Cooperation in a risky world *

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Abstract

We study the effect of environmental risk on cooperation in the Voluntary Contribution Mechanism. Our baseline is the standard setting in which the personal return from the public good is deterministic, homogeneous, and publicly known. Our experimental treatments alter this classic design by making the marginal per capita return from the public good probabilistic. In the *homogeneous risk* treatment, the random draw is made for the whole group, while in the *heterogeneous risk* treatment this happens independently for each group member. Our main result is that risk does not harm cooperation either in the one-shot or in the finitely repeated version of the game. This suggests that the standard experimental methodology provides a robust and conservative measure of human cooperation.

Keywords: Cooperation; Voluntary Contribution Mechanism; Environmental Risk.

JEL Classification: C72; D83.

1 Introduction

Many economic interactions create tension between individual and collective interests. For this reason, human cooperation has become one of the central topics in behavioral economics. Since the pioneering work of Isaac, McCue, and Plott (1985), numerous economists have studied cooperation

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using the Voluntary Contribution Mechanism (VCM in short).[1] Over time, VCM has become a widely accepted experimental testbed for studying various environmental and institutional aspects of cooperation (Ledyard, 1995; Chaudhuri, 2011).

Strikingly, what has once evolved to become the "gold standard" in experimental economics - that is, a version of VCM based on a deterministic, homogeneous and publicly known personal returns from the public good - seems far off as compared not only to the seminal work by Isaac, McCue, and Plott (1985), but also to many real world situations. Isaac, McCue, and Plott (1985) use heterogeneous returns from the public good which are entirely private knowledge, a design that certainly adds realism to the experimental game. For instance, the benefits that the individuals derive from establishing public facilities for health care or education are likely to be heterogeneous, private knowledge, and furthermore subject to randomness and variation over time.[2]

Yet, relatively little is still known about how the patterns of cooperation change once the decision-making environment shifts away from the "gold standard" paradigm. Addressing this issue seems important in terms of both the internal and the external validity of laboratory experiments. First, the data from alternative settings can be informative about the robustness and the limitations of the large body of experimental findings based on the standard VCM setup. Second, as recently documented in a carefully crafted lab-in-the-field experiment by Stoop, Noussair, and van Soest (2012), the usual patterns of cooperation observed in the standard VCM may not prevail in analogous (yet richer and more uncontrollable) real world environments. Explaining such discrepancy and rendering the findings from lab experiments applicable to naturally occurring settings calls for a greater care for the ecological validity of laboratory experiments. Our experimental is a step in that direction.

Herein, we tweak the standard VCM by incorporating two kinds of *environmental risk* which may occur either at the individual or at the group level. In both cases, the personal return from the public good is not deterministic, but probabilistic - either high or low. Both outcomes are equiprobable, become known ex post, and the lottery is mean-preserving with respect to the standard VCM scenario. Finally, in the *homogeneous risk* treatment, the random draw is made in each round for the whole group. In the *heterogeneous risk* treatment, in turn, this happens in each round independently for each group member.

The experiment consists of two incentivized VCM-based tasks. In the first part, we elicit players' conditional contributions to the public good, their unconditional contribution in a one-shot interaction, as well as their beliefs about other group members' contributions. In the second

[1] According to another early study by Isaac, Walker, and Thomas (1984), this seminal work dates back to 1980. Ledyard (1995) lists the study by Isaac, McCue, and Plott (1985) as the first economic experimental on public goods, along Kim and Walker (1984) (who conducted their experiments two months later).

[2] Of course, using the standard design has major advantages. First, it reduces the degree of unwarranted uncertainty in the decision-making environment, thus improving the experimenter's control over subjects' decisions. Second, it makes the outcomes of different experiments easier to compare and replicate, thus fostering the accumulation of empirical knowledge.

part, the participants play a finitely repeated VCM game under partner matching. We implement the environmental risk treatments in a between-subject manner. Given the proper randomization of social and risk preferences across experimental conditions, our investigation provides causal evidence on the effect of environmental risk on different layers of human cooperation.

Our main result is that risk does not harm cooperation. Neither the conditional contributions, nor the unconditional contributions, nor the beliefs about other group members' contributions in the one shot game decrease under environmental risk. Furthermore, the correlation between players' unconditional contributions and their beliefs about others' behavior remains stable across experimental treatments. Regarding the repeated VCM game, in all experimental conditions we observe the typical patterns of behavior: relatively high contributions in the initial round of the game, and their gradual decay over time. Heterogeneous risk has no effect on cooperation relative to the riskless control condition at any stage of the repeated game. Homogeneous risk improves cooperation in early rounds relative to both remaining conditions, but this positive effect quickly fades away. Altogether, these findings suggest that standard experimental methodology provides a robust yet conservative measure of human cooperation.

2 Related literature

In this section, we review the economic literature which experimentally investigates how deviations from the "gold standard" design - in which the marginal per capita return (MPCR) from the public good ought to be deterministic, homogeneous and publicly known - affect cooperation in the voluntary contribution mechanism. We refer to those settings as non-standard VCM settings. Typically, a non-standard setting is achieved by adding some sort of randomness to the process that transforms decisions into outcomes. Whenever such randomness is lottery-like, i.e. it involves a finite set of outcomes with publicly known probabilities (which is the case of the present experiment), we classify it as *environmental risk*. Otherwise, a non-standard setting is said to involve *environmental uncertainty*. All these studies use a VCM game that is being repeated over multiple periods, with the exception of Fischbacher, Schudy, and Teyssier (2014) who use a sequence of one-shot VCM games with varying MPCR schemes, and Björk, Kocher, Martinsson, Nam Khanh, et al. (2016) who combine these two setups just as we do in the present study[3] .

Interestingly, our literature review suggests that the earliest experiment based on the VCM paradigm by Isaac, McCue, and Plott (1985) does not meet the "gold standard" criteria: even though their MPCR is deterministic, it is also heterogeneous among players and remains privately know (which, in turn, is public knowledge). However, the most prominent studies following Isaac, McCue, and Plott (1985) are already based on the "gold standard" approach (see, for instance,

[3]We have come across the working paper by Björk, Kocher, Martinsson, Nam Khanh, et al. (2016) – who use an approach similar to ours to investigate the effects of risk and ambiguity on cooperation – while finishing the present manuscript.

Kim and Walker, 1984; Andreoni, 1988; Isaac and Walker, 1988a,b).

To the best of our knowledge, Fisher, Isaac, Schatzberg, and Walker (1995) are the first to experimentally compare standard and non-standard VCM settings. They build two control conditions based on the the standard design which only differ in the value of MPCR (which can be either high or low). In their main experimental treatment, MPCR comes with environmental uncertainty: it is heterogeneous and has an unknown distribution (even though players are aware of their own MPCR). Their main finding is that behavior is sensitive to the variations in one's own MPCR, but not to the presence of the environmental uncertainty about other players' MPCRs. In a similar vein, Boulu-Reshef, Brott, Zylbersztejn, et al. (2016) propose an experiment in which environmental uncertainty about MPCR takes the form of an individual random draw from a uniform distribution, so that neither personal MPCR nor other players' MPCRs are known to any individual at the time of decision-making. They also report that cooperation is neutral to the presence of environmental uncertainty. Finally, in Gangadharan and Nemes (2009) the environmental uncertainty is related to whether players obtain the return from the public good or not (the probabilities of which remain unknown to players). This form of environmental uncertainty is found to hurt cooperation as compared to the analogous "gold standard" setting. Moreover, this result also prevails in a risky environment where the probability of not benefiting from the public good is publicly known (Dickinson, 1998; Gangadharan and Nemes, 2009).

