2015

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Todd L. Cherry
Appalachian State University

E. Lance Howe
University of Alaska Anchorage

James J. Murphy
Chapman University

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Comments
Working Paper 15-03

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Todd L. Cherry

E. Lance Howe

and

James J. Murphy*

RRH: SHARING AS RISK POOLING IN A SOCIAL DILEMMA

* Corresponding author.

Funding for the research was provided by the National Science Foundation (grant #0729063). We wish to thank Ben Saylor for programming support and Dan Allen for research assistance.

Cherry: Professor, Appalachian State University, Boone, NC 28608. Phone 1-828-262-2148, E-mail cherrytl@appstate.edu. Senior Research Fellow, CICERO Center for International Climate and Environmental Research - Oslo, P.O. Box 1129 Blindern, 0318 Oslo, Norway

Howe: Associate Professor, University of Alaska Anchorage, Anchorage, AK 99508. Phone 1-907-786-5409, E-mail elhowe@uaa.alaska.edu

Murphy: Professor, University of Alaska Anchorage, Anchorage, AK 99508. Lecture Professor, Nankai University, Tianjin, China. Affiliated Faculty, Chapman University, Orange, CA. Phone 1-907-786-1936, E-mail murphy@uaa.alaska.edu

ABSTRACT

In rural economies with missing or incomplete markets, idiosyncratic risk is frequently pooled through informal networks. Idiosyncratic shocks, however, are not limited to private goods but can also restrict an individual from partaking in or benefiting from a collective activity. In these situations, a group must decide whether to provide insurance to the affected member. In this paper, we describe results of a laboratory experiment designed to test whether a simple sharing institution can sustain risk pooling in a social dilemma with idiosyncratic risk. We test whether risk can be pooled without a commitment device and, separately, whether effective risk pooling induces greater cooperation in the social dilemma. We find that even in the absence of a commitment device or reputational considerations, subjects voluntarily pool risk thereby reducing variance in individual earnings. In spite of effective risk pooling, however, cooperation in the social dilemma is unaffected.

JEL Classifications: C92, D81, O13, Q20

Keywords: collective action; experimental economics; idiosyncratic risk; income smoothing; insurance; lab experiment; public goods; risk pooling; resource sharing; social dilemma; social-ecological systems; team production

INTRODUCTION

Subsistence communities, in low-income and high-income countries alike, rely on the yields of natural resources that are susceptible to both covariate shocks (which impact an entire community, *e.g.*, droughts or floods) and idiosyncratic shocks (which impact an individual within a community, *e.g.*, illness, injury or disabled equipment). Although incomplete insurance and credit markets limit the ability of households to insure against risk, meaningful risk sharing (or risk pooling) does arise through informal mechanisms both within and across communities. Covariate shocks are difficult to insure locally, but idiosyncratic risk can often be pooled within communities. A variety of informal risk sharing mechanisms have been documented in remote rural communities around the world, including gift-giving, food sharing, remittances, rotating savings and unstructured loans (Fafchamps 2003). These risk pooling arrangements are facilitated through a transfer of resources among group members, and can therefore also be referred to as resource pooling or resource sharing. In this paper, we describe results from a laboratory experiment designed to test the conditions under which idiosyncratic risk is pooled. We focus on idiosyncratic risk and voluntary sharing within a social dilemma, which is representative of many types of activities in a rural context.

A growing body of literature within development economics explores the theoretical and empirical dimensions of risk sharing arrangements that protect against idiosyncratic risk. Research has found that a large share of intra-village risk is pooled and standard theory suggests that self-enforcing agreements, under which an individual's gain from defection is less than the long-term benefits of cooperation, are critical to the success of these risk sharing networks (Posner 1980, Kimball 1988, Fafchamps and Lund 2003, Genicot and Ray 2003, DeWeerdt and Dercon 2006, Fafchamps and Gubert 2007). Under full insurance, a commitment device must be strong enough (e.g. through heavy punishment or a legal option) to maintain self-enforcing agreements, creating a risk pooling network that is immune from individual defection. With only limited commitment, however, theory predicts only partial risk sharing and less than full insurance (Posner 1980, Kimball 1988, Ligon *et al.* 2002). Evidence from empirical studies is generally consistent with limited commitment models as a high degree of partial consumption smoothing is often observed but informal mechanisms, including risk sharing, fail to provide full insurance (e.g., Townsend 1994, Udry 1994, Jalan and Ravallion 1999, Ligon *et al*. 2002, Fafchamps and Gubert 2007).

These and other efforts have contributed to the understanding of informal risk sharing and its ability to insure against shocks to private assets and income, but shocks are not limited to private goods. In remote rural communities with active risk pooling networks, productive activities are often done collectively. In hunter-gatherer societies, for instance, participation in collective activities and the associated food sharing has been well documented (Kaplan *et al.* 1985). Indeed, there is archeological and ethnographic evidence indicating a long history of public good provision in foraging communities (Hawkes 1993). Likewise, in the collective agrarian arrangements in West Africa, output is pooled and distributed among members of the collective as needed (West 2010). An individual's ability to participate in, or to receive the benefits from, collective action can be affected by idiosyncratic shocks, such as illness or mechanical problems, and the group must decide whether to provide insurance through sharing.

The specific example that motivates our research design is the collective hunting and gathering activities observed in the remote rural mixed economies of the Russian Far East and Alaska. In these remote regions, where standard measures of income poverty are extreme, wild foods or "subsistence" comprise a significant share of the diet. In the relatively isolated communities within these regions individuals belong to distinct networks which harvest greens, berries, fish and mammals. Food collectively obtained is then distributed to individuals within the network (Wolfe and Magdanz 1993, Magdanz *et al.* 2002, Argetsinger and West 2009, Gerkey 2010). Salmon fishing in Western Alaska and Kamchatka Russia, for instance, is primarily done in extended groups (often family) in which individuals contribute labor, gear, and cash to harvest and process fish. Individual members contribute not only in the harvesting, processing, and distribution of the catch but there is also extensive preparation for the harvest season (e.g. repairing nets, boats, and fish camp infrastructure).

