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Voluntary Contributions to a Mutual Insurance Pool

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Abstract

We study mutual-aid games in which individuals choose to contribute to an informal mutual insurance pool. Individual coverage is determined by the aggregate level of contributions and a sharing rule. We analyze theoretically and experimentally the (*ex ante*) efficiency of equal and contribution-based coverage. The equal coverage mechanism leads to a unique no-insurance equilibrium while contribution-based coverage develops multiple equilibria and improves efficiency. Experimentally, the latter treatment reduces the amount of transfers from high contributors to low contributors and generates a "dual interior equilibrium." That dual equilibrium is consistent with the co-existence of different prior norms which correspond to notable equilibria derived in the theory. This results in asymmetric outcomes with a majority of high contributors less than fully reimbursing the global losses and a significant

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minority of low contributors less than fully defecting. Such behavioral heterogeneity may be attributed to risk attitudes (risk tolerance vs risk aversion) which is natural in a risky context.

1. Introduction

In spite of the prevalence of assistance and universal insurance in a growing number of countries, the economic theory of insurance tends to ignore the fact that one's coverage against insurable risk will often not depend solely on one's own contributions. In this paper, we wish to examine cases in which individual coverage against risk is determined by the aggregate level of voluntary contributions in a group and a sharing rule. We designate this type of insurance scheme as "voluntary mutual aid." We envision mutual aid here as a unifying concept that can be useful for analyzing various institutions. Mutual-aid pools offer insurance to members of a specified group, typically sharing a common characteristic. The homogeneity of members facilitates the full coverage of independent random losses at fair price and enhances solidarity among members and their willingness to contribute to the pool. To illustrate this point, Schwindt and Vining (1998) motivate their proposal for a mutual insurance pool for transplant organs by the incentive it provides to donate. Group members are free to join and contribute and they redistribute resources between themselves according to a sharing rule. All members are impartially treated and resources are divided between them according to needs or participation: those who need or participate most are helped most. Mutual-aid organizations have existed at least since the medieval craft guilds.[1] Important contemporary examples of voluntary mutual-aid pool are "climate clubs" of adherents to international climate policy agreements (Nordhaus, 2015) that offer some kind of mutual insurance against differential climate change damages and trade unions that provide unionized workers with protection against employment hazards. However, trade unions and climate clubs are perfect illustrations of the problem raised by the group's heterogeneity to voluntary mutual-aid pools. Workers who didn't unionize and countries who didn't sign the agreement may still benefit from the contributions of unionized workers or cooperative countries. Thus, a conflict arises between insurance motives and incentives, which needs to be resolved. For illustration, going back to the proposal of a mutual insurance pool for transplant organs, Howard (2007) remarks that the pool derives its efficiency by linking very explicitly the willingness to donate and the ability to benefit from transplantation and by punishing free riders: persons who refuse to donate but would gladly accept organs from others.

In contrast with formal mutual insurance schemes in which paying a premium is contractual, compulsory and excludable,[2] voluntary contributions and indemnities to a mutual-aid pool constitute an informal insurance scheme with no contract, no legal

[1] Friendly Societies were found throughout Europe in the 18th and 19th centuries. During the Great Depression, the American "fraternity societies" and the English "workers clubs" provided their members with health insurance. (Almost) complete consumption insurance in small communities (Townsend, 1994) and in large societies (Mace, 1991; Cochrane, 1991; Schulhofer-Wohl, 2011) reveals an efficient implicit structure of mutual insurance in those groups. Anecdotally, we have been aware of the example of students contributing to a fund used to reimburse contraveners who have been fined for fare dodging in public transportation.

[2] In Barigozzi *et al.* (2013), mutualization corresponds to participating policies in which policyholders jointly hold the residual claims on the common pool. Policyholders share the aggregate risk and, after an initial contribution, contribute whatever amount is needed yearly to meet the losses insured by the pool (on participating policies. See also Doherty and Dionne, 1993; Smith and Stutzer, 1990, 1995;

obligation, and no excludability of eligible members. In particular, non-excludability confers a public good or common resource dimension to the mutual aid. In the absence of transaction costs (loading), all risk-averse agents exposed to a random loss and maximizing their expected utility of wealth would purchase full insurance on a competitive insurance market (Mossin, 1968). Full coverage is also realizable in our case with informal mutual insurance if everyone contributes the fair premium that he would be willing to pay on a private insurance market. However, the cooperation of all members of a mutual-aid pool is problematic when the pool is heterogeneous. We demonstrate in this paper that the mere heterogeneity of risk attitudes is sufficient to hamper the cooperation of members of a mutual-aid group.

Drawing on the rich literature on voluntary contributions to public goods,[3] we ask whether mutual aid enhances fairness and the level of individual contributions to the point of offsetting the selfish drive. To this end, we study, both theoretically and experimentally, two different types of mutual aid conditioning or not the reimbursement of individuals who incur a random monetary loss on their preliminary contribution to an insurance pool. *Equal coverage* guarantees an equal reimbursement to all individuals who incur a loss irrespective of their voluntary contribution to the insurance pool. In contrast, *contribution-based coverage* partly conditions the individuals' reimbursement on their own voluntary contributions. The second regime introduces an incentive to increase individual contributions. We compare the (*ex ante*) efficiency of these two types of mutual aid in enhancing the sense of responsibility of individual contributors to the pool as measured in terms of individual contributions. Equal and contribution-based coverage also reflects different conceptions of equity. Indeed, equal coverage guarantees equal reimbursement for a given loss whereas contribution-based coverage guarantees equal reimbursement for a given effort. While the first approach represents an egalitarian view of equity, the second one is close to the notion of "just deserts" of Frohlich, Oppenheimer, and Kurki (2004), in which individuals' earnings are a proportion of their contributions to income. We compare the net transfers of income, unrelated with the occurrence of loss, among low and high contributors to the insurance pool in these two regimes.

Our equilibrium analysis exhibits contrasting predictions under the different conditions implemented. Two focal outcomes are natural in our context. The first one is the no-insurance outcome in which nobody contributes and therefore no insurance is created for the group.

The second, that we call the full-insurance outcome, is such that the sum of contributions is high enough to provide full coverage of all losses (including for those who had not fully contributed). Whereas the equal coverage policy leads to a unique no-insurance equilibrium, the contribution-based policy leads to multiple equilibria according to which both no-insurance and full-insurance equilibria coexist. Our finitely repeated laboratory experiment allows us to analyze whether behavior converges to the predicted Nash equilibria, and to identify which equilibrium is selected in the case of multiple equilibria.

In accordance with predictions, the experimental evidence shows that the equal coverage policy generates least contributions and greatest transfers from high contributors to low contributors. The contribution-based coverage policy provides stronger

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Picard, 2009; on mutual risk-sharing agreements, see notably Bourles and Henriet, 2012). This is different in our games since full coverage is not guaranteed.

[3] See, among many others, Andreoni, 1993; Fehr and Gächter, 2000; Isaac and Walker, 1988; Andreoni, Harbaugh, and Vesterlund, 2003; Masclet *et al.*, 2003; or Sefton, Shupp, and Walker, 2007.

incentives to contribute, which we interpret as an enhanced sense of individual responsibility. It also reduces the amount of transfers unrelated with the occurrence of a loss from high contributors to low contributors. However, under the latter regime full coverage is only rarely attained, even though this is a potential equilibrium. The observed situation can best be described as a "dual interior equilibrium." This dual equilibrium is consistent with the co-existence of different prior norms in the population which correspond to notable equilibria derived in the theory. That particular outcome is generated by two stable clusters of high and low contributors. High contributors have an incentive to reduce their contribution below fair insurance whereas low contributors have an incentive to give a little to reap the external benefit of coverage thanks to the high contributors. This type of equilibrium can be explained with heterogeneous players who exhibit different risk attitudes (risk averse versus risk tolerant).