Other implementations of environmental risk yield mixed conclusions. Like our study, these experiments usually compare standard design with its non-standard equivalent in which MPCR is a realization of a mean-preserving-spread lottery. Studies by Levati, Morone, and Fiore (2009); Levati and Morone (2013) suggest that there might be a large and negative effect of what we call a homogeneous environmental risk (i.e., MPCR is randomly determined for all group members) on cooperation, but its occurrence depends on the way in which the MPCR lottery is calibrated. In Levati, Morone, and Fiore (2009), the risky version of VCM is a social dilemma solely in expected terms: conditional on the realization of the MPCR, it is either individually and socially efficient to contribute nothing (if MPCR is low), or individually and socially efficient to contribute the whole endowment (if MPCR is high). They report a negative effect of environmental risk on cooperation. In Levati and Morone (2013), in turn, the risky environment preserves the social dilemma nature of VCM regardless of the realization of MPCR. In this context, moving from the standard setting to environmental risk to environmental uncertainty (by making the probabilities unknown to players) does not affect cooperation. Similar phenomenon has been recently documented by Björk, Kocher, Martinsson, Nam Khanh, et al. (2016) in both one-shot and repeated games. Finally, Fischbacher, Schudy, and Teyssier (2014) introduce environmental risk by allowing MPCR to vary within a group according to a publicly known distribution. In their one-shot, strategy-method VCM setting they observe that this form of environmental risk has a negative effect on both conditional and unconditional contributions.

Altogether, we draw the following conclusions from these accumulated findings. First, deviating from the “gold standard” design may have a negative effect on cooperation, regardless of whether such deviation is due to environmental uncertainty or environmental risk. However, given that this literature is relatively small and dispersed, it seems well-founded to call for a systematic replication of the existing findings and an exploration of new non-standard VCM settings. Second, the existing findings are quite mixed and it remains unclear why negative effects arise in some particular decision-making contexts but not in others. This, in turn, calls for a tighter control of the channels through which such behavioral differences may arise.

Our experiment is designed to serve both of these purposes. We build on, and extend, the study of Fischbacher, Schudy, and Teyssier (2014). Like them, we study the effect of environmental risk in a 4-person VCM game and use their calibration of deterministic and risky MPCR. However, there are two important features that distinguish our design from theirs. First, the focus on the behavioral effects of heterogeneous returns gives the environmental risk in their experiment a competitive nature: the misfortune of some means benefits to others. Here, we are interested in varying the level at which the environmental risk arises: either at the individual level (heterogeneous risk treatment) or at the group level (homogeneous risk treatment). For this reason, we implement a non-competitive environmental risk: the realizations of risky MPCR within a group of players can be either perfectly correlated, or perfectly independent.[4] To the best of our knowledge, we provide the first experimental investigation that varies the level at which the environmental risk is seeded.

Second, our analysis of the potential links between environmental risk and cooperation is built of different blocks than in Fischbacher, Schudy, and Teyssier (2014). They use the within-subject approach and elicit players' conditional contributions to the public good, as well as their unconditional one-shot contributions, in a series of VCM games. Our experimental treatments are implemented in a between-subject manner. Like Fischbacher, Schudy, and Teyssier (2014), we observe conditional and unconditional decisions in a static setting. Moreover, following Fischbacher, Gächter, and Quercia (2012), we enrich this design by adding belief elicitation and a finitely repeated VCM interaction. This refinement allows us to measure how individual beliefs are formed, to establish their link with behavior, and to trace the evolution of cooperation under various environmental risks. To enhance the experimental control, we also collect background information on risk preferences and other-regarding preferences in our experimental sample.

[4]Whether environmental risk is competitive or not may have behavioral consequences. For instance, Krawczyk and Le Lec (2010) study competitive and non-competitive (anologous to our heterougeneous risk) environmental risk in the dictator game. They report that people tend to be less selfish if the realization of outcomes comes with a non-competitive risk; however, both types of riskdecrease transfers as compared to the standard, deterministic dictator game. See also Brock, Lange, and Ozbay (2013); Krawczyk and Lec (2016).

3 Experimental design

3.1 Voluntary Contribution Mechanism

In the classic voluntary contribution mechanisms, a group of N individuals (each endowed with a certain number of tokens e on their private accounts) funds the public good in the following manner. Each individual privately decides on his level of contribution to the public good c (with $c \leq e$) and keeps any tokens which has not been contributed. The public good is defined as a sum of individual contributions, and the marginal per capita return from the public good is $\alpha < 1$. Thus, the payoff of the individual i in this game (denoted π_i) is given as:

$$\pi_i = e_i - c_i + \alpha \times \sum_{j=1}^{N} c_j \tag{1}$$

In this experiment, we are interested in two classic cases: one in which the game is played once, and another in which it is finitely repeated (so that the number of repetitions is public knowledge) in constant groups. In both cases, standard theory (which assumes that all players are self-interested payoff maximizers) suggests that having $\frac{1}{N} < \alpha < 1$ generates a social dilemma. Although the group welfare is maximized when all players make full contributions, the dominant strategy of each individual is to contribute nothing (which leads to the unique Nash equilibrium in a one-shot game, and the subgame perfect Nash equilibrium in a finitely repeated game).

Following the standard design used in numerous VCM experiments, in our baseline condition the value of α is deterministic, homogeneous and publicly known. In our environmental risk treatments (either homogeneous - HomR, or heterogeneous - HetR), MPCR is generated through a mean-preserving. Both α_{HomR} and α_{HetR} are drawn from a binary set $\{\underline{\alpha}, \bar{\alpha}\}$ such that $Pr(\underline{\alpha}) = Pr(\bar{\alpha}) = 0.5$ and $E(\alpha_{HomR}) = E(\alpha_{HetR}) = \alpha$. The rules of this lottery are public knowledge, but its outcome remains unknown in the decision-making stage of the game. Thus, the timing of the events is as follows: first, each player decides about his contribution to the public good; then, the lottery determines his MPCR. The key difference between the two treatments is that α_{HomR} is being drawn for the entire group, whereas α_{HetR} is being drawn independently for each group member. Finally, we set $\frac{1}{N} < \underline{\alpha} < \alpha < \bar{\alpha} < 1$ which guarantees that the social dilemma nature of the game is maintained for all the possible values of MPCR, so that the standard predictions extend to the game played under environmental risk.

3.2 Calibration of the experimental games

In the laboratory experiment, players forms groups of four. Each player is endowed with 10 Experimental Currency Units (ECU) which he allocates (in integer values) between his private account and the public good. In the baseline treatment, each ECU invested in the public good yields the return of 0.4 ECU to every player (which is public knowledge). In the HomR and

HetR treatments, each ECU invested in the public good yields either 0.3 ECU or 0.5 ECU to each player, both outcomes being equally likely. This MPCR scheme is the same as in Fischbacher, Schudy, and Teyssier (2014). The rules of the lottery are publicly known in each treatment, but its outcomes remain unknown when players decide about their contributions.

4 Experimental procedures

212 students (49.53% males, average age 21.5) were recruited using hroot (Bock, Baetge, and Nicklisch, 2014). We had 72 participants (in 18 groups) in both the baseline and the HomR treatments, and 68 participants (in 17 groups) in the HetR treatment.We run a total of 10 experimental sessions in June, September and October 2016 in the GATE-LAB, the experimental laboratory of the GATE Lyon-Saint-Etienne research institute in France. All sessions were computerized using zTree (Fischbacher, 2007). The usual length of an experimental session was one hour. In addition, each session was preceded by a series of online tasks that were administered one week in advance and had to be completed at least 24 hours before the start of the laboratory session. We chose this method to minimize the contamination between the two sets of observations. The average payoff was 14.70 Euros; this amount includes the gains from online tasks, as well as the payoffs earned in the laboratory experiment.