It is not uncommon for a network member contributing equipment, cash or labor in preparation for the harvest to be unable to participate in harvesting or processing due to illness, injury or other unforeseen circumstance. Similarly, because salmon is dried on fish racks and stored in elevated platforms, animals sometimes enter camp and destroy a household's store of harvested food. These events are independent of shock to a private activity, such as a wage-paying job. Finally, although not the primary focus of this study, the yield from harvesting subsistence resources is stochastic, and as a result some groups may be more successful than others. In such cases, as in other remote regions, other community members must decide how much of the collective catch should be allocated to other community members (Fienup-Riordan 1986).

These idiosyncratic shocks to a collective, or group, activity in these communities are independent of a shock to a private activity, and motivated the shock treatments in our experimental design. That is, the return on investment to the private activity is certain whereas environmental risk is added to existing strategic risk in the group activity. As with private goods, the idiosyncratic shock introduces risk to individuals which can be pooled over the group. But, unlike private goods, a shock within a social dilemma can affect the aggregate level of resources available to the group. Because idiosyncratic shocks can affect a member's ability to contribute to the production of group benefits, it complicates the strategic environment of the collective action and potentially undermines cooperation by all members. For example, when other group members observe low levels of participation in the group activity, it may be difficult to discern whether this is due to free-riding or a negative shock such as illness. Historical evidence suggests that shirking via feigned illness may have been common in the early American colonies and resulted in widespread food shortages (Bradford 2006).

However, when idiosyncratic risk exists within a social dilemma, voluntary risk sharing can not only smooth individual income levels, but can also maintain cooperation by reducing or eliminating the riskiness of the group activity. Questions arise about whether groups can effectively pool risk to smooth income when the income is derived from group resources, and whether sharing can overcome the adverse effects of risk on the collective production of those resources.

This paper uses a series of lab experiments to focus on the sharing of idiosyncratic risk in a social dilemma setting. While our design uniquely addresses idiosyncratic risk within a social dilemma there are several related studies that are consistent with some features of our design. Charness and Genicot (2009) and Selton and Ockenfels (1998) explore risk sharing in a two player solidarity game in which one player randomly receives a positive shock in each round and each player is allowed to "share" with the other player. Charness and Genicot (2009) find strong evidence for risk sharing, or solidarity, in the absence of an explicit commitment device and note that increasing the potential for direct reciprocity significantly increases risk pooling. Barr and Genicot (2008) and Attanasio *et al.* (2012) test the effects of different levels of commitment in a game in which individuals can pool outcomes from a risky gamble. Risk in this study, however, is not explicitly idiosyncratic or exogenous. They vary levels of commitment and find that limiting commitment reduces the frequency with which individuals pool earnings from the gamble. Kaplan *et al.* (2012) use a series of laboratory experiments to test whether resource sharing can be explained by risk sharing motivations versus other alternatives. They find strong evidence for risk pooling motivations. When subjects individually harvest from a highly variable resource they are more likely to form reciprocal sharing relationships compared to harvesting from low risk environments. Finally, Erkal *et al.* (2011) explore the effects of relative earnings on giving decisions, where earnings are based on a tournament-style real effort activity. While not the focus of their study, they find that players receiving a negative shock also receive large and significant transfers from other players.

There is also a large experimental literature that focuses on covariate, or aggregate, risk in a social dilemma. Much of this research focuses on a common pool resource environment and generally finds that increased environmental uncertainty leads to lower levels of cooperation (see Gangadharan and Nemes 2009, for a review). Of these, the most closely related to our study is Gangadharan and Nemes 2009, who introduce an aggregate shock into a public goods game. Treatments varied whether this shock was associated with the private or the public good, and whether the probability distribution was known ("risk") or unknown ("uncertainty"). They find that individuals will avoid investing in a risky private account, preferring the strategic uncertainty associated with the group account. However, when the group account faces a possible shock, and therefore includes both environmental and strategic uncertainty, cooperation drops significantly.

In the Arctic and sub-Arctic regions that motivated the paper, particularly in Alaska, the scale of harvest by subsistence users is a small percentage of the total harvest. For example, in the Kuskokwim salmon fishery, subsistence accounted for 21% of the total catch between 1980 and 2004. The bulk of the salmon harvests are from commercial fisheries, approximately 78% during this same period (Howe and Martin 2009). With other resources, such as marine mammals, harvest quotas are strictly enforced. Moreover, because these communities do not have access to commercial markets, and because harvesting entails significant effort and financial costs, the incentives to overharvest the resource are quite weak. As a result, the key questions for these communities focus on cooperation in jointly harvesting the resource and sharing the fruits of the harvest. This is, in effect, a team production problem for which the linear public goods game is a reasonable approach (Alchian and Demsetz 1972, Croson 2001, Carpenter *et al.* 2009).

Our team production experiments vary a standard linear public goods game in which we introduce the potential for a negative idiosyncratic shock. The shock eliminates the individual's allocations to, and returns from, the group activity. In some treatments, individuals are given an opportunity to share with the fellow group member who incurs the shock. Because individuals can avoid the shock by shifting resources from the group activity to the private activity, we decompose the welfare loss into two components: the direct loss due to the shock and the indirect loss due to changes in cooperative behavior.