The remainder of this paper is organized as follows. Section 2 presents the equilibrium analysis of our experimental games. Section 3 details the experimental design. Section 4 analyzes the results. Section 5 concludes and discusses the implications of these findings.

2. Games and Incentives

2.1. The Model

In our set-up, every individual decides which part of his income to contribute to a mutual fund, which has the purpose of covering losses for randomly hit individuals. A key feature of mutual insurance is that the level of coverage is not chosen individually but rather determined collectively. This is a crucial difference with private insurance. Therefore individuals are embedded in a strategic setting in which they choose their contribution to the mutual fund, which in turn defines the level of coverage that applies to each agent. Overinsurance is prohibited: if the sum of contributions exceeds total losses, all subjects who experience a loss are fully covered and the surplus is burned.

Let us now introduce some notations. The experiment involves groups of n players choosing their contributions to a mutual fund in a risky context in which each player can be randomly hit by a loss. We denote the set of players in a group by $N = \{1, \ldots, n\}$. Initially, each player is endowed with the same level of income $y > 0$. Player i chooses his contribution $x_i \in [0, y]\ \forall i \in N$, and might experience an *ex post* random loss. We denote by $\theta_i \in \{0, 1\}$ the state of nature for player i, where $\theta_i = 1$ if player i is hit by the loss and 0 otherwise. M is the set of players hit by the loss, i.e., $M = \{i \in N : \theta_i = 1\}$. Each individual hit loses d. In our experiment, a fixed number of players $m = |M|$ are randomly hit within a group. This hypothesis makes the total amount of losses $\ell = d.m$ a sure value, thus shortening the gap between the situation of a small experimental group and what the law of large numbers would naturally achieve in a large group.[4] Player i's payoff is denoted by $\pi_i(x_i, x_{-i}, \theta)$, where $x_{-i} = (x_1, \ldots, x_{i-1}, x_{i+1}, \ldots, x_n) \in [0, y]^{n-1}$ stands for the individual contributions of the other group members and $\theta = (\theta_1, \ldots, \theta_n) \in \{0, 1\}^n$ summarizes the states of nature associated with the n players. Denote u_i, player i's twice-differentiable vNM-utility function with $\partial u_i(\pi_i)/\partial \pi_i > 0$ and $\partial^2 u_i(\pi_i)/\partial(\pi_i)^2 \leq 0$.

[4] An interesting extension of the analysis would consist of introducing uncertainty on the probability of being hit by a loss.

Therefore, the latter maximizes his expected utility function given by

$$U_i = \sum_{\hat{\theta}=0,1} p_i(\hat{\theta}) \sum_{M\backslash\{i\}\subset N\backslash\{i\}} \left(\prod_{j\in M\backslash\{i\}} p_j \right) .u_i\left(\pi_i(x_i, x_{-i}, \theta)\right), \tag{1}$$

where $p_i(\hat{\theta}) = \text{Prob}(\theta_i = \hat{\theta})$ and $p_i(1) = 1 - p_i(0) = p_i = p, \forall i \in N$.

We distinguish between two archetypal mutual insurance mechanisms, namely *equal coverage* and *contribution-based coverage*. The rest of this section is devoted to a thorough description and analysis of these games.

2.2. The Equal Coverage Mechanism

Under equal coverage, players i's payoffs depend not only on the contribution profile but also on the state of nature θ_i. Specifically, when he does not incur a loss (i.e., when $\theta_i = 0$) player i's payoff is given by

$$\pi_i(x_i, x_{-i}, \theta_i) = \pi_i^0 = y - x_i. \tag{2}$$

Otherwise, when player i incurs a loss (i.e., when $\theta_i = 1$), his payoff is given by

$$\pi_i(x_i, x_{-i}, \theta_i) = \pi_i^1 = y - x_i - d\left(1 - c(x_i, x_{-i})\right), \tag{3}$$

where $d(= \ell/m) > 0$ is the loss suffered in the bad state of nature. $c(x_i, x_{-i})$ is a uniform coverage rate which depends positively on the sum of contributions. In this game, we consider the following coverage rate $c(x_i, x_{-i}) = \min\{\frac{1}{\ell}\sum_{j=1}^{n} x_j, 1\}$. Under loss we have $c(x_i, x_{-i}) < 1$ and player i's expected utility function is given by

$$U_i = p\, u_i\left(y - x_i - d\left(1 - \frac{\sum_{j=1}^{n} x_j}{\ell}\right)\right) + (1-p)\, u_i(y - x_i). \tag{4}$$

Differentiating (4) with respect to x_i we get

$$\frac{\partial U_i}{\partial x_i} = p \frac{\partial u_i\left(\pi_i^1\right)}{\partial \pi_i^1}\left(-1 + \frac{d}{\ell}\right) - (1-p)\frac{\partial u_i\left(\pi_i^0\right)}{\partial \pi_i^0} < 0. \tag{5}$$

As $d < \ell$, the first term into brackets in the right-hand side of (5) is clearly negative $\forall(x_i, x_{-i}) \in [0, y]^n$. Therefore, 0 contribution is a dominant strategy $\forall i \in N$ in the presence of a loss and $(0, \ldots, 0)$ is an equilibrium profile of the game with equal coverage. To check the uniqueness of the equilibrium, it remains to show that if player i were in a position to balance the budget, he would rather choose a null contribution. Formally, this will be the case if, given a contribution profile for others $\tilde{x}_{-i}$ such that $0 < \ell - \sum_{j\neq i} \tilde{x}_j \leq y$, the following inequality holds:

$$U_i(0, \tilde{x}_{-i}) \geq U_i\left(\ell - \sum_{j\neq i} \tilde{x}_j, \tilde{x}_{-i}\right), \forall i \in N, \forall \tilde{x}_{-i} \in [0, y]^{n-1}, 0 < \ell - \sum_{j\neq i} \tilde{x}_j \leq y. \tag{6}$$

Condition (6) can be rewritten:

$$p\, u_i\left(y - \frac{d}{\ell}\left(\ell - \sum_{j\neq i} \tilde{x}_j\right)\right) + (1-p)\, u_i(y) \geq u_i\left(y - \left(\ell - \sum_{j\neq i} \tilde{x}_j\right)\right). \tag{7}$$

As $d/\ell < 1$, it becomes clear that (7) always holds. Therefore, a balanced budget does not arise in equilibrium and $(0, \ldots, 0)$ is the only equilibrium of the game with equal coverage.

2.3. The Contribution-Based Coverage Mechanism

Under this mechanism, the individual i's coverage rate, $c_i(x_i, x_{-i}, \theta)$, depends on his contribution to the pool relative to the contributions of other individuals incurring a loss. As in the previous game, his indemnity can never exceed his loss (i.e., $c_i(x_i, x_{-i}, \theta)$ lies between 0 and 1) and the sum of indemnities paid to the players incurring a loss is always covered by the sum of contributions.

When the sum of contributions covers all the losses, each individual is fully insured and receives a sure payoff. When this sum does not cover all the losses, reimbursement is partial and the compensation of every player incurring a loss is proportional to his own contribution relative to that of the other players incurring a loss.[5] Therefore, under partial coverage, $c_i(x_i, x_{-i}, \theta)$ can be given by the following formula:

$$c_i(x_i, x_{-i}, \theta) = \begin{cases} \min\left\{\frac{\sum_{j=1}^n x_j}{\ell} \frac{x_i}{\frac{1}{m}\sum_{j=1}^n x_j.\theta_j}, 1\right\} & \text{if } \sum_{j=1}^n x_j.\theta_j \neq 0 \\ \min\left\{\frac{\sum_{j=1}^n x_j}{\ell}, 1\right\} & \text{otherwise.} \end{cases} \tag{8}$$

In what follows, we will simply denote $c_i = c_i(x_i, x_{-i}, \theta)$ for notational clarity.