4.1 One week before the experiment: risk preferences and other-regarding preferences

One week before the experimental session, all registered participants received an email with a personal code and a link to two online tasks - the risk preferences test by Gneezy and Potters (1997) and the Social Value Orientation (SVO) Slider Measure by Murphy, Ackermann, and Handgraaf (2011) - to be completed at least 24 hours before the laboratory session.[5] These tasks were incentivized and presented in random order. All payoffs were expressed in Experimental Currency Units (ECU), with 100 ECU being worth 2.50 Euros. Subjects received no immediate feedback about the outcomes, and were paid for each of them at the end of the experimental session in the laboratory.

In the risk preferences test by Gneezy and Potters (1997), a decision-maker is endowed with 100 ECU, some (or all) of which he can invest in the following lottery: 50% chance of multiplying the investment by the factor of 2.5 times, and 50% chance of losing the invested amount. Any decision-maker who does not invest the whole amount is considered as being risk averse, and the invested amount is used as a measure of risk aversion.[6]

[5]These tests were followed by an unrelated psychological questionnaire – the Spitefulness Scale by (Marcus, Zeigler-Hill, Mercer, and Norris, 2014) – so as to cloud the expectations that the participants could have formed about the tasks in the experimental session. Subjects were paid a flat fee of 2 Euros for completing this part.

[6]A potential shortcoming of this method is that it cannot serve to distinguish between risk-neutral and risk-

Table 1: Risk preferences and other-regarding preferences across experimental conditions

	Average outcome			
Measure:	Baseline	HetR	HomR	p
Gneezy-Potters test	56.74	50.90	53.14	0.479 (F-test)
SVO profile:				
Competitive	0	1	0	
Individualistic	39	40	48	0.343 (χ^2 test)
Prosocial	33	27	24	

In the Social Value Orientation (SVO) test by Murphy, Ackermann, and Handgraaf (2011), a decision-maker chooses an allocation of money for himself and for another person amongst 9 possible allocations in 6 different distributional tasks. Then, these choices are transformed into an individual score. We use the original set of distributional tasks (all the amounts are expressed in ECU) and the strategy method to elicit responses in the role of the decision-maker. We collect choices in the role of the decision-maker from all the participants. We also inform them that they will be randomly and anonymously matched in pairs at the end of the experiment, that in each pair one person will be randomly chosen as the decision-maker, and that both players' payoffs from this task will correspond to the decision-maker's choice in a randomly selected task.

Based on our measures of risk preferences and other-regarding preferences, we find that participants are properly randomized with respect to both characteristics. Table 1 summarizes the average scores in the Gneezy-Potters test and the distribution of profiles (as defined by Murphy, Ackermann, and Handgraaf, 2011) in the SVO test. In both cases, we do not reject the null hypothesis that all experimental conditions yield the same outcomes.[7]

4.2 Experimental session: VCM games

The *in situ* stage of the experiment consists of two parts. In each part, we implement a 4-player VCM game, and groups remain constant throughout the experiment (all of which is public knowledge). We use neutral framing: each player can invest a certain amount in a common

averse agents, since both types should invest their whole endowment. However, this does not seem to be a concern in the light of the existing empirical evidence: the fraction of people who invest their whole endowment is fairly small. This is also the case in our experimental sample. See Charness, Gneezy, and Imas (2013) for a related discussion.

[7]Furthermore, for the Gneezy-Potters test we find similar proportions of risk-averse subjects (i.e., those who did not invest their whole endowment) in all conditions: 79.17% in the baseline treatment, 85.29% in HetR and 77.78% in HomR. χ^2 test does not reject the null hypothesis that these outcomes come from the same distribution ($p = 0.491$). Additional non-parametric results are provided in the Appendix B.1.

group project. The common procedures for each part are as follows. The paper instructions are distributed at the begining of each part and read aloud.[8] In the baseline treatment, subjects are also provided with a table that summarizes the individual payoff generated through different combinations of personal and group contributions. In each of the risk treatment, a separate table is provided for both possible values of MPCR. Finally, the participants are asked to take a short quiz of comprehension. After answering any remaining questions, the experimental game begins.

In the first part of the experiment, subjects are endowed with 10 ECU (equivalent of 3 Euros) and their contribution may be any integer value between 0 and 10 ECU. They play the following one-shot VCM game. First, they are asked to make one unconditional contribution without knowing anything about other players' behavior. Then, they provide eleven consecutive conditional contributions, each of them being a response to a possible value of the average contribution from the other group members (which are also integers between 0 and 10 ECU). Following the classic experiment by Fischbacher, Gächter, and Fehr (2001), the rules of the one-shot game guarantee that all choices are incentivized. At the end of the game, one player is selected at random. For the non-selected players, we take into account their unconditional contributions. For the selected player, we take into account his conditional contribution that corresponds to the average unconditional contribution of the remaining players. Then, we also elicit each players' beliefs about the average contribution to the public good of the remaining group members: they can earn 5 ECU for a correct guess (with a 1 ECU margin of error). No feedback (either on the outcoms of the MPCR lottery or about about other players' behavior) is provided at that point.

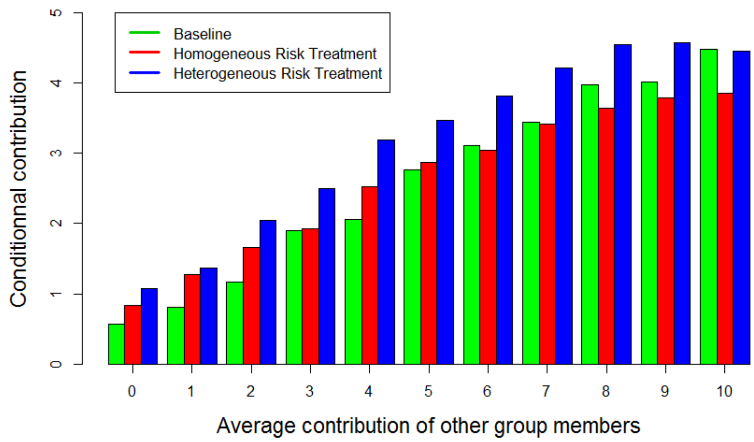
In the second part of the experiment, subjects play a VCM game for 10 rounds in constant groups that have not changed since the previous part (all of which is public knowledge). The renewable endowment in each round is 10 ECU. We provide round-to-round feedback on the individual contribution, the sum of all group members' contributions, the individual return from the group project, the return from the private account, and the individual gain. One round is drawn for payoff at the end of the experiment.

5 Results

In this section, we summarize our main empirical results from the one-shot and finitely repeated VCM games. We show that all outcomes are stable across our experimental conditions, and remain in line with the standard patterns of behavior previously documented in numerous experiments using the standard VCM setting.

[8] These instructions, translated from French to English, are provided in the Appendix A.

Figure 1: Conditional contributions across treatments: whole sample



5.1 Conditional and unconditional contributions in the one-shot VCM

Result 1. The patterns of conditional contributions do not vary significantly across our three experimental conditions.

Support. Figure 1 summarizes the variation of the average conditional contributions in our experimental treatments. In all three treatments, conditional contributions follow a standard pattern: they tend to increase in the value of the other group members' average contribution, but are far from reaching it. Moreover, F-test does not reject the null hypothesis that the average conditional contributions are the same in all three treatments for almost every value of other group members' average contribution. The sole exceptions are the values of 2 ($p = 0.048$) and 4 ($p = 0.031$); however, this result does not survive the Bonferroni correction for multiple comparisons. Therefore, we conclude that conditional contributions do not vary significantly across our treatments.[9]

Furthermore, in all treatments we find a similar scope of pure free-riding (that is, contributing zero regardless of what others do): 27.78% in the baseline treatment, 19.12% in HetR and 33.33% in HomR. χ^2 test does not reject the null hypothesis that these outcomes come from the same distribution ($p = 0.162$). The mean patterns of conditional contributions after excluding those players (Figure 2) remain unchanged.[10]

[9] Additional non-parametric results are provided in the Appendix B.2.