Compared to existing experimental research on risk pooling, our study differs along the commitment dimension, the nature of the shock, and the strategic environment. Like Charness and Genicot (2009), we introduce sharing without commitment, but in contrast to their study, we eliminate all opportunities for individual reciprocity. In addition, we add a treatment that tests whether perfectly enforced sharing commitments affect decisions about the level of participation in the group activity. Several experimental studies of risk-pooling focus on the sharing of gains from a lottery (Barr and Genicot 2008, Attanasio *et al.* 2012), but very few (Erkal *et al.* 2011, Kaplan *et al.* 2012) allow subjects to pool negative shocks through sharing or some other mechanism. Finally, we are unaware of any studies that investigate the pooling of idiosyncratic risk in a social dilemma and the resulting effects on cooperation.

Our results suggest that risk not only increases the variability of individual earnings, but also induces significant earnings losses due to less cooperative behavior. Contrary to theory, however, we find significant levels of risk pooling without commitment and without the possibility for direct reciprocity. Surprisingly, while individuals do cooperate in pooling risk, high levels of sharing commitments appear to have no effect on cooperation in the social dilemma. As a result, there is less variation in income but no improvement in aggregate welfare in the treatments with a shock and the opportunity for sharing.

EXPERIMENTAL DESIGN

To investigate the impact of idiosyncratic risk in a social dilemma and the elements of risk sharing arrangements that might mitigate any adverse effects, we construct a set of four treatments that are summarized in Table 1: a Baseline to provide a clear internal and external benchmark, a Shock treatment that introduces idiosyncratic risk and sheds light on the impact of risk in a social dilemma, and two sharing treatments that vary levels of sharing commitments.
<INSERT TABLE 1>

Baseline. The Baseline treatment is a standard linear public goods game in which individual earnings are $\pi_i = (e - x_i) + (m/n)\,\Sigma_i\, x_i$, where $e = 20$ is the initial resource endowment, x_i is the amount of resources individual *i* allocates to the group activity, $m = 2$ is the multiplier on the aggregate amount of resources allocated to the group activity, and $n = 5$ is the number of subjects in a group. The marginal per capita return (MPCR) from the group activity is m/n = 0.40. These parameters are identical in all four treatments. After all subjects completed their allocation decisions, the results were announced. Subjects received information about their own resource allocation decisions and earnings. Subjects were also informed about the aggregate amount of resources allocated to the group activity, but the individual decisions of the other four group members were not revealed. While standard theory predicts that nothing will be allocated to the group activity, experimental evidence consistently shows positive, though less than socially optimal, allocations that decline over time (Ledyard 1995). We expect to observe this well-documented behavior in the Baseline treatment.

Shock Treatment. The Shock treatment parallels the Baseline, but introduces idiosyncratic risk by randomly selecting one group member to receive a negative shock after all allocation decisions have been made. The idiosyncratic shock results in the entire loss of the individual's allocation to the group activity, but has no impact on the individual's allocation to his private activity. In addition, the shock prevents the individual from receiving any returns from the group activity. Instead, the group returns are equally distributed among the remaining $n-1$ group members who did not receive the shock. This structure is meant to parallel the types of shocks described in the introduction, such as the loss of one's harvest due to spoilage or an animal entering camp and destroying food stores.

The identity of the person shocked is not announced. Instead, group members are only informed about whether they are affected by the shock. Expected earnings in the shock treatment are $\pi_i = [(n-1)/n] \cdot [(m/(n-1)) \cdot \Sigma_i (x_i - x^s) + (e - x_i)] + (1/n) \cdot (e - x_i)$, where x^s is the group allocation of the subject who incurs the shock. The expected MPCR remains unchanged at 0.40.

The potential for a negative shock to eliminate an individual's return from the group activity introduces an additional disincentive to allocate resources to the group activity. In addition to the usual strategic risk that defines the collective action problem, group members also face an environmental risk due to the potential idiosyncratic shock. More specifically, in the no-shock Baseline treatment, earnings from an individual's own allocation to the group activity are $(m/n) \cdot x_i > 0$, whereas the Shock treatment introduces a $1/n$ chance that these earnings will instead be zero. This implies that an individual who is predisposed towards cooperation and allocates the entire resource endowment to the group activity ($x_i = e$) risks earning nothing. Shifting resources from the group activity to the private activity avoids both the strategic and the environmental risk, and guarantees that earnings will be at least e. Therefore, we expect to find that, relative to the no-shock Baseline, the Shock treatment will have fewer resources allocated to the group activity, lower individual and group earnings, and greater variance in individual earnings.

Sharing Treatments. The remaining two treatments allow the $n-1$ individuals who are unaffected by the shock to share a percent of their returns from the group activity, $s_i \in [0\%, 100\%]$, with the individual who was shocked. The decision was framed as a percent of the returns from the group account, rather than a specific dollar amount, because the actual returns from the group account were unknown at the time the sharing decision was made. In both treatments, all agents make sharing decisions simultaneously without knowing the sharing decisions of other players. Treatments differ in whether a binding sharing commitment is made and disclosed to the group prior to the resource allocation decision. In both sharing treatments, expected individual earnings are: $\pi_i = [(n-1)/n] \cdot [(1 - s_i) \cdot ((m/(n-1)) \cdot \Sigma_i (x_i - x^s)) + (e - x_i)] + (1/n) \cdot [(e - x_i) + \Sigma_{j \neq i} s_j \cdot ((m/(n-1)) \cdot \Sigma_{j \neq i} x_j)]$.

In the Without Commitment treatment, all n subjects simultaneously make both an allocation and a sharing decision. After all subjects submit both decisions, results are announced. Subjects are informed of the aggregate amount of resources allocated to the group activity and the average sharing decision of the other $n-1$ group members, $[1 / (n - 1)] \cdot \Sigma_{j \neq i} s_j$, which represents the percent of the returns from the group activity that would be shared with individual i if he were shocked.

