative Matching with Nontransferabilities." *Econometrica* 75 (4): 1073–1102.

Munshi, Kaivan, and Mark Rosenzweig. 2009. "Why is Mobility in India so Low? Social Insurance, Inequality, and Growth." National Bureau of Economic Research Working Paper 14850.

Murgai, Rinku, Paul Winters, Elisabeth Sadoulet, and Alain de Janvry. 2002. "Localized and Incomplete Mutual Insurance." *Journal of Development Economics* 67 (2): 245–74.

Sadoulet, Loic. 2000. "Equilibrium Risk-Matching in Group Lending." Econometric Society World Congress 2000 Contributed Papers 1302.