[10] Once again, we do not detect any significant differences between the mean outcomes observed in the three treatments. The mean conditional contribution associated with the other group members' average contribution of 2 and 4 are (weakly) significantly different ($p = 0.058$ and $p = 0.037$, respectively), but this result does not survive the application of the Bonferroni correction.

Figure 2: Conditional contributions across treatments: free-riders excluded

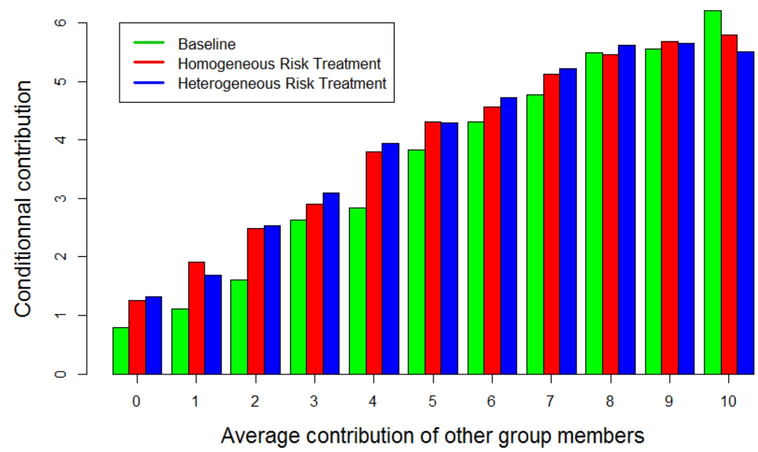


Table 2: Unconditional contributions and beliefs across experimental conditions

	Average			
Measure:	Baseline	HetR	HomR	p
Unconditional contribution	3.60	4.06	4.26	0.445
Beliefs about others	4.40	4.78	4.48	0.584
Pearson's r	0.448	0.557	0.684	0.117

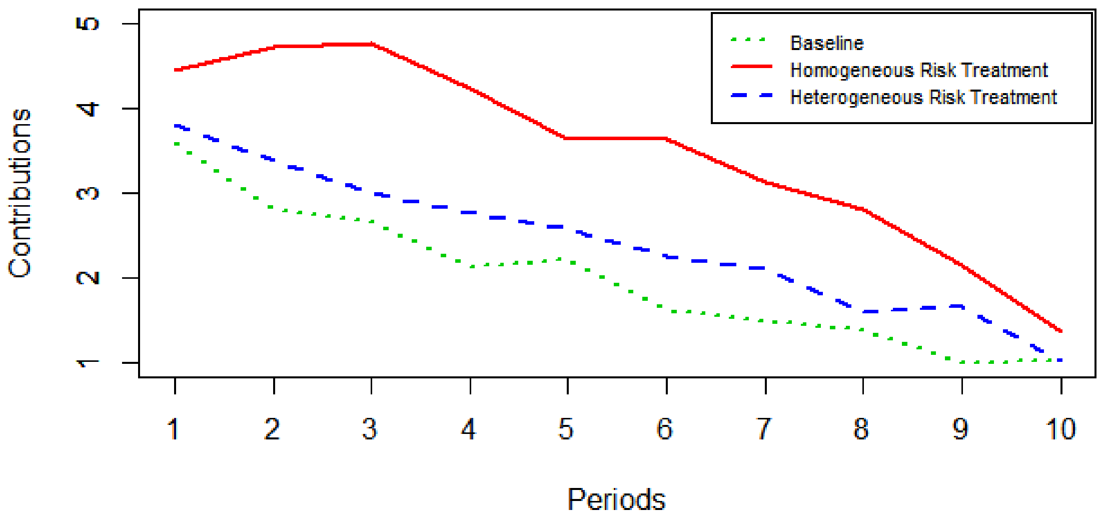
Note. p-values correspond to F-test for the equality of means scores (lines 1 and 2), or to Jennrich's test for correlation coefficients (line 3; all coefficients are significantly different to zero at the 1% level).

Result 2. Neither the unconditional contributions, nor the beliefs about other players' behavior, nor the correlation between these two outcomes vary significantly across our experimental conditions.

Support. Table 2 summarizes the average unconditional contributions and the beliefs about other players' behavior in each experimental treatment. F-test does not reject the null hypothesis that the average unconditional contributions are the same in all experimental conditions. We report the same outcome when testing for the symmetry of beliefs across treatments. Finally, in all treatments we find a strong and positive correlation between unconditional contributions and beliefs: all correlation coefficients are found to be statistically significant at the 1% level, but not statistically different one from another (Jennrich's test yields $p = 0.117$). Additional non-parametric results are provided in the Appendix B.3.

Our Result 2 echoes the previous findings from VCM experiments (see, for instance, Weimann, 1994; Croson, 1996; Neugebauer, Perote, Schmidt, and Loos, 2009; Fischbacher and Gächter, 2010) that (i) the beliefs about others' contributions tend to be above the individual contribution levels,

Figure 3: Dynamics of cooperation across treatments: mean contributions



and that (*ii*) these two variables are positively correlated.

5.2 Cooperation in the repeated VCM

So far, we have presented systematic evidence suggesting that the environmental risk does not affect the patterns of contributions observed in the static VCM. In this part, we turn to investigating the effects of environmental risk in the dynamic setting of a finitely repeated VCM.[11]

Figure 3 depicts the dynamics of mean contributions in the repeated VCM games. Once again, we observe standard patterns of behavior. In all three treatments, the initial contributions are relatively high (around 40% of the endowment on average), and then collapse, reaching similar levels (around 10% of the endowment on average) in the final (tenth) round of the game. The curves from the baseline treatment and the HetR treatment have similar slopes and run closely to each other in a standard manner. In both cases, we observe a steady fall of contributions over time. The evolution of cooperation in the HomR treatment is slightly different: players manage to maintain cooperation in the first three rounds of the game, but then it collapses exactly as in the

[11] Players' choices in the first round of the repeated VCM game are consistent with their unconditional contributions in the static VCM game. For all treatments, two-sided paired t-test does not reject the null hypothesis that the mean difference between the two contributions equals zero. The results are as follows. Baseline treatment: mean unconditional one-shot contribution of 3.60 vs. mean round 1 contribution of 3.60 ($p = 1.000$); HetR: 3.81 vs. 4.06 ($p = 0.534$); HomR: 4.44 vs. 4.26 ($p = 0.634$). Non-parametric signed-rank test yields consistent results.

remaining treatments. Due to this early-stage gap, the average contribution in that treatment is found to be higher than elsewhere. We remain cautious about this result and do not overstate its importance, given that it only stems from an early and fugitive deviation from the usual dynamics of cooperation. Rather, we interpret it as evidence that homogeneous environmental risk does not decrease contributions to the public good.

Below, we summarize these findings and provide their statistical support. The statistical analysis is based on the regression models presented in Table 3.[12] In models M1-M3, we regress individual contributions on treatment dummies (one for HomR and one for HetR) using different sets of observations: round 1 observations (M1), round 10 observations (M2), or all observations (M3). Model M4 extends M3 by additionally incorporating round dummies (representing rounds 2-3, 4-5, 6-7, 8-9, and 10) as well as their interactions with the treatment dummies. To account for the potential within-group correlation of observations due to repeated interactions, the residuals are clustered as the group level in models M2-M4 (there are 53 clusters in total), and the delete-one-jackknife resampling procedure is applied to estimate standard errors so as to account for the potential small sample bias.[13].