In the With Commitment treatment, each subject first commits to sharing a percentage of returns from the group activity, which are unknown at the time of the sharing decision. After all group members submit their sharing decisions, the average sharing decision of other $n-1$ group members is announced. Each group member then submits his allocation decision. Thus, prior to the allocation decision, each subject knows exactly what percent of the group returns he will receive if shocked. This reduces the idiosyncratic environmental risk associated with the group activity and should result in more resources allocated to the group activity relative to the Shock treatment.

While each sharing mechanism provides an opportunity for group members to pool idiosyncratic risk, standard theory predicts no sharing in the absence of a commitment device. While Charness and Genicot (2009) have demonstrated the possibility for risk pooling without commitment, we go a step further in that our design removes the possibility for individual reciprocity. In both our sharing treatments, it is impossible for subjects to gain information about the individual allocation or sharing decisions of other players. We test the null hypothesis of no sharing, but considering the substantial literature on cooperative behavior and partial risk pooling, we expect to observe at least some risk sharing, which would smooth income. Since sharing is just a redistribution of wealth, there is no impact on the group's aggregate earnings.

Sharing at least some of the returns from the group activity mitigates the adverse impacts of the idiosyncratic shock. As a result, if sharing is used as insurance, then these commitments should increase allocations to the group activity. This implies that group allocations should be higher in the With Commitment treatment relative to the Without Commitment treatment. Also, if we observe non-trivial rates of sharing, we expect that relative to the Shock treatment, both sharing treatments will have more resources allocated to the group activity, greater individual and group earnings, and less variation in individual earnings.

Experiment details. One hundred and twenty undergraduate students were recruited from the undergraduate student population at the University of Alaska Anchorage to participate in the experiment. All sessions were programmed and conducted using software developed specifically for this research project. (The related code can be freely downloaded at: http://econlab.uaa.alaska.edu/Software.html). Upon entering the lab, participants signed a consent form acknowledging their voluntary participation and agreeing to abide by lab rules. The computerized instructions included both graphical and written explanations, and concluded with an interactive quiz that required correct responses before proceeding to the decision environment. (Experiment instructions can be viewed at http://econlab.uaa.alaska.edu/shocksharing/. The use of diagrams in the instructions was motivated by Eckel *et al.* 2010.). Figure 1 shows an example of the subject computer screen from the Baseline treatment. <INSERT FIGURE 1>

The four treatments were conducted over 12 sessions, with each treatment repeated in three sessions. In each session, 10 subjects were randomly divided into two groups of five and subjects remained in the same group for all *T*=15 rounds. There were a total of *N*=120 unique subjects, and *G*=24 unique groups evenly divided among the four treatments. We therefore collected a total of 360 group-level and 1,800 individual-level observations. At the end of the session, subjects were called one at a time to be paid privately in cash. Lab dollars were converted to US$ at $1 per experiment token. Average individual cash earnings were $24.77 ($\sigma$=0.64) plus an additional $5 for showing up on time.

To avoid risk pooling over rounds, individual cash earnings were determined by a single randomly selected round. This design choice parallels the severity of naturally occurring shocks. For individuals living in subsistence-dependent communities, an idiosyncratic shock, such as the inability to harvest due to injury or the loss of an entire harvest due to animals or spoilage, can mean that one's survival depends upon the largesse of the community. As in the experiment, people in these communities cannot self-insure against the risk. The experimental design, by paying one period, mimics this inability to self-insure.

RESULTS

The experimental findings are organized around two topics. First, we review the treatment effects on allocations to the group activity, income levels and income smoothing. We discuss how idiosyncratic risk affects cooperative behavior and how the sharing mechanisms can mitigate these impacts. We then investigate the different sharing mechanisms further to examine how sharing commitments influence the underlying individual behavior that leads to the treatment effects. The aggregate results section provides a basic overview of the key results using summary statistics. The hypotheses are then tested using the panel models presented in the conditional results section.

Aggregate Results. Figure 2 presents the mean individual allocation to the group activity over time by treatment. Table 2 complements the figure by providing summary statistics for all rounds combined. In the Baseline treatment, which establishes the benchmark earnings and group resource allocation levels without idiosyncratic risk or sharing, mean individual allocations to the group activity is 10.4 tokens (52% of the 20-token initial endowment). Group allocations in the first round average 13.1 tokens (65%), decaying to 7.0 tokens (35%) in the final round. This general pattern of moderate levels of cooperation in the early rounds, which then decay over time, is typical in a standard public goods experiment. <INSERT FIGURE 2 > <INSERT TABLE 2>

When the environmental risk associated with the group activity is introduced in the Shock treatment (which does not allow sharing), people tend to redirect resources away from the risky group activity and into the safe private activity. On average, individual allocations to the group activity drop by about one-third relative to the no-shock Baseline. Average allocations to the group activity start at 8.8 tokens in round 1 (44%), decaying to 4.3 tokens (21%) in round 15. The average over all rounds is 7.0 (35%). As a result, relative to the no-shock Baseline, the mean earnings in the Shock treatment are 20% lower (24.2 vs. 30.4).