In the game with contribution-based coverage, players' payoffs in each state of nature are analogous to those given by Equations (2) and (3). Thus, player i solves the following program:

$$\max_{x_i} U_i = p\left[\frac{1}{C_{n-1}^{m-1}} \sum_{M\backslash\{i\}\subset N\backslash\{i\}} u_i\,(y - x_i - d(1 - c_i))\right] + (1 - p)\,u_i(y - x_i). \tag{9}$$

When $c_i < 1$, i.e., when there is a loss, the FOC of (9) is:

$$MRS_i^{0,1} = \frac{p}{1-p}\frac{1}{C_{n-1}^{m-1}} \sum_{M\backslash\{i\}\subset N\backslash\{i\}} \left(-1 + d\frac{\partial c_i}{\partial x_i}\right), \tag{10}$$

where $MRS_i^{0,1} = \frac{\partial u_i(\pi_i^0)}{\partial \pi_i^0} / \frac{\partial u_i(\pi_i^1)}{\partial \pi_i^1}$.

We claim that $(x_1^*, \ldots, x_n^*) = (0, \ldots, 0)$ is an equilibrium of this game. To see this, note that $\partial c_i/\partial x_i|_{x_{-i}=(0,\ldots,0)} = m/\ell$, $\forall x_i > 0$. Consequently, the right-hand side of (10) equals 0 when $x_{-i} = (0, \ldots, 0)$ and $\partial U_i(x_i, x_{-i})/\partial x_i|_{x_{-i}=(0,\ldots,0)} < 0$. Therefore we indeed have $x_i^* = 0$.

Of course, other outcomes might also arise in equilibrium. As an antidote against the relative complexity of the set-up with contribution-based coverage and to give explicit solutions involving strictly positive contributions, in what follows we will restrict our attention to homogeneous preferences and illustrate our purpose in more detail by taking two examples with conventional specifications of individuals' utility function.[6]

[5] If none of the players hit by a loss has contributed, each of them gets the same share of the mutual fund.

[6] Note that we do not require that players actually have the same preferences. It is sufficient that they *believe* others' preferences are the same as their own preferences. Psychologically founded patterns

Table 1: Parameter values used in the experiment

n	y	d	ℓ	p	m
12	100	100	400	1/3	4

Henceforth, we then focus on symmetric Nash equilibria, since it is expected that homogeneous players behave the same way.

First of all, let us consider symmetric equilibria in which players give (strictly) positive contributions but do not reimburse the global losses, so that a loss remains. Rewriting (10) accordingly, it turns out that such symmetric equilibria, whatever the amounts contributed, can only be sustained in the very special case where when all individuals' preferences are such that $MRS^{0,1} = \frac{p}{1-p}\frac{(m-1)(n-m)}{m^2}$.[7]

A more interesting candidate symmetric outcome to examine is the one in which everyone contributes $x_0 = \ell/n$ and all the losses can be entirely reimbursed. We now investigate this issue using in turn a constant absolute risk aversion (CARA) and a constant relative risk aversion (CRRA) utility function.

The contribution profile $(\ell/n, \ldots, \ell/n)$ will indeed be an equilibrium profile if player i has no incentive to deviate to partial coverage choosing $x_i^D < \ell/n$, given the fact that all other players choose ℓ/n. x_i^D can then be derived from (10) given the symmetric contribution profile of others, $x_{-i}^S = (\ell/n, \ldots, \ell/n)$.[8] To verify that a deviation from ℓ/n is not profitable, we must check that

$$U_i\left(\frac{\ell}{n}, x_{-i}^S\right) \geq U_i\left(x_i^D, x_{-i}^S\right). \tag{11}$$

EXAMPLE 1: *CARA utility function.*

Consider the following parametric form:

$$u(\pi) = -\exp\{-\sigma\pi\}, \tag{12}$$

where $\sigma > 0$ *represents players' absolute risk aversion.*

Using (12), *Condition* (11) *can be rewritten:*

$$p.\exp\left\{-\sigma\left(y - x_i^D - d.c_i\left(x_i^D, x_{-i}^S\right)\right)\right\} + (1-p)$$
$$.\exp\left\{-\sigma\left(y - x_i^D\right)\right\} \geq \exp\left\{-\sigma\left(y - \frac{\ell}{n}\right)\right\}, \tag{13}$$

A straightforward numerical analysis using the parameter values of our experiment (given in Table 1) shows that condition (13) holds for any reasonable value of σ (≥ 0.003), which allows us to conclude that given x_{-i}^S there is no profitable deviation for player i. Therefore, in addition to the no-insurance equilibrium $(0, \ldots, 0)$,

emphasize this tendency to project own preferences, even exaggeratedly, onto others (this is the so-called "false consensus effect").

[7] Or $MRS^{1,0} = 0.75$ with the parameter values detailed in Table 1.

[8] Under the conditions given in Table 1, numerical analysis shows that, with both utility functions considered in the section (CARA and CRRA utility functions), x_i^D lies between 9 and 10 for all relevant values of individuals' risk aversion.

$(x_1, \ldots, x_n) = (\ell/n, \ldots, \ell/n)$ is another symmetric equilibrium of the game with contribution-based coverage in this example.

EXAMPLE 2: *CRRA utility function. Let us consider a CRRA utility function and assume that players' utility function is given by*

$$u(\pi) = \begin{cases} \frac{1}{1-\eta}\pi^{1-\eta} & \text{if } \eta \neq 1 \\ \ln \pi & \text{otherwise,} \end{cases} \tag{14}$$

where $\eta > 0$ *represents players relative risk aversion.*

Plugging (14) *into condition* (11) *yields:*

$$\begin{cases} p \frac{1}{1-\eta}\left(y - x_i^D - d\left(1 - c\left(x_i^D, x_{-i}^S\right)\right)\right)^{1-\eta} + (1-p)\frac{1}{1-\eta}(y - x_i^D)^{1-\eta} \leq \frac{1}{1-\eta}\left(y - \frac{\ell}{n}\right)^{1-\eta} & \text{if } \eta \neq 1 \\ p \ln\left(y - x_i^D - d\left(1 - c\left(x_i^D, x_{-i}^S\right)\right)\right) + (1-p)\ln(y - x_i^D) \leq \ln\left(y - \frac{\ell}{n}\right) & \text{if } \eta = 1. \end{cases} \tag{15}$$

With the parameter values of our design, one can check numerically that condition (15) holds for all relevant values of $\eta > 0$. Thus, there is no profitable deviation from ℓ/n and $(\ell/n, \ldots, \ell/n)$ is consequently a symmetric equilibrium of the game with contribution-based coverage under the CRRA utility specification.

Therefore, it is still true in this illustration that, as with a CARA specification of the utility function, both $(0, \ldots, 0)$ and $(\ell/n, \ldots, \ell/n)$ are equilibria of the game.

2.4. Discussion

The above analysis emphasizes the incentives brought by each mechanism. Unambiguously, in the equal coverage mechanism, equilibrium forces drive contributions to the no-insurance outcome in which nobody contributes to the mutual fund. In contrast, results are not clear-cut with contribution-based coverage since the no-insurance outcome is always an equilibrium but the symmetric full-insurance outcome is another potential equilibrium. Interestingly, the no-insurance equilibrium is sustainable even for people with arbitrarily large degrees of risk aversion while full insurance can be obtained for individuals with arbitrarily low (but strictly positive) degrees of risk aversion. We considered a simplified version of our set-up to tackle the technical complexity of the game with contribution-based coverage. Still, we believe that our conclusions are of a wider applicability due to the robustness of our findings to an extended class of preferences (namely, CARA and CRRA specifications).