Result 3. We find no differences across treatments both in the first round and in the final round average contributions in the repeated VCM game.

Support. This result stems from the regression models M1 and M2 summarized in the first two columns of Table 3. In both models, treatment dummies are neither individually nor jointly significant at the conventional levels.

Result 4. The overall average contribution is higher in the HomR treatment than in the remaining experimental conditions. However, this difference is mostly driven by a transient variation at an early stage of the game: players in the HomR treatment manage to maintain cooperation in the first three rounds of the game, while the decay of cooperation is triggered instantaneously in other conditions.

Support. This result stems from the regression models M3 and M4 summarized in columns 3 and 4 of Table 3. Model M3 suggests that the aggregate average contribution in HomR is significantly different than in the baseline treatment ($p = 0.006$) and in the HetR treatment ($p = 0.047$). However, model M4 indicates that these differences are mainly driven by different dynamics in rounds 1 to 3. First, the model confirms that contributions in the baseline treatment decrease over time in a monotone way: the coefficients β_3 to β_7 are all significant and we strongly reject the null hypothesis of their equality ($p < 0.001$). The insignificance of coefficients β_{13} to β_{17}, in turn, suggests that this pattern is preserved in the HetR treatment. However, the same cannot be said about the HomR treatment. The significance and the size of coefficient β_8, coupled with the insignificance of coefficients β_9 to β_{12}, points to the conclusion that the treatment effect reported

[12] Additional non-parametric results are provided in the Appendix B.4 and B.5. Furthermore, double-censored tobit regressions yield equivalent results. These additional estimates are provided in the Appendix C.

[13] See Jacquemet and Zylbersztejn (2014) for a detailed description of this procedure

Table 3: The patterns of cooperation over time and across treatments: regression analysis

	Dep. variable: contribution in round t			
Model:	M1	M2	M3	M4
Observations:	$t = 1$	$t = 10$	$t \in \{1; 10\}$	$t \in \{1; 10\}$
Intercept (β_0)	3.597^a	1.014^a	1.989^a	3.597^a
	(0.376)	(0.325)	(0.275)	(0.342)
$1[HomR]$ (β_1)	0.847	0.347	1.497^a	0.847
	(0.532)	(0.518)	(0.519)	(0.528)
$1[HetR]$ (β_2)	0.212	0.016	0.429	0.212
	(0.540)	(0.477)	(0.398)	(0.438)
$1[round2-3]$ (β_3)				-0.861^b
				(0.356)
$1[round4-5]$ (β_4)				-1.431^a
				(0.355)
$1[round6-7]$ (β_5)				-2.049^a
				(0.374)
$1[round8-9]$ (β_6)				-2.410^a
				(0.399)
$1[round10]$ (β_7)				-2.583^a
				(0.437)
$1[round2-3] \times 1[HomR]$ (β_8)				1.160^b
				(0.480)
$1[round4-5] \times 1[HomR]$ (β_9)				0.917
				(0.636)
$1[round6-7] \times 1[HomR]$ (β_{10})				0.986
				(0.690)
$1[round8-9] \times 1[HomR]$ (β_{11})				0.438
				(0.684)
$1[round10] \times 1[HomR]$ (β_{12})				-0.500
				(0.681)
$1[round2-3] \times 1[HetR]$ (β_{13})				0.243
				(0.446)
$1[round4-5] \times 1[HetR]$ (β_{14})				0.291
				(0.498)
$1[round6-7] \times 1[HetR]$ (β_{15})				0.416
				(0.538)
$1[round8-9] \times 1[HetR]$ (β_{16})				0.233
				(0.519)
$1[round10] \times 1[HetR]$ (β_{17})				-0.196
				(0.534)
N	212	212	2120	2120
R^2	0.013	0.004	0.041	0.122
$Prob > F$	0.256	0.769	0.021	< 0.001

Note. a/b indicate statistical significance at the 1%/5% level. In all models, the set of explanatory variables includes treatment dummies. In M4, it also includes (pairwise) round dummies and their interactions with treatment dummies. In M2-M4, residuals are clustered at the group level (53 clusters), standard errors are computed using the leave-one-out jackknife procedure.

in model M3 is merely due to the fact that the decay of cooperation in the HomR treatment is delayed by two rounds relative to the baseline and HetR treatment.[14]

5.3 Additional robustness analysis

In the last set of regressions, we investigate the link between the exposure to random realizations of MPCR in the past and present contribution decisions. Clearly, a rational decision-maker should not condition his future choices on any random outcomes observed in the past. However, an important body of behavioral research has documented that in many contexts (such as lotteries or sports betting) people may misperceive randomness and make biased choices, for instance by following the "law of small numbers" (see Rabin, 2002). In this part, we want to show that our results are not driven by this kind of misperception of randomness in the game.

For each treatment, we estimate a regression model that explains individual contribution at time t with the following set of variables. To integrate information about one's past experience with random MPCR, we include a dummy variable indicating whether the realization MPCR in $t-1$ was high ($1[\bar{\alpha}_{t-1}] = 1$) or low ($1[\bar{\alpha}_{t-1}] = 0$). Then, we also take into account the relative frequency of high MPCR in all rounds preceding $t-1$ (variable $Freq(\bar{\alpha})_{(1;t-2)}$), as well as an interaction between these two variables. Finally, we account for the general decay of contributions over time by adding round dummies. This model is estimated separately for each of the environmental risk treatments. The results of this exercise are presented in Table 4. None of the coefficients γ_1 to γ_3 is found to be significant at the conventional levels in either model. This suggests that players' decisions are not biased by the past realizations of random MPCR.

6 Concluding remarks

This paper offers a novel study of the effects of environmental risk on cooperation in the VCM game. Our main result is that moving from the standard environment with a deterministic MPCR to the environments in which MPCR is risky does not deteriorate cooperation.

More generally, this study extends the previous literature and furthers our understanding of the effects of environmental randomness on cooperation in the following ways. First, the behavioral

[14]One might suspect that this short-lived bloom of cooperation in HomR may be driven by "lucky" outcomes of the MPCR lottery. However, descriptive statistics from rounds 1 and 2 do not support the hypothesis that "lucky" groups feel more encouraged to cooperate than the "unlucky" ones. To see this, let us compare the evolution of contributions between rounds 1 and 2 in those groups that experienced $\bar{\alpha}$ in $t = 1$ (12 groups, 48 subjects) with those that experienced $\underline{\alpha}$ in $t = 1$ (6 groups, 24 subjects). Not surprisingly, in both groups we observe similar average contributions in $t = 1$ (4.563 and 4.208, respectively) in which decisions are made before the first MPCR lottery takes place. Then, these contribution levels are maintained in $t = 2$ regardless of the the value of α drawn for those groups in the previous round (4.958 and 4.250, respectively). Therefore, groups do not seem to condition their behavior in $t = 2$ on the realization of α in $t = 1$. Related evidence is provided in Table 4.