In Table 2, the average earnings in the Shock treatment of those who were not shocked (27.0) are lower than the Baseline (30.4) as a result of the reduced allocations to the group activity. This suggests that the presence of risk in the group activity has two effects on earnings: a direct effect due to the shock and an indirect effect as a result of changes in allocation behavior. We test this by decomposing earnings into these two effects in Table 3. The column labeled “Before Shock, Before Sharing” reports individual earnings before the welfare loss from the shock and before income is redistributed through sharing. A comparison of the average earnings in the Shock and Baseline treatments reveals that changes in allocation behavior accounted for just over half of the earnings decline. Specifically, of the total difference in average earnings between the two treatment (24.2–30.4= –6.2), 55 percent of the earnings loss occurred before the shock (27.0–30.4= –3.4) as a result of subjects shifting some tokens from the group activity to the private activity. The direct effect of the shock (from 27.0 before the shock to 24.2 after the shock) accounts for the other 45 percent of the total earnings loss. Hence, the chilling indirect effect of idiosyncratic risk on cooperation is roughly equal to the direct earnings loss resulting from the shock. <INSERT TABLE 3>

The mean standard deviation of earnings is presented in Tables 2 and 3 and provides a measure of the average variability in an individual’s earnings over time. The mean standard deviation of earnings (s) is calculated as the mean of the individual within-subject standard deviations (σ_i), specifically: $s = (1/N) \cdot \Sigma_i \, \sigma_i$, where $\sigma_i = [1/(T-1)] \cdot \Sigma_t \, (\pi_{it} - \Pi_i)^2$, and $\Pi_i = (1/T) \cdot (\Sigma_t \, \pi_{it})$. By definition, the idiosyncratic shock introduces volatility to an individual’s earnings over time. Average earnings are higher in those rounds when the individual is not shocked (27.0), than when he does incur the shock (12.9). As a result, the mean standard deviation in the Shock treatment is higher than the Baseline (7.18 vs. 5.39). Before accounting for the shock, the mean standard deviation in the Shock treatment is actually lower than the Baseline (4.46 vs. 5.39). This follows from the reduction in resources allocated to the group activity in the Shock treatment. However, the negative direct effect of the shock dominates, leading to an overall increase in earnings variability. These results illustrate the additional complexity that arises when idiosyncratic risk exists within a social dilemma: not only does the shock have a direct impact on earnings, but it also has an indirect impact as individuals reduce their allocations to the group activity in order to lower their exposure to this environmental risk.

The two sharing treatments offer the potential to mitigate both the direct effects of the shock and the indirect effects of reduced allocations to the group activity. By sharing with other group members and mutually insuring against the environmental risk, it is possible to both increase earnings and reduce earnings variability (relative to the Shock treatment). In each of the sharing treatments, fully insuring all group members against the idiosyncratic risk would require the individual sharing decisions to average 20 percent of the group returns ($s_i = 0.20$), but the standard game-theoretic prediction is that sharing will be non-existent ($s_i = 0.00$). We do, however, observe considerable sharing in both treatments. Figure 3 shows that sharing begins around full insurance in both treatments (26% Without Commitment and 21% With Commitment), but declines over time to roughly 10% in each treatment.
<INSERT FIGURE 3>

This high level of sharing helps smooth incomes by mitigating the direct effects of the shock. If income smoothing were perfect, then individual earnings would be independent of the shock, and as a result, there would be no difference in average earnings between those who were shocked and those who were not. When the allocation and sharing decisions are made simultaneously in the Without Commitment treatment, it appears that income smoothing does occur at near-perfect levels. Figure 4 presents the difference in average earnings over time between those who were not shocked and those who were. In the Without Commitment treatment, this difference in any given round is modest, moreover there are nearly as many rounds (6 of 15) in which the shock victims actually earn more than their benevolent counterparts. As a result, over all rounds, Table 2 shows that average earnings of the two groups are nearly identical in this treatment. <INSERT FIGURE 4>

Interestingly, although we do observe near-perfect income smoothing, it does not appear that this has any effect on the allocation of resources to the group activity. In fact, average allocations in the Without Commitment treatment (7.2) are about the same as the Shock treatment (7.0). As a result, average earnings in the two treatments are similar. This would suggest that, in the absence of prior commitments about how much risk will be covered by the group, the ability to share does reduce the riskiness of the group activity and reduce earnings fluctuations, but it has no impact on collective action. This outcome is certainly not consistent with prior expectations as it suggests that subjects view the sharing and resource allocation decisions independently. While these data do not allow us to adequately test related hypotheses, this finding warrants future research.

The sequential nature of the With Commitment treatment introduces the ability to pre-commit to a sharing decision before making an allocation decision. With mean sharing around 18%, the shock has a negligible effect on earnings (24.3 for those who were not shocked vs. 24.1 for those who did incur the shock). In fact, in Figure 4, shock victims actually earn slightly more than the other group members in four of the first five rounds. However, despite perfect information about the generous sharing commitments, the average allocation to the group activity (6.9) is no different than the Shock (7.0) or Without Commitment treatments (7.2). Therefore, it seems that high levels of income smoothing are possible with or without a sharing commitment mechanism, but sharing has no impact on cooperation in a social dilemma.

***Conditional Results*.** The informal conclusions discussed above are confirmed using more rigorous conditional analyses presented in Table 4. We estimate three panel models that use the same basic structure: $Y_{it} = \beta_0 + \beta_1 \cdot \theta_{it} + \beta_2 \cdot t + \omega_i + \varepsilon_{it}$, where Y_{it} is the individual allocation to the group activity (Model 1), sharing (Model 2), or earnings (Model 3) of subject i in round t, θ_{it} is a set of treatment indicator variables that capture the treatment effects, ω_i captures unobserved individual subject characteristics and ε_{it} represents the contemporaneous error term. Because subjects participated in multiple rounds of a single treatment, subject-specific heterogeneity is modeled as a random effect. We also use a Huber (1967) and White (1980) robust estimate of variance. <INSERT TABLE 4>

Consistent with the previous discussion of aggregate results, the allocation decision in Model 1 reveals that the introduction of idiosyncratic risk in the Shock treatment significantly reduces allocations to the group activity relative to the Baseline (p=0.00). Surprisingly, the With Commitment and Without Commitment treatments have similar results. Both coefficients are negative and significant, and a Wald chi-square test fails to reject the joint hypothesis that group allocation decisions in the Without Commitment, With Commitment and Shock treatments are equal (*p*=0.97). Results from the sharing model (Model 2) also corroborate the aggregate findings. Individuals do exhibit significant levels of sharing in both sharing treatments. The coefficient for the intercept, which indexes the omitted simultaneous decision Without Commitment treatment, indicates average sharing of 21% and is positive and significant. As expected, the coefficient on the With Commitment treatment is not significant, indicating that there is no difference in the sharing rates between the two treatments.