The intuition behind these results is as follows. Under the equal coverage mechanism the marginal return to contribution remains moderate whatever the amounts contributed, which in turn kills any incentives to contribute strictly positive amounts. In contrast, under the contribution-based coverage mechanism, the marginal return to contribution depends on the size of the amount contributed relatively to the contributions of others. Therefore, two conflicting forces are at stake here. Players have clear incentives to contribute little and reap some benefits of the contributions of others; but they are limited by the fear of "punishment" in the form of low coverage if their own contribution falls too much below the contributions of others. Which of these two conflicting forces prevails will depend eventually on the penalty imposed on low contributors. Multiple equilibria can be achieved depending on the inequality among individual contributions.

Concerning (*ex ante*) efficiency, it could be also noticed that the marginal individual cost of player i's contribution is $p\frac{\partial u_i}{\partial \pi_i^1} + (1-p)\frac{\partial u_i}{\partial \pi_i^0}$ and its marginal social benefit in terms of an increase in the coverage rates equals $p\frac{1}{C_{n-1}^{m-1}}\sum_{j=1}^{n}\sum_{M\setminus\{j\}\subset N\setminus\{j\}} d\frac{\partial c_j}{\partial x_i}\frac{\partial u_j}{\partial \pi_j^1}$ (which reduces to $p\sum_{j=1}^{n}\frac{d}{\ell}\frac{\partial u_j}{\partial \pi_j^1}$ under equal coverage). Obviously, comparisons are tricky between the marginal cost and the marginal benefit and would depend on the distribution of individuals' risk attitudes in the population. However, it is worth noting that, despite the large differences that existed between these games and contrary to the contrasting incentives emphasized in this section, it is possible to draw similar welfare implications across mechanisms. For example, consider the stylized case with homogeneous preferences.[9] In this case, symmetric allocations of contributions would be such that, under partial coverage, the marginal social benefit of a player's contribution always exceeds its marginal cost for both regimes. More precisely, in the equal coverage regime, this rewrites $\frac{p}{1-p}(-1 + n.d/\ell) \geq MRS^{0,1}$, or $MRS^{0,1} \leq 1$ with our parameterization. In the contribution-based coverage regime, this rewrites $\frac{p}{1-p}(-1 + n\frac{m+n(m-1)}{m^2}) \geq MRS^{0,1}$, or $MRS^{0,1} \leq 14.5$ with our parameterization. These inequalities unambiguously hold under both regimes for any degree of risk aversion (since $MRS^{0,1} \leq 1$ with $\pi^0 \geq \pi^1$). Hence, in our set-up, creating a mutual fund that fully covers the loss is a relevant socially optimal target *ex ante* across all the regimes under consideration. Interestingly, this target is also the optimal policy under private fair insurance for risk-averse individuals (see Mossin, 1968). Thus, the optimal mechanism under mutual insurance coincides with the optimal mechanism under fair private insurance. As a result, the *ex ante* efficiency of mutual insurance mechanisms can be judged by their ability to enhance voluntary contributions. Consequently, any outcome different from full insurance can be considered as (*ex ante*) sub-optimal and would reflect coordination failure.[10]

2.5. On Partial Insurance Outcomes

Beyond the existence of these two focal issues of no insurance and full insurance, one could wonder whether "interior" equilibria exist such that the total losses are only partially covered by some individuals' contributions. The range of possible outcomes is obviously very large but to illustrate this class of outcomes, consider the subset of equilibria such that r players contribute 0 while the $n-r$ remaining ones ($n-r>0$) contribute at some level $\overline{x} > 0$. It turns out that such equilibria can be sustained, for any $\overline{x}$, with an intermediate number of zero contributors ($8 \leq r \leq 10$ with our parameterization).[11] Indeed, as described in Equation (8), when zero contributors are too few, they suffer, in expectation, a high penalty because some players are likely to contribute a (strictly) positive number of tokens and get all the indemnities. Therefore, there is no incentive to contribute a null amount when the number of zero contributors is too small. On the other hand, when zero contributors are too numerous, it does not pay for other players to contribute strictly positive amounts, because the relative benefit for positive contribution (in terms of an increase in the coverage rate) is relatively modest if total

[9] This assumption is common in the literature on voluntary contribution mechanisms, which predicts a social optimum of full contribution for homogeneous groups in a riskless context.

[10] Another way to assess the efficiency of insurance institutions is to look at realized payoffs, or *ex post* efficiency. As long as the sum of contributions does not exceed losses, the insurance mechanism maintains incomes constant in the aggregate under both regimes, no matter how large the partial coverage. Subjects then support, on average, one nth of the total amount of losses. Therefore, *ex post* efficiency is not a criterion that can be used to evaluate the optimality of either regime.

[11] We describe here the intuition for the existence of such a class of equilibria. A formal proof is available from the authors upon request.

contributions are low. As the number of contributors in these equilibria is not larger than 4, no surplus can be generated.

In the above analysis we derive symmetric equilibria, but note that it does *not* imply that we expect symmetric outcomes to be achieved in our experiment. Indeed, the coordination issue that affects our contribution-based coverage treatment is likely to induce asymmetric behaviors depending on the equilibrium outcome targeted by individuals. Asymmetry in players' behavior can also naturally be triggered by the heterogeneity of preferences. Specifically, subjects' risk attitudes are likely to differ. More precisely, it can be seen from Equation (10) that when $MRS_i^{0,1} \leq \frac{p}{1-p}\frac{1}{C_{n-1}^{m-1}}\sum_{M\setminus\{i\}\subset N\setminus\{i\}}(-1+d\frac{\partial c_i}{\partial x_i})$, it is optimal for player i to contribute $x_i^* = \min\{y, \ell - \sum_{j\neq i} x_j\}$. This condition is automatically met when $MRS_i^{0,1}$ tends to 0 (as its RHS is non-negative). In other words, extremely risk-averse subjects have incentives to unconditionally give as much as they can until global losses are recovered. It is straightforward to observe that the greater the MRS (players' risk tolerance) the harder it is to validate the condition. Hence relatively low risk aversion naturally hinders players' incentives to contribute. In contrast, in the polar case where subjects are all risk-neutral, the symmetric equilibrium $(\ell/n, \ldots, \ell/n)$ exhibited above where everyone is fully insured and gets $y - \ell/n$ cannot be sustained. Indeed it can be shown that any deviation to a contribution strategy x^D, $0.0008 < x^D < \ell/n$, would lead to higher expected payoffs.[12]

Again in the contribution-based coverage treatment, the set of possible equilibria is potentially very large. The experimental data will give us clues for eliciting the most likely equilibria and see how players eventually reach a specific outcome.

3. Experimental Design

We now describe the protocol used in our experiment. We implemented the two mechanisms detailed in the previous section under a between-subject design.

Twelve participants form a group ($n = 12$). At the beginning of each period, each participant receives an endowed income of 100 tokens.[13] Everyone can contribute to a common pool that serves to compensate the participants who will incur a loss of their entire income. The individual contribution is a number of tokens chosen between 0 and 100. Four of the 12 group members are then randomly hit by the loss ($m = 4$) so that the total loss is 400 tokens ($\ell = 400$).

The equilibrium is to contribute nothing in the equal coverage treatment. In the contribution-based coverage treatment, both no-insurance and full-insurance equilibria exist, the achieved issue remaining eventually empirical.[14] Each session consists of 50 periods, allowing us to observe long-run contribution dynamics.