Table 4: Present contributions and random MPCR in the past: regression analysis

	Dep. variable: contribution in round t	
Treatment:	HetR	HomR
Intercept (γ_0)	2.323^a	4.554^a
	(0.571)	(1.130)
$1[\bar{\alpha}_{t-1}]$ (γ_1)	0.314	-0.605
	(0.442)	(0.786)
$Freq(\bar{\alpha})_{(1;t-2)}$ (γ_2)	0.690	0.574
	(0.616)	(1.356)
$1[\bar{\alpha}_{t-1}] \times Freq(\bar{\alpha})_{(1;t-2)}$ (γ_3)	0.463	0.390
	(0.847)	(1.777)
Round (dummy variables):		
4 (γ_4)	-0.210	-0.448
	(0.309)	(0.440)
5 (γ_5)	-0.413	-1.090
	(0.288)	(0.590)
6 (γ_6)	-0.665	-1.099
	(0.449)	(0.606)
7 (γ_7)	-0.889	-1.599^b
	(0.485)	(0.705)
8 (γ_8)	-1.331^b	-1.858^b
	(0.475)	(0.654)
9 (γ_9)	-1.259^a	-2.505^a
	(0.270)	(0.782)
10 (γ_{10})	-1.914^a	-3.290^a
	(0.279)	(0.746)
N	544	576
R^2	0.070	0.091
$Prob > F$	< 0.001	0.010

Note. a/b indicate statistical significance at the 1%/5% level. Observations come from rounds 3-10. Residuals are clustered at the group level (17 clusters in HetR, 18 clusters in HomR), standard errors are computed using the leave-one-out jackknife procedure.

reaction to environmental risk seems to be different for competitive and non-competitive risks. In the light of the combined evidence from Fischbacher, Schudy, and Teyssier (2014) (in which the risk involves within-group competition) and our study (in which the calibration of the VCM game is the same, but the risk, whether homogeneous or heterogeneous, always has a non-competitive nature), it seems that the presence of competition might be detrimental for cooperation under environmental risk. This observation echoes the previous work by Krawczyk and Le Lec (2010) who show that competition undermines sharing in the dictator games with risky outcomes. Put together, this body of evidence suggests that social interactions under risk are sensitive to competition which may partially mute other-regarding concerns.

Second, our study contributes to the recent experimental investigations of the effects of environmental randomness on the provision of public goods. Together with the recent studies by Levati and Morone (2013), Boulu-Reshef, Brott, Zylbersztejn, et al. (2016) and Björk, Kocher, Martinsson, Nam Khanh, et al. (2016), the results of our experiment point to the robustness of the standard patterns of cooperation not only across different domains of (non-competitive) risk, but also across different domains of (non-competitive) randomness: risk, ambiguity and uncertainty.

Altogether, we find strong support for the "gold standard" approach to studying human cooperation by means of the Voluntary Contribution Mechanism paradigm in which the marginal per capita return from the public good is deterministic, homogeneous and publicly known. We reckon that standard methodology provides a robust and conservative measure of human cooperation.

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A Experimental instructions (translated from French)

Instructions: Baseline Treatment

Thank you for participating to this experiment in economics. Please turn off your phone and do not communicate with the others unless we ask you to. If you have any questions, you can press the red button at the left of your desk at any time, we will come to answer you in private.
During this experiment, you are going to make decisions. These decisions can make you earn money. During the whole experiment, we will not talk about Euros, but about Experimental Currency Units (ECU). Your earnings will be computed in ECU, then converted in Euros at the time of the payment. The conversion rate is the following: 10 ECU = 3 Euro. At the end of the session, you will receive your payment. You will be paid in Euros, in cash and in private in a separated room.
This session comprises 2 parts. Your total gain for this session will be the sum of your gains in both parts. The instructions below describe the content of Part 1. The instructions for Part 2 will be distributed at the end of Part 1. During the whole session, your decisions are anonymous.
Preliminary part:
In order to match your answers of the online questionnaire and your answers at this session, please indicate the code we sent you by mail. If you have doubts, please press the red button on the left-hand side of your desk.
Instructions for Part 1:
In this first part, the computer program will randomly form groups of 4 people. At the beginning of the part, each member of the group has 10 ECU. Each group member can invest a part of this amount in a common group project. The amount must be between 0 and 10 ECU. Then the sum of the amounts invested in the common project is multiplied by 1.6 and equally redistributed between the 4 group members. For all the group members, the amount that is not invested in the common project is stored on a personal account. Thus, if a group member stores X ECU on his/her personal account, he/she will recover exactly X ECU.
Your gain is computed in the following way:

$$\text{Your gain} = [10 - (\text{amount invested})] + \frac{1,6 \times \text{sum of amounts invested}}{4} \tag{2}$$

Your task consists in (i) choosing successively 2 "types of amount" that you wish to invest in the common project and (ii) estimating the amount invested by the other group members.

- On the first screen, you need to enter an "unconditional amount". This is the amount you want to invest in the common project independently of the amounts invested by the 3 other group members. Once this amount is chosen, confirm by clicking on the OK button.
- On the second screen, you need to enter "conditional amounts". These are the amounts you want to invest for each average amount invested by your group members. Once these amounts are chosen, confirm by clicking on the OK button.
- On the third screen, you need to estimate what will be the average amount invested in the project by your three group members.

How is your gain computed?
The computer program will randomly select a member of your group:

- If you are not the randomly selected group member, the amount taken into account to compute your gain will be your unconditional amount.
- If you are the randomly selected group member, the amount taken into account to compute your gain will be the conditional amount corresponding to the average of the unconditional amounts of your 3 group members, rounded up to the nearest whole number.

If you estimate exactly the average amount plus or minus 1 ECU, you will receive 5 ECU. Otherwise, you will not receive anything. You will be informed about your earnings for this part at the end of the experiment.
Note that the conditional and unconditional amounts can have an impact on your payment.
The table displayed in these instructions shows your gain in ECU depending on your level of contribution to the project as well as the average level of contribution of your group members.
Before beginning Part 1, you have to reply to a questionnaire that will be distributed.
Please read these instructions again. If you have any questions, please push the red button on the left-hand side of your desk and we will come to answer you in private.

		Average contribution of other group members										
		0	1	2	3	4	5	6	7	8	9	10
	0	10	11.2	12.4	13.6	14.8	16	17.2	18.4	19.6	20.8	22
	1	9.4	10.6	11.8	13	14.2	15.4	16.6	17.8	19	20.2	21.4
	2	8.8	10	11.2	12.4	13.6	14.8	16	17.2	18.4	19.6	20.8
	3	8.2	9.4	10.6	11.8	13	14.2	15.4	16.6	17.8	19	20.2
	4	7.6	8.8	10	11.2	12.4	13.6	14.8	16	17.2	18.4	19.6
Your contribution	5	7	8.2	9.4	10.6	11.8	13	14.2	15.4	16.6	17.8	19
	6	6.4	7.6	8.8	10	11.2	12.4	13.6	14.8	16	17.2	18.4
	7	5.8	7	8.2	9.4	10.6	11.8	13	14.2	15.4	16.6	17.8
	8	5.2	6.4	7.6	8.8	10	11.2	12.4	13.6	14.8	16	17.2
	9	4.6	5.8	7	8.2	9.4	10.6	11.8	13	14.2	15.4	16.6
	10	4	5.2	6.4	7.6	8.8	10	11.2	12.4	13.6	14.8	16

Table 1: Your gain depending on your contribution and on the average contribution of your three group members when the multiplier factor is equal to 1.6

Instructions for Part 2: This part lasts 10 periods.

During this whole part, you belong to the same group as in Part 1. At the beginning of each period, each group member has 10 ECU. Each group member can invest a part of this amount in a common group project. The amount must be between 0 and 10 ECU. Then the sum of the amounts invested in the common project is multiplied by 1.6 and equally redistributed between the 4 group members. For all the group members, the amount that is not invested in the common project is stored on a personal account. Thus, if a group member stores X ECU on his/her personal account, he/she will recover exactly X ECU.

Your gain is computed in the following way:

$$\text{Your gain} = [10 - (\text{amount invested})] + \frac{1,6 \times \text{sum of amounts invested}}{4} \tag{3}$$

At the end of each period, each group member receives information about his/her level of contribution to the project, the total amount invested by the group members, the return of the project, the return of his/her personal account, as well as his/her gain.