The earnings model in Table 4 (Model 3) is not conditioned upon whether an individual was shocked in a given round, therefore it provides an estimate of an individual's expected earnings and is a measure of the relative welfare impacts among the different treatments. The earnings model indicates that, in the presence of an idiosyncratic shock, the expected individual earnings are lower than the no-shock Baseline (all three treatment coefficients are negative and significant). More importantly, a joint test of the hypothesis that the three treatment coefficients are equal cannot be rejected (*p*=0.98), which indicates that neither sharing treatment had a significant effect on expected earnings relative to the Shock treatment.

Of course, individual earnings in a given round may be affected by the shock and the magnitude of this impact depends upon the extent to which the other group members share. Perfect smoothing implies that individual earnings are independent of the idiosyncratic shock (Townsend 1994, Mace 1991, Fafchamps and Lund 2003). To test the income smoothing hypothesis, Model 4 (Table 5) modifies the individual earnings model in Model 3 by adding three new explanatory variables that interact the treatments with an indicator variable (Shocked) that equals one if individual *i* incurred the shock in round *t*. Model 4 only includes data from the three treatments that include the idiosyncratic shock, and therefore does not include the Baseline treatment. The intercept can be interpreted as referencing the earnings of an individual who was not shocked in the Shock treatment. The income smoothing hypothesis implies that each of the three interaction coefficients should equal zero (*i.e.*, for a given treatment, if the interaction term is zero, then we cannot reject the hypothesis that individual earnings are independent of the shock). <INSERT TABLE 5>

Clearly, without the ability to share in the Shock treatment, the income smoothing hypothesis is rejected. Earnings of individuals who are shocked earn 13.70 less than those who were not shocked. In contrast, results are consistent with the earnings smoothing hypothesis in both the Without Commitment treatment (*p*=0.87) and the With Commitment treatment (*p*=0.99). In our environment, this simple sharing institution nearly eliminates the effects of idiosyncratic risk for the individual. Thus, the conditional results support the observations made using the aggregate results. Without sharing, an idiosyncratic shock has both a direct effect on the earnings of the shock victim, and an indirect effect on the earnings of the entire group due to reduced allocation of resources to the group activity. The ability to share without any commitment mechanism does smooth individual earnings, but because group allocations are unchanged relative to the Shock treatment, the indirect effects of the shock persist and, as a result, average earnings are no greater than without sharing. Group allocations, sharing and earnings in the With Commitment treatment are statistically indistinguishable from the Without Commitment treatment.

CONCLUSION

We examine whether a sharing institution can facilitate risk pooling in a social dilemma with idiosyncratic risk. A standard public goods game is augmented with a negative idiosyncratic shock and a simple sharing mechanism in which subjects make private, voluntary transfers to a fellow group member who was adversely affected by a shock. As predicted, environmental risk via the shock is found to significantly reduce average earnings. This impact on earnings can be decomposed into two effects that are roughly equal in magnitude: the reduced earnings that are a direct consequence of the shock, and the indirect effect due to behavioral changes to avoid the shock.

In contrast to basic theory, however, we find high levels of anonymous sharing in both sharing treatments. In both treatments, sharing completely removes the additional variance of individual earnings due to the shock, evidence consistent with the income smoothing hypothesis. As such, risk pooling emerges without a strong self-enforcing agreement, an assumption needed in related theoretical models. This result is similar to that of Charness and Genicot (2009), but is stronger in that risk pooling is maintained even when the possibility for direct individual reciprocity is eliminated. Although near-perfect income smoothing is observed in the sharing treatments, surprisingly, collective action, measured in terms of the allocation of resource to the group activity, does not improve with sharing.

This risk-pooling result is also consistent with ethnographic accounts of food sharing in Western Alaska and the Russian Far East (Wolfe and Magdanz 1993, Gerkey 2010). While no formal tests of consumption smoothing exist for Arctic communities, risk pooling is one explanation for the extensive food sharing observed in similar hunter gatherer societies (Kaplan and Hill 1985, Kaplan *et al.* 2012).

In conclusion, consistent with econometric results based on survey data from rural contexts, we find that subjects successfully pool risk in an environment with idiosyncratic risk. While sharing mechanisms have unique behavioral implications, high levels of risk pooling are observed without reputation or a strong commitment device.