Regarding procedures, we have conducted 6 experimental sessions per treatment, for a total of 12 sessions of 12 participants each. In order to capture the possible role of cultural differences regarding the feeling of individual responsibility, half of the

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[12] More precisely, the expected payoff of a deviator, who chooses $x^D < \ell/n$ (any deviation to $x^D > \ell/n$ is obviously irrelevant since the surplus is burned), is $y - x^D - pd(1 - c(x^D))$, where $c(x^D) = \frac{m}{\ell}\frac{x^D\ell - x^D}{3\ell/n + x^D}$, which turns out to be greater than $y - \ell/n$ as soon as $x^D > 0.0008$.

[13] At the beginning of the first period, to avoid the possibility of negative earnings, each participant was given an endowment of 110 tokens. This does not influence the theoretical predictions.

[14] We did not tell the subjects explicitly that full coverage required an individual average contribution of 33 or 34, to avoid introducing a focal point and an experimenter demand effect. We acknowledge, however, that contributing 33 or 34 may be less salient than contributing 0. Thus, this equilibrium may be less focal than the equilibrium with a null contribution.

Table 2: Summary statistics by session and by treatment

Treatment	Session Number	Average Contribution	Percentage of Null Contribution
Equal Coverage	1	9.25	46.50%
	2	10.76	39.17%
	3	14.35	39.33%
	4	8.24	56.67%
	5	5.90	57.67%
	6	4.13	76.17%
	Sub-total	8.77	53.00%
Contribution-Based Coverage	1	14.71	29.50%
	2	19.81	25.83%
	3	19.75	16.17%
	4	13.79	24.50%
	5	13.23	43.00%
	6	13.11	28.17%
	Sub-total	15.74	28.00%

sessions for each treatment were run in the BUL-CIRANO lab (Center for Interuniversity Research and Analysis on Organizations), Montreal (Canada), and half at GATE (Groupe d'Analyse et de Théorie Economique), Lyon (France), on the same dates. In total, the experiment summoned 144 French-speaking participants, mostly students. It was programmed with the REGATE software (Zeiliger, 2000).

Upon arrival in the laboratory, each participant randomly drew a ticket with a computer name out of a bag. After the instructions were distributed and read aloud, the participants' questions were answered in private and a questionnaire was used to check that all instructions had been well understood.[15] The latter were written in neutral terms. The average duration of sessions was an hour and a half including the payment of participants that was done privately in a separate room. The conversion rate was 300 tokens = 1.55 Canadian dollar = 1 euro at the time of the experiment. The average earnings were 35 Canadian dollars or 23 euros.

4. Results

In this section, we analyze contributions to mutual aid which conditions outcomes and efficiency. We first compare contribution levels between treatments in the aggregate. Then, we examine the heterogeneity of strategies and individual determinants of contribution behavior.

4.1. Aggregate Contributions and Efficiency

Table 2 displays summary statistics on aggregate behavior at the session level, by showing the average contribution and the share of null contributions.

[15] The instructions for the two treatments have been translated and are presented in an Appendix in the Supporting Information.

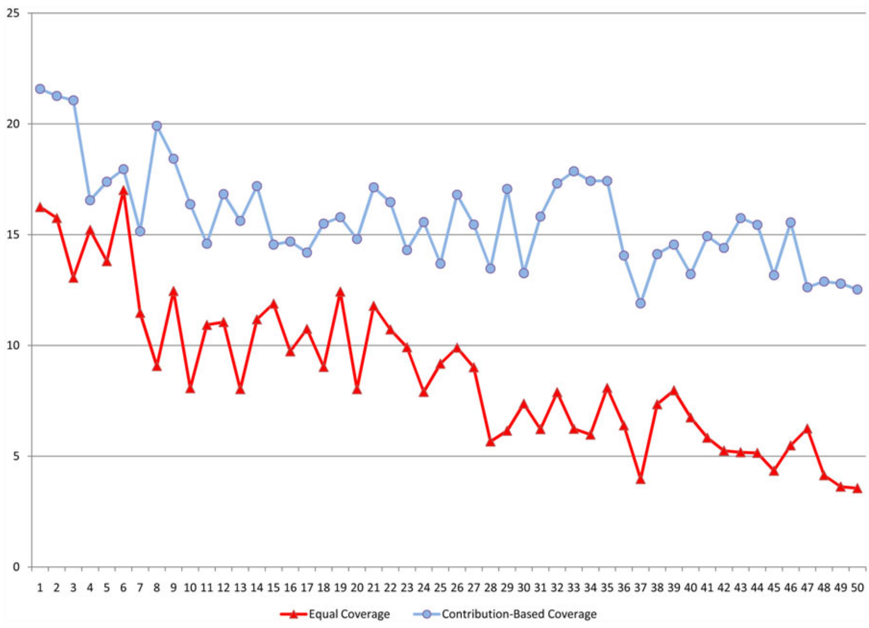

Figure 1: Evolution of the average contributions over time by treatment.

Table 2 shows that voluntary contributions per group of 12 players in a session over all the 50 periods are not sufficient to cover aggregate losses. No surplus was found for both treatments. Hence, it is worth noticing that, although full coverage equilibrium is a distinct possibility under contribution-based coverage, players do not conform to this outcome in the data.[16]

As a crude approximation, the incentives brought by each treatment are reflected in the difference of average contributions across treatments. The frequency of equilibrium play corresponding to the null contribution is higher in the equal coverage treatment (53%). Subjects only contributed an average of 8.77 ($SD = 16.55$) in this treatment. Under contribution-based coverage, subjects contribute a larger amount of 15.74 ($SD = 17.77$) and null contributions only represent 28% of the observations. However, even if the latter treatment succeeds in overcoming players' tendency to contribute 0, it fails to fully cover the losses. Subjects consequently get partially insured. More precisely, the individuals who incur a loss on average contribute and recover only 26.3% of the loss under the equal coverage policy and 47.2% under the contribution-based policy. Beyond the coordination failure issue caused by the multiplicity of equilibria, this average outcome may mask, as we shall see later, a contrasted situation due to the heterogeneity of risk preferences, with risk-averse players asking for high coverage and risk-tolerant ones enjoying low coverage.

Figure 1 displays the evolution of average voluntary contributions over time for each treatment.

Figure 1 shows the sharp contrast in mean behavior between the two treatments. Differences can already be seen in the initial contributions and in the respective trends. In comparison with the contribution-based coverage treatment, under equal coverage mean contributions start at a lower level, decline more rapidly, and converge to zero.

[16] Only 4% of fair contributions have been found in the data.

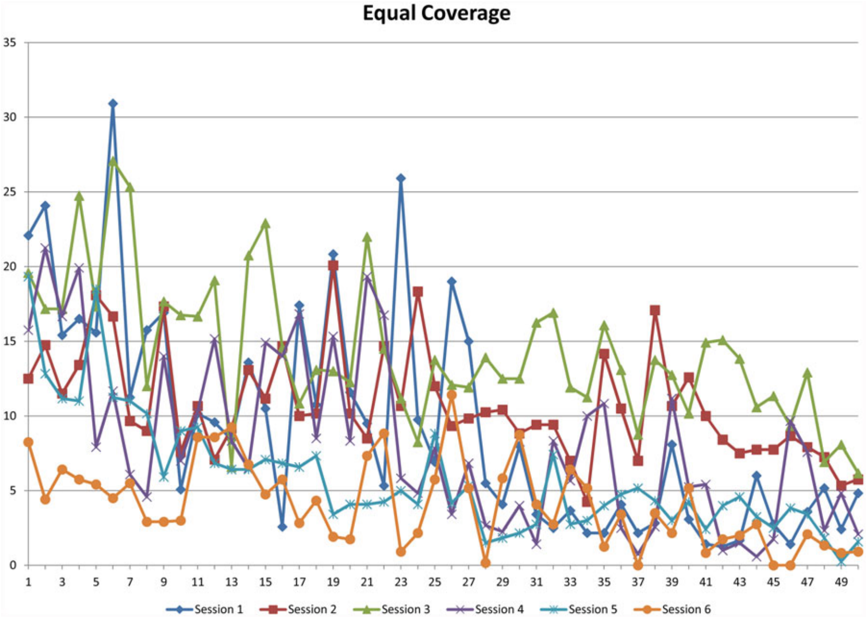

Figure 2: Evolution of the average contributions over time by group under equal coverage.