How is your gain computed?

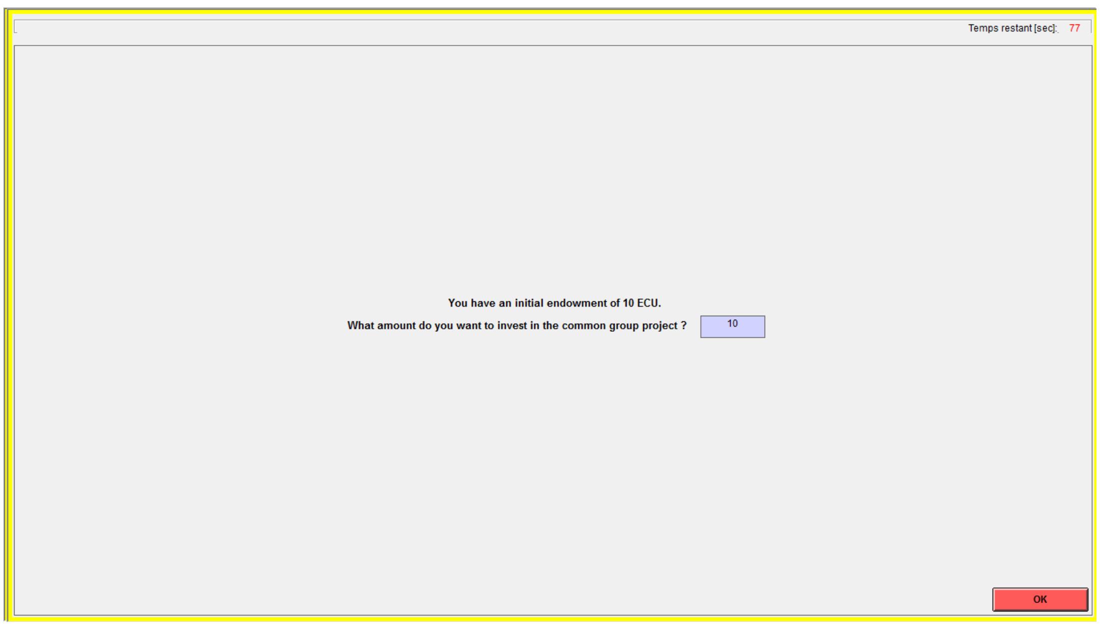
For this part, one period will be randomly selected and gains will be added to the gains of Part 1.

Please read these instructions again. If you have any questions, please push the red button on the left-hand side of your desk and we will come to answer you in private.

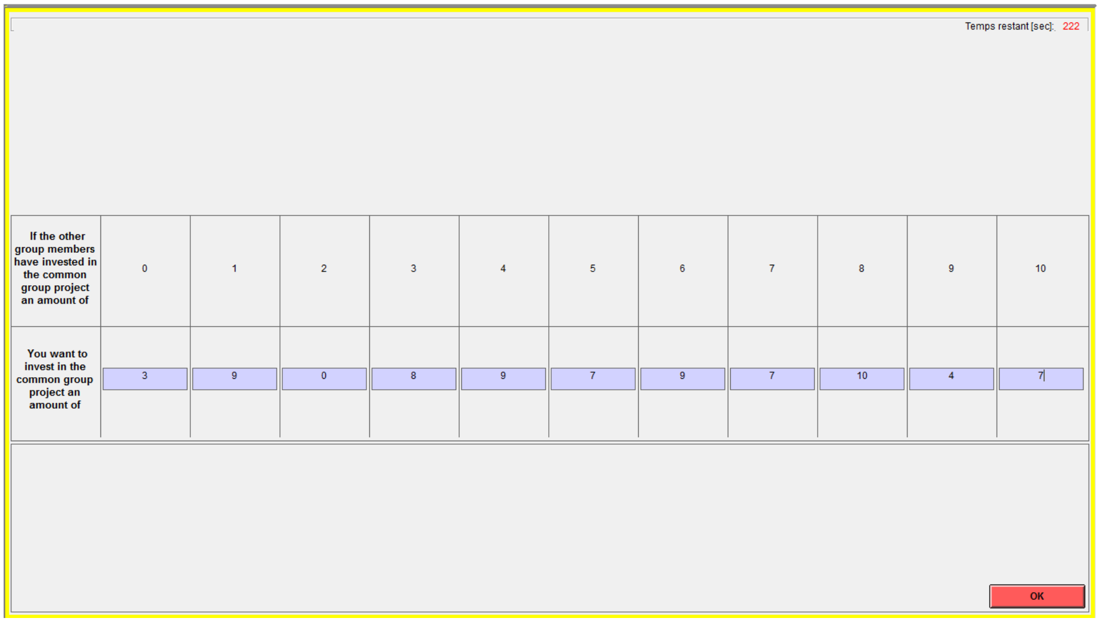
Questionnaire:

1. How many group members do you have?
   - 1
   - 2
   - 3
   - 4
2. After drawing lots, the average contribution of the other group members is equal to 5 ECU. Compute your profit if your finale contribution is:
   - 0 ECU
   - 5 ECU
   - 10 ECU

   In the following questions, we consider some randomly obtained amounts of a fictional participant.



Screen 1: Unconditional amount



Screen 2: Conditional amounts

Screen 3: Estimation of the contributions

3. Suppose that the participant is randomly selected and that the average contribution of the other members is equal to 6.6 ECU. Which amount will be selected for his/her contribution?

   - 9
   - 7
   - 5
   - 10

4. Suppose that the participant is not randomly selected and that the average contribution of the other group members is equal to 6.6 ECU. Which amount will be selected for his/her contribution?

   - 9
   - 7
   - 5
   - 10

5. The average contribution of the other group members is equal to 6.6 ECU. Did the participant earn the 5 ECU that depend on his/her estimation concerning the average level of contribution of his/her group members?

   - Yes
   - No

Instructions: Homogeneous Risk Treatment

Thank you for participating to this experiment in economics. Please turn off your phone and do not communicate with the others unless we ask you to. If you have any questions, you can press the red button at the left of your desk at any time, we will come to answer you in private.
During this experiment, you are going to make decisions. These decisions can make you earn money. During the whole experiment, we will not talk about Euros, but about Experimental Currency Units (ECU). Your earnings will be computed in ECU, then converted in Euros at the time of the payment. The conversion rate is the following: 10 ECU = 3 Euro.
At the end of the session, you will receive your payment. You will be paid in Euros, in cash and in private in a separated room.
This session comprises 2 parts. Your total gain for this session will be the sum of your gains in both parts. The instructions below describe the content of Part 1. The instructions for Part 2 will be distributed at the end of Part 1. During the whole session, your decisions are anonymous.

Preliminary part:
In order to match your answers of the online questionnaire and your answers at this session, please indicate the code we sent you by mail. If you have doubts, please press the red button on the left-hand side of your desk.
Instructions for Part 1:
In this first part, the computer program will randomly form groups of 4 people. At the beginning of the part, each member of the group has 10 ECU. Each group member can invest a part of this amount in a common group project. The amount must be between 0 and 10 ECU. Then the sum of the amounts invested in the common project is multiplied either by 1.2 or by 2 (each possibility has a 50% chance to be realized) and equally redistributed between the 4 group members.
For all the group members, the amount that is not invested in the common project is stored on a personal account. Thus, if a group member stores X ECU on his/her personal account, he/she will recover exactly X ECU.
Your gain is computed in the following way:

$$\text{Your gain} = [10 - (\text{amount invested})] + \frac{r \times \text{sum of amounts invested}}{4} \tag{4}$$

where r is the multiplier factor of the common project and is worth either 1.2 or 2 depending on the outcome of the random draw.
Your task consists in (i) choosing successively 2 "types of amount" that you wish to invest in the common project and (ii) estimating the amount invested by the other group members.