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FIGURE 1

Example of the Subject Interface for the Baseline Treatment

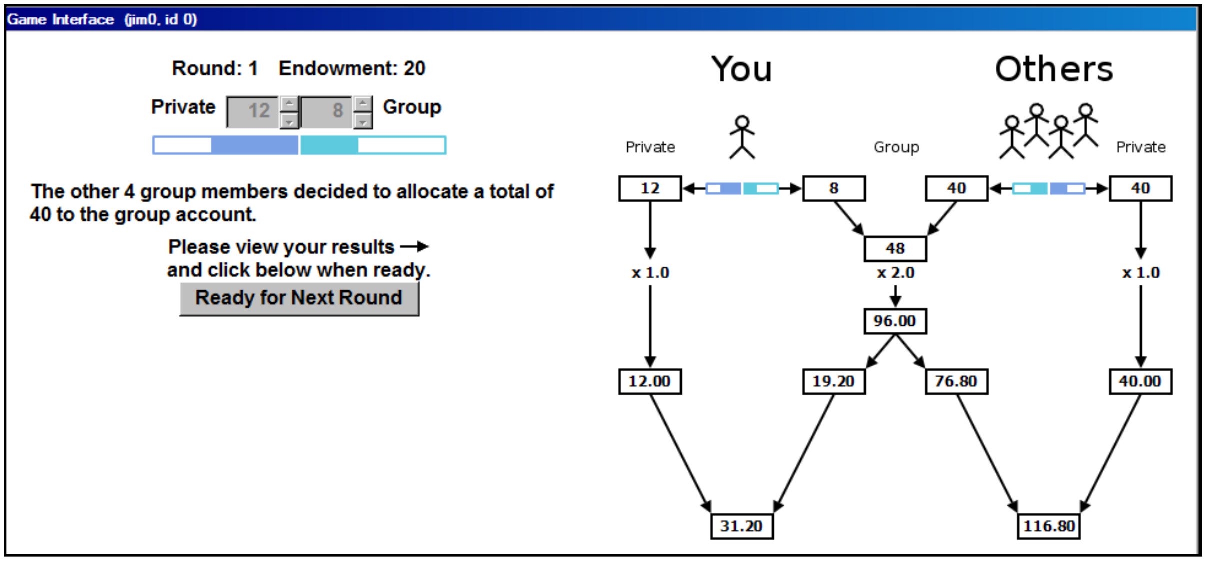

FIGURE 2

Mean Individual Allocation to the Group Account

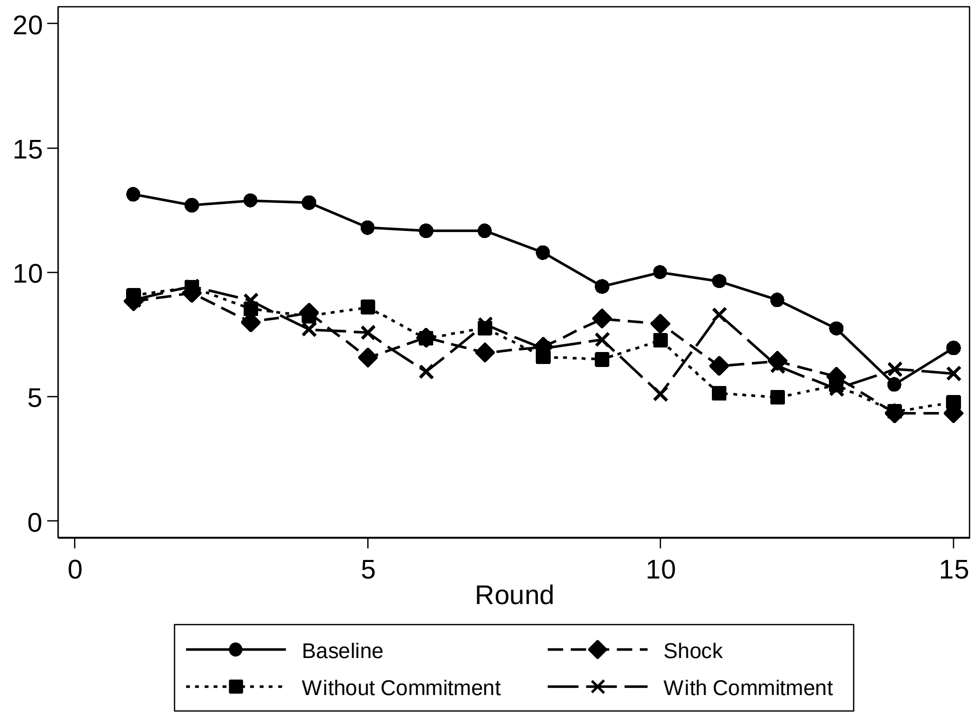

FIGURE 3

Mean Individual Percent Shared

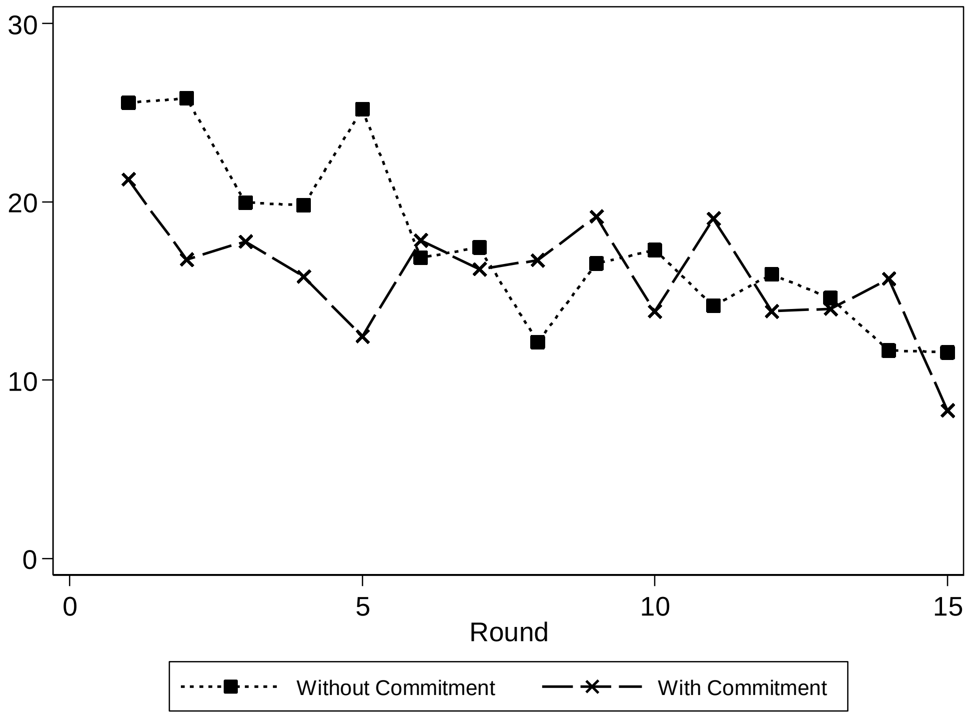

FIGURE 4

Consumption Smoothing (Average Earnings: Not Shocked minus Shocked)