Figures 2 and 3 disaggregate the description of average behavior at the group (i.e., session) level. They show a striking difference in average behavior in the first period across groups. While there is a wide dispersion of average contributions across groups in the equal coverage treatment, a remarkable concentration can be observed in the contribution-based coverage treatment. The latter suggests that the subjects do not immediately play the equilibrium and follow a common prior in the absence of information on the others' behavior. A common prior is common knowledge and may serve as a social norm (Lévy-Garboua, Meidinger, and Rapoport, 2006). Assume, for instance, that the prior is that "all should equally contribute to get full coverage." The same norm initially applies to both treatments. However, it is much more strictly enforced with contribution-based coverage than with equal coverage which treats high and low contributors equally. Consequently, rational subjects do not deviate much from the prior norm of equal contribution and full coverage by fear of punishment (in terms of a relatively low coverage rate) when their final coverage is partially based on their own contribution relative to the contributions of others. In contrast, the lack of punishment in the equal coverage treatment sets no bound on their private incentive to lower their contributions so that average deviations from the norm across groups critically vary then with the proportion of selfish players in each group. Behavior evolves differently across treatments as the individuals get gradually informed about others' behavior. The contribution-based coverage stabilizes the average contributions at a relatively high level in all groups, whereas equal coverage leads to a uniform decline of contributions toward zero.

In complement to these statistics, a simple regression of mean contributions on the inverse of time[17] helps us quantify the main differences of behavior across treatments.

[17] A hyperbolic shape was preferred to declining linear curve because it forces contributions to be positive and allows identification of a stationary equilibrium.

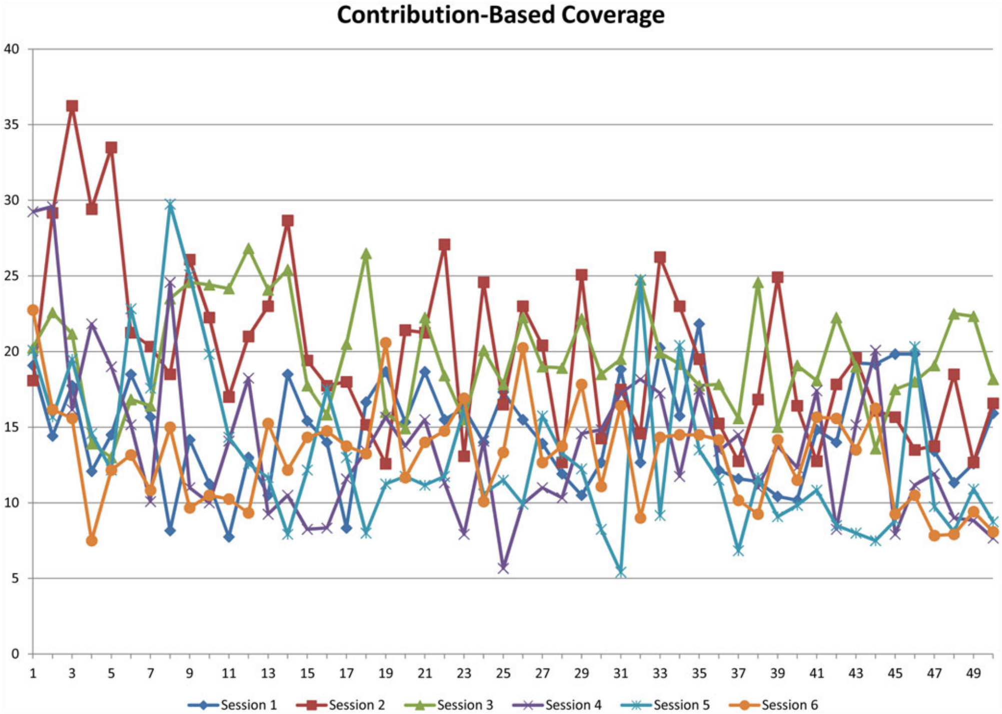

Figure 3: Evolution of the average contributions over time by group under contribution-based coverage.

Table 3 analyzes this influence of time on individual contributions by estimating an ordinary least squares model for each treatment.

Table 3 confirms a difference between the two treatments in the initial average contribution: 21.33 for the equal coverage treatment and 24.09 in the contribution-based coverage treatment. The lower initial value under the equal coverage mechanism is consistent with the lack of an enforcement institution for the social norm of equal contribution in this treatment. Another significant difference among treatments lies in the higher asymptotic level of average contributions for the contribution-based coverage treatment: 14.89 versus 7.53.[18]

4.2. Determinants of Individual Contribution Behavior

To understand the determinants of individual contribution behavior, we proceed to an econometric analysis that is based on a two-step estimation procedure.[19] We first explain the decision to contribute, and next the choice of the amount contributed conditional on the decision to contribute. Indeed, we assume that these two decisions are separated

[18] These values and the difference between them may be biased upward by the limited duration of the game. However, the difference is so large that we can safely conclude that the contribution-based coverage treatment is much more efficient and yields higher contribution levels than the equal coverage treatment.

[19] A tobit model of type 2 (generalized tobit) would be ideal for a one-step estimation, but it is not user-friendly with panel data.

Table 3: Evolution of the average contributions over time by treatment

	Equal Coverage		Contribution-Based Coverage	
	Coeff.	***t*-stat.**	**Coeff.**	***t*-stat.**
1/Period	13.80*	5.70	9.29*	5.975
Constant	7.528*	17.25	14.89*	53.14
Observations	50		50	
$\overline{R}^2$	0.391		0.415	

Note: *Statistically significant at the 1% level.

in the subjects' decision process and that there may be a selection bias in the contribution decisions. The first decision is studied by means of a random-effects probit model; and the conditional contribution is estimated with a feasible generalized least squares model corrected for the potential selection bias. This panel data analysis with random effects accounts for the fact that the same subject is observed fifty times.

Among the independent variables, we control for a time trend and demographic variables.[20] We also introduce a number of lagged exogenous variables and individual controls.[21] Lagged variables are intended to capture the process of convergence to equilibrium and temporary deviations from the time trend. A positive effect of the sum of the other subjects' contributions in the previous period is intended to capture conditional cooperation (a subject contributes all the more as the others contributed more in the past; see Fischbacher, Gächter, and Fehr, 2001). We also include a variable indicating whether the participant has incurred a loss in the previous period. Persistent bad luck is captured by the difference between the actual number of losses suffered by a participant during the elapsed periods and the expected number of losses given the objective probability of a loss. This variable captures the effect of an over-prevalence of bad luck on current contribution behavior. Last, we introduce in the second equations the Inverse of the Mill's Ratio (IMR) derived from the estimation of the first equations to control for a potential selection bias. These models are estimated separately for each of the two treatments because we assume that behavior is driven by different factors in various institutional environments.[22] Table 4 displays the results of these regressions.

Table 4 unambiguously attributes the decline in the mean contribution to an increasing propensity to not contribute in the equal coverage treatment, and to a

[20] Our experimental design also includes a simple test of risk aversion. More precisely, at the beginning of the session, the participants had a choice between getting a show-up fee of 5 Canadian dollars (2 euros) and participating at the end of the session in a lottery in which they had equal chances of winning either 11 dollars (5 euros) or 0. They tossed a coin at the end of the session to determine their extra earnings. The participants who exhibited a "certainty effect" by choosing the show-up fee were tentatively considered as being more-risk averse. However, since Kahneman and Tversky (1979), there has been an agreement among decision theorists that observing a "certainty effect" is no reliable evidence of risk aversion. Indeed, no clear pattern emerged concerning the impact of participants' lottery choices on their contribution behavior.

[21] The individual controls include age, gender, student or worker status, education level, mathematical training, past participation in an experiment, and location of the session (Lyon, Montreal).

[22] Non-parametric Wilcoxon rank-sum tests were performed for assessing whether two samples of observations came from the same distribution. The null hypothesis is that the probability distributions of the two treatments considered are equal. The null is rejected in comparisons involving the percentage of zero contributions and gains. Therefore, the two treatments will be considered separately in the regression analyses.

Table 4: Probability and determinants of the positive contributions by treatment (periods 2 to 50)

Treatment	Equal Coverage				Contribution-Based Coverage			
	Random Effects Probit Model		FGLS Panel		Random Effects Probit Model		FGLS Panel	
Variable	**Coeff.**	***t*-stat.**	**Coeff.**	***t*-stat.**	**Coeff.**	***t*-stat.**	**Coeff.**	***t*-stat.**
Period	−0.022*	−10.806	−0.095	−0.767	0.0017	1.389	−0.134*	−6.646
Others' contribution $t-1$	0.026	0.556	−0.827	−1.572	0.011	0.318	−0.108	−0.328
Loss in $t-1$	−0.348*	−7.248	4.191**	2.027	−0.5099*	−10.336	−3.243*	−3.235
Losses minus anticipated losses	0.030	1.499	0.288	0.920	0.018**	2.001	0.600*	3.211
Age	−0.042*	−3.240	0.879**	2.157	−0.029*	−2.771	−0.021	−0.066
Gender (Males = 1)	−0.414*	−3.481	7.344**	1.890	−1.640*	−13.049	−1.025	−0.294
Experience	−0.357	−1.577	−11.516*	−2.514	0.305*	3.487	−0.595**	−0.197
Student (Reference: worker and unemployed)	0.129	0.602	−8.111	−1.485	−0.926	−1.418	−4.141	−0.846
Graduate	0.750*	6.218	−7.001	−1.198	0.622*	3.178	−9.078*	−2.444
Mathematical training	−0.185	−1.510	2.645	0.659	−0.460*	−2.808	2.515	0.702
Montreal (Reference: Lyon)	0.525*	4.076	−8.416	−1.560	0.916*	7.464	9.314*	2.783
Constant	1.418*	3.564	32.027*	3.158	3.692*	4.856	25.123**	2.342
ρ	0.625*	26.639			0.621	22.280		
IMR			−14.441**	−1.673			3.186	0.730
R^2			0.178				0.078	
Observations	3528		1655		3528		2537	
Value of the likelihood								
V: constrained	−2438.68				−2094.92			
V: probit	−2244.30				−1949.83			
V: probit panel	−1493.57				−1411.18			

Note: * Statistically significant at the 1% level; ** Statistically significant at the 5% level.

diminishing amount of contributions in the contribution-based coverage treatment. These observations corroborate the very different nature of equilibria in these two treatments: a corner solution in the first case versus interior equilibria in the latter. The cultural dimension is also found to play a role because French subjects contribute less under both policies. Last, only few demographic variables intervene.

Short-run fluctuations around these trends are triggered by the occurrence and past frequency of losses. The occurrence of a loss diminishes the probability of a positive contribution in the next period in both treatments, whereas an excess frequency of losses in the past convinces players to contribute more in the contribution-based treatment only.[23] None of these two effects of experienced losses on the decisions to contribute is consistent with expected utility maximization under risk. The lagged negative effect of a loss may reveal a gambler's fallacy (Tversky and Kahneman, 1974) or a "bomb crater" effect (Mittone, 2006), in which the unlucky individual underestimates the chances that his bad luck persists in the future. An alternative explanation is that participants try to regain the experienced loss by saving on contributions. The effect of an excess frequency of losses in the past evokes the "hot hand fallacy" (Gilovich, Tversky, and Vallone, 1985). Individuals behave as if they think that, if they have been lucky or unlucky for some time, they will continue to be so in the future because it reflects

[23] An excess frequency of loss has no positive effect on contributions in the equal coverage treatment because not contributing is then a dominant strategy.

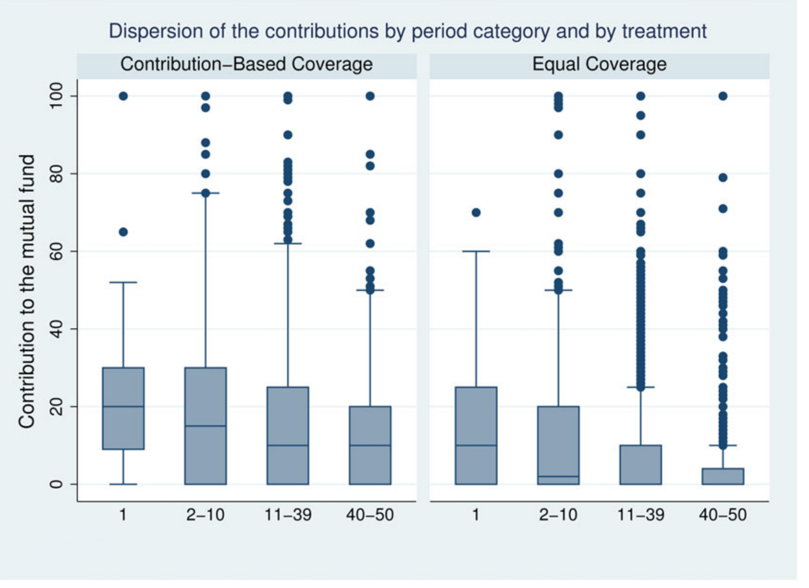

Figure 4: Dispersion of the contributions by block of periods and by treatment.
Note: The horizontal line within each bar represents the median; dots correspond to outliers.

their nature, and so they must take proper risk coverage. Such behavior runs counter the gambler's fallacy effect.

In contrast with the literature on public goods games, Table 4 shows that conditional cooperation, captured by the influence of others' contributions in the previous period on one's own contribution level, does not affect behavior. Thus, in the presence of risk, players' strategies seem to be more dictated by Nature than by others' behavior or by reciprocity.

4.3. Heterogeneity of Strategies

Recent experimental literature has emphasized the heterogeneity of preferences and its impact on behavior in public goods games (see Burlando and Guala, 2005). To give a feeling of heterogeneity of individual behaviors, Figure 4 displays the dispersion of contributions over time. Notably, it shows a strong disparity across treatments. The median contribution drops in the equal coverage treatment, while it remains more stable in the contribution-based coverage treatment. Meanwhile, the gap between the first and last quartiles lessens with time.