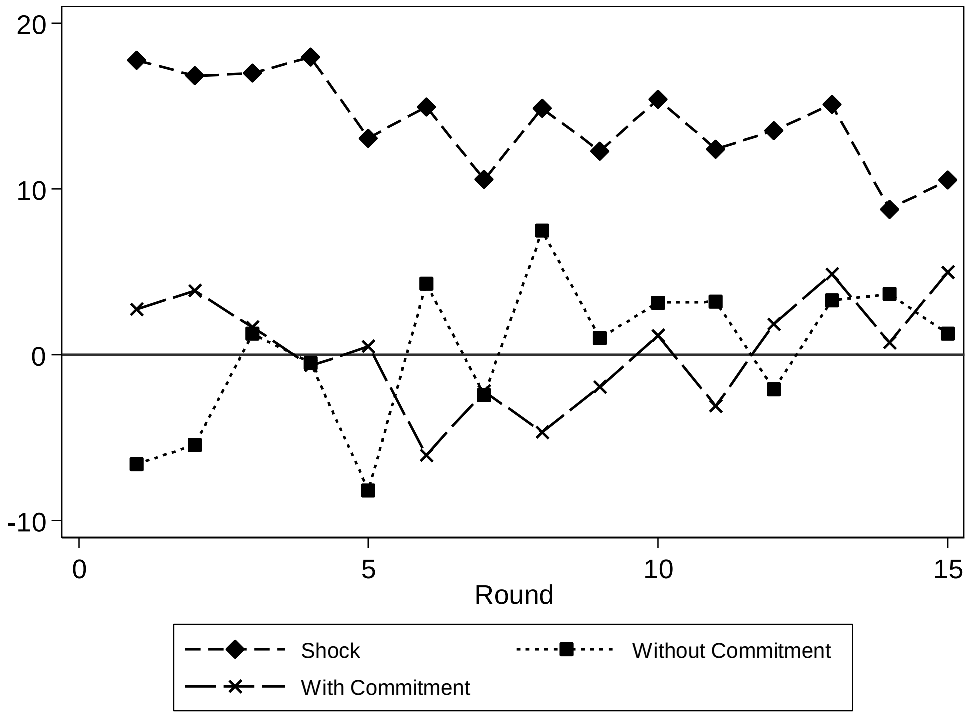

TABLE 1
Experimental Design

Treatment	Features	Summary
Baseline	Baseline	Standard VCM
Shock	Baseline + Shock	Add idiosyncratic shock
Without Commitment	Baseline + Shock + Sharing	Simultaneously make allocation and sharing decisions.
With Commitment	Baseline + Shock + Sharing	Make sharing decision. Aggregate sharing announced. Make allocation decision.

TABLE 2
Mean Individual Decisions and Earnings

Treatment	Allocation to Group Account	Sharing	Level of Earnings: Not Shocked	Shocked	All	Mean Standard Deviation of Earnings
Baseline	10.4	--	--	--	30.4	5.39
Shock	7.0	--	27.0	12.9	24.2	7.18
Without Commitment	7.2	16%	24.4	24.2	24.4	6.10
With Commitment	6.9	18%	24.3	24.1	24.3	5.63

TABLE 3
Decomposition of Earnings

	Average Earnings (all subjects)			Mean Standard Deviation of Earnings		
	Before Shock Before Sharing	After Shock Before Sharing	After Shock After Sharing	Before Shock Before Sharing	After Shock Before Sharing	After Shock After Sharing
Baseline	30.4	--	--	5.39	--	--
Shock	27.0	24.2	--	4.46	7.18	--
Without Commitment	27.2	24.4	24.4	4.37	7.47	6.10
With Commitment	26.9	24.3	24.3	4.26	6.82	5.63

TABLE 4
Conditional Estimates of Individual-Level Treatment Effects

	Model 1: Allocation to Group Account (x_{it})	Model 2: Sharing (s_{it})	Model 3: Earnings (π_{it})
Baseline Treatment	(omitted)	n/a	(omitted)
Shock Treatment	-3.36	n/a	-6.19
	(0.00)		(0.00)
Without Commitment Treatment	-3.20	(omitted)	-5.99
	(0.01)		(0.00)
With Commitment Treatment	-3.44	0.017	-6.07
	(0.00)	(0.573)	(0.00)
Round	-0.34	-0.007	-0.27
	(0.00)	(0.00)	(0.00)
Intercept	13.10	0.212	32.49
	(0.00)	(0.00)	(0.00)
χ^2	73.89	29.23	60.57
	(0.00)	(0.00)	(0.00)
N	1800	900	1800

p-values in parentheses calculated using robust standard errors. In all three models, “omitted” means the data are included, but the treatment dummy variable is omitted. In the sharing model, “n/a” means the data from the two treatments without sharing are not applicable and therefore not included.

TABLE 5
Conditional Estimates of Individual Earnings

	Model 4: Earnings (π_{it})
Shock Treatment	Omitted
Without Commitment Treatment	-2.48
	(0.01)
With Commitment Treatment	-2.62
	(0.00)
Shocked ×	-13.70
Shock Treatment	(0.00)
Shocked ×	-0.27
Without Commitment Treatment	(0.87)
Shocked ×	-0.01
With Commitment Treatment	(0.99)
Round	-0.19
	(0.000)
Intercept	28.42
	(0.000)
χ^2	370.22
	(0.000)
N	1350

Model does not include Baseline treatment because it does not include a shock. p-values in parentheses calculated using robust standard errors.