In order to track this heterogeneity properly, homogeneous groups of participants and strategies have been separated by a cluster analysis based on three discriminating variables: the frequency of positive contributions, the average and the standard deviation of contributions. The standard deviation of contributions identifies the variety of strategies. As shown below, two clusters for all treatments are enough to oppose very different strategies, and Table 5 characterizes these strategies for each treatment.[24]

[24] Insofar as we want to identify the most contrasting groups of behavior, we have used a difference criterion as an aggregation mean. The maximum link method (the distance between two groups is

Table 5: Cluster analysis of strategies

Treatment	Equal Coverage		Contribution-Based Coverage	
Clusters	Cluster 1 (High Contributors)	Cluster 2 (Low Contributors)	Cluster 1(High Contributors)	Cluster 2 (Low Contributors)
Frequency of non-null contributions				
Average %	37.051	7.939	44.622	21.815
Standard deviation	10.252	6.364	6.847	11.139
Average of the contributions				
Average number of tokens	14.177	2.379	20.828	7.235
Standard deviation	11.504	2.475	10.046	4.954
Average of the std. dev. of the contributions				
Average	13.843	5.558	13.609	9.769
Standard deviation	8.637	5.377	8.735	4.686
Number of observations	39	33	45	27

In Table 5, cluster 1 describes the high contributors and cluster 2 the low contributors. High contributors differ from low contributors, since the null hypothesis is often rejected in comparisons between treatments of the statistics presented in Table 5. High contributors give considerably more than low contributors but they adopt a more variable strategy, reflected by a larger standard deviation. The larger variability of contributions for high contributors may be caused, at least in part, by the common tendency to not contribute after being hit (gamblers' fallacy), as this would affect high contributors much more than low contributors. Between 55% and 62% of participants are classified as high contributors. Within each cluster of subjects, behaviors are rather comparable.

Aggregate earnings remain unchanged across regimes but the distribution of earnings between individuals depends on their respective contributions. More precisely, the sharing rule takes the form of a transfer from high contributors to low contributors. Average payoffs for the clusters of high contributors and low contributors are respectively 61.83 and 72.12 in the equal coverage treatment and 65.65 and 68.10 in the contribution-based coverage treatment. Therefore, the amount of transfer from high contributors to low contributors which is unrelated to the occurrence of a loss is diminished when coverage rates are determined on the basis of individual contributions. This reflects the fact that a higher level of contribution from low contributors under contribution-based coverage alleviates the burden of high contributors.

given by the distances of the furthest object of each group) and the Ward method (minimizing the intra-group variance) are best fitting. Since the Ward method tends to produce smaller groups, we have favored this method, that is, the minimization of the squared sum of the errors (the squared Euclidian distance $\sum_{k=1}^{p}(z_{ki} - z_{kj})^2$). Regarding the choice of the number of partitions, insofar we want to preserve the greatest differences between groups, we examine the decreasing curve of the distances between the merged partitions in each stage. This curve must diminish in a monotonic fashion as the near partitions are merged in each stage. If a net difference is observed in the course of iteration, it is not reasonable to group other partitions.

What determines the heterogeneity of contributions in the mutual-aid game? We saw previously that risk attitudes were a major source of difference in contribution behavior. In an attempt to coordinate on a "normal" contribution, all risk-averse players would be attracted by the fair contribution whereas all risk-tolerant players would be attracted by the null contribution. This conjecture is remarkably consistent with the observed mean contribution in the first round of the contribution-based coverage treatment. Indeed, if we assume that 28% of our subjects are non–risk-averse (this is the mean frequency of null contributions in Table 2), the mean contribution in the first round (with no knowledge of others) would be given by 0.28 (0) + 0.72 (33.33) = 24 which is to be compared with the observed mean contribution of 24.09! It is worth noticing that these two prior norms of fair contribution for risk–averse players and no contribution for non–risk-averse players coincide with the two extreme symmetric equilibria $(\ell/n, \ldots, \ell/n)$ and $(0, \ldots, 0)$ respectively. These equilibria would be reached in a one-shot game if all players were of one type or the other. The natural heterogeneity of risk attitudes makes this situation extremely unlikely. Instead, we observe two clusters illustrated by Table 5: a majority of risk-averse high contributors and a minority of low contributors. Abstracting from short-run deviations that may be caused by the occurrence of a loss, high contributors have an incentive to reduce their contribution—particularly so in the equal coverage treatment—and low contributors have an incentive to give a little to reap the external benefit of coverage thanks to the large contributions of the high contributors. This parallel behavior of the members of the two clusters may remain stable over time if the preoccupation with risk dominates reciprocity motives. It generates an asymmetric interior equilibrium with a mixture of high and low contributors in which the non-risk-averse players impose a negative externality on the risk-averse players who are forced to overcontribute for less than full insurance. Note that this particular type of asymmetric equilibrium seems consistent with the heterogeneity of norms and risk attitudes but less consistent with other social preferences like inequity aversion. Indeed, in our context, if players prominently wanted to reduce the inequalities between payoffs, we would more likely observe symmetric outcomes with similar amounts contributed.

5. Concluding Remarks

In this paper, we study games in which individuals choose to contribute voluntarily to a mutual-aid pool. Mutual-aid groups provide informal mutual insurance to their members who remain free to choose their contribution and receive a share of total contributions if they incur a loss. They appear under various guises to offer insurance and assistance to members of occupational groups, trade unions, communities of villagers or countries, and so on. In spite of its importance in social life and in public policies, mutual aid has received little attention in the economic theory of insurance. We derived the Nash equilibria of two mutual-aid games, defined respectively by equal coverage and by contribution-based coverage of group members who experience a random loss. We limit our study of mutual-aid groups to exogenous and fixed groups, leaving the endogenous formation of such groups for further research.

If we assume that players are homogeneous and essentially risk–averse, we can conclude that contribution-based coverage takes us only half-way to efficiency since the latter requires full insurance. In that respect, one could say that coordination failures that arise from the existence of multiple equilibria have been only partially overcome by the provided incentives. This is a conventional interpretation in game theory. However, if we recognize the heterogeneity of risk attitudes, a very different interpretation arises which interferes with the issue of coordination failures. This new interpretation was suggested by the observation of a norm-induced behavior in the first round and the emergence of a "dual interior equilibrium" with a majority of high contributors and a significant minority of low contributors. Under the latter interpretation, players have heterogeneous risk attitudes, with a majority of risk-averse subjects and a significant minority of risk-tolerant players. These two groups share very different prior norms: fair contribution and full insurance for the risk–averse, but zero contribution and no insurance for the risk-tolerant players. This type of preference heterogeneity is natural in a risky context and it seems to take precedence over reciprocity and inequity aversion in our data, which demonstrates that voluntary contribution mechanisms in a risky context may yield very different outcomes than mechanisms with sure outcomes. It leads to a dual interior equilibrium in which the two groups interact, with the risk-averse group less than fully contributing and the risk-tolerant group less than fully defecting.

Under homogeneous risk attitudes, the mean coverage rate equals 47.2% in the contribution-based treatment so that coordination failures are responsible for a social loss of 52.8% of the optimal (full) insurance. The picture is very different under heterogeneous risk attitudes. If we assume then that each of the two groups is homogeneous, the mean coverage rate equals 62.5% for the (risk–averse) high contributors and 21.7% for the (risk–tolerant) low contributors in the contribution-based coverage treatment. The presence of risk-tolerant players deprives the high contributors of 37.5% of their optimal insurance, 21.7% of which is transferred to the former and 15.8% is a social loss. We can also compare across treatments the efficiency gains brought by imposing a coverage that is proportional to contributions rather than equal for all. Under homogeneous preferences, the mean coverage rate would be raised from 26.1% to 47.2% for everybody. However, under heterogeneous preferences, the mean coverage would be raised from 26.1% to 62.5% for (risk–averse) high contributors whereas it would be cut down from 26.1% to 21.7% for (risk–tolerant) low contributors.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix: Instructions (translated from French).