- On the first screen, you need to enter an "unconditional amount". This is the amount you want to invest in the common project independently of the amounts invested by the 3 other group members. Once this amount is chosen, confirm by clicking on the OK button.
- On the second screen, you need to enter "conditional amounts". These are the amounts you want to invest for each average amount invested by your group members. Once these amounts are chosen, confirm by clicking on the OK button.

- On the third screen, you need to estimate what will be the average amount invested in the project by your three group members.

How is your gain computed?
The computer program will randomly select a member of your group:

- If you are not the randomly selected group member, the amount taken into account to compute your gain will be your unconditional amount.
- If you are the randomly selected group member, the amount taken into account to compute your gain will be the conditional amount corresponding to the average of the unconditional amounts of your 3 group members, rounded up to the nearest whole number.

If you estimate exactly the average amount plus or minus 1 ECU, you will receive 5 ECU. Otherwise, you will not receive anything. You will be informed about your earnings for this part at the end of the experiment.
Note that the conditional and unconditional amounts can have an impact on your payment.
The table displayed in these instructions shows your gain in ECU depending on your level of contribution to the project as well as the average level of contribution of your group members.
Before beginning Part 1, you have to reply to a questionnaire that will be distributed.
Please read these instructions again. If you have any questions, please push the red button on the left-hand side of your desk and we will come to answer you in private.

Average contribution of other group members												
		0	1	2	3	4	5	6	7	8	9	10
Your contribution	0	10	10.9	11.8	12.7	13.6	14.5	15.4	16.3	17.2	18.1	19
	1	9.3	10.2	11.1	12	12.9	13.8	14.7	15.6	16.5	17.4	18.3
	2	8.6	9.5	10.4	11.3	12.2	13.1	14	14.9	15.8	16.7	17.6
	3	7.9	8.8	9.7	10.6	11.5	12.4	13.3	14.2	15.1	16	16.9
	4	7.2	8.1	9	9.9	10.8	11.7	12.6	13.5	14.4	15.3	16.2
	5	6.5	7.4	8.3	9.2	10.1	11	11.9	12.8	13.7	14.6	15.5
	6	5.8	6.7	7.6	8.5	9.4	10.3	11.2	12.1	13	13.9	14.8
	7	5.1	6	6.9	7.8	8.7	9.6	10.5	11.4	12.3	13.2	14.1
	8	4.4	5.3	6.2	7.1	8	8.9	9.8	10.7	11.6	12.5	13.4
	9	3.7	4.6	5.5	6.4	7.3	8.2	9.1	10	10.9	11.8	12.7
	10	3	3.9	4.8	5.7	6.6	7.5	8.4	9.3	10.2	11.1	12

Table 1: Your gain depending on your contribution and on the average contribution of your three group members when the multiplier factor is equal to 1.2

Average contribution of other group members												
		0	1	2	3	4	5	6	7	8	9	10
Your contribution	0	10	11.5	13	14.5	16	17.5	19	20.5	22	23.5	25
	1	9.5	11	12.5	14	15.5	17	18.5	20	21.5	23	24.5
	2	9	10.5	12	13.5	15	16.5	18	19.5	21	22.5	24
	3	8.5	10	11.5	13	14.5	16	17.5	19	20.5	22	23.5
	4	8	9.5	11	12.5	14	15.5	17	18.5	20	21.5	23
	5	7.5	9	10.5	12	13.5	15	16.5	18	19.5	21	22.5
	6	7	8.5	10	11.5	13	14.5	16	17.5	19	20.5	22
	7	6.5	8	9.5	11	12.5	14	15.5	17	18.5	20	21.5
	8	6	7.5	9	10.5	12	13.5	15	16.5	18	19.5	21
	9	5.5	7	8.5	10	11.5	13	14.5	16	17.5	19	20.5
	10	5	6.5	8	9.5	11	12.5	14	15.5	17	18.5	20

Table 2: Your gain depending on your contribution and on the average contribution of your three group members when the multiplier factor is equal to 2

Instructions for Part 2: This part lasts 10 periods.
During this whole part, you belong to the same group as in Part 1. At the beginning of each period, each group member has 10 ECU. Each group member can invest a part of this amount in a common group project. The amount must be between 0 and 10 ECU. Then the sum of the amounts invested in the common project is multiplied either by 1.2 or by 2 (each possibility has a 50% chance to be realized) and equally redistributed between the 4 group members.
For all the group members, the amount that is not invested in the common project is stored on a personal account. Thus, if a group member stores X ECU on his/her personal account, he/she will recover exactly X ECU.
Your gain is computed in the following way:

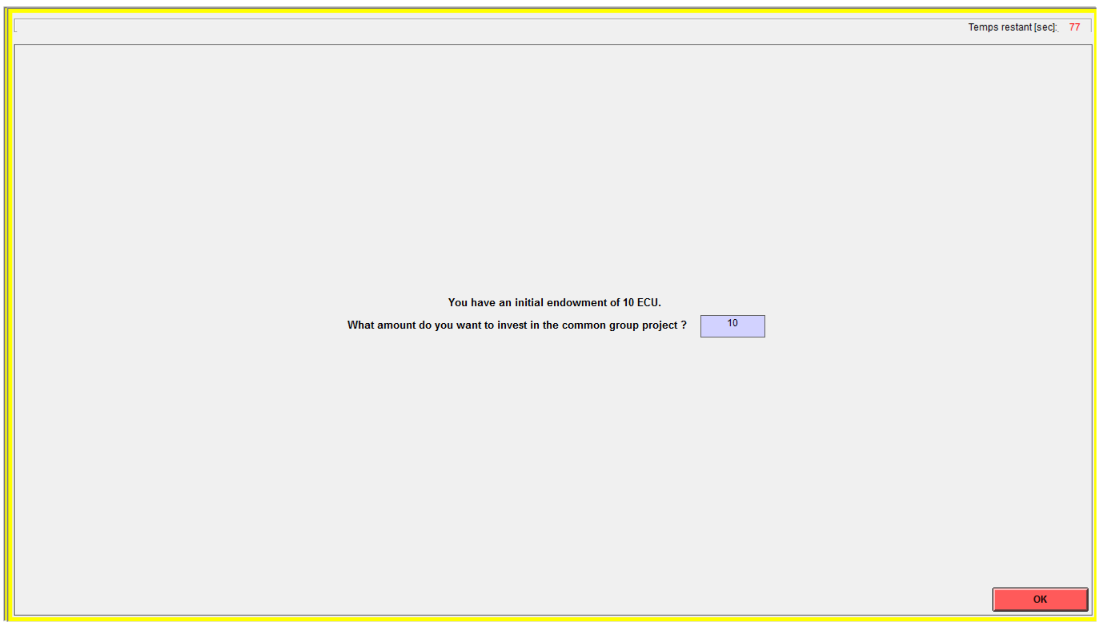
$$\text{Your gain} = [10 - (\text{amount invested})] + \frac{r \times \text{sum of amounts invested}}{4} \qquad (5)$$

where r is the multiplier factor of the common project and is worth either 1.2 or 2 depending on the outcome of the random draw.
Your task consists in choosing the amount you want to invest in the common project.
At the end of each period, each group member receives information about his/her level of contribution to the project, the total amount invested by the group members, the return of the project, the return of his/her personal account, as well as his/her gain.
How is your gain computed?
For this part, one period will be randomly selected and gains will be added to the gains of Part 1.
Please read these instructions again. If you have any questions, please push the red button on the left-hand side of your desk and we will come to answer you in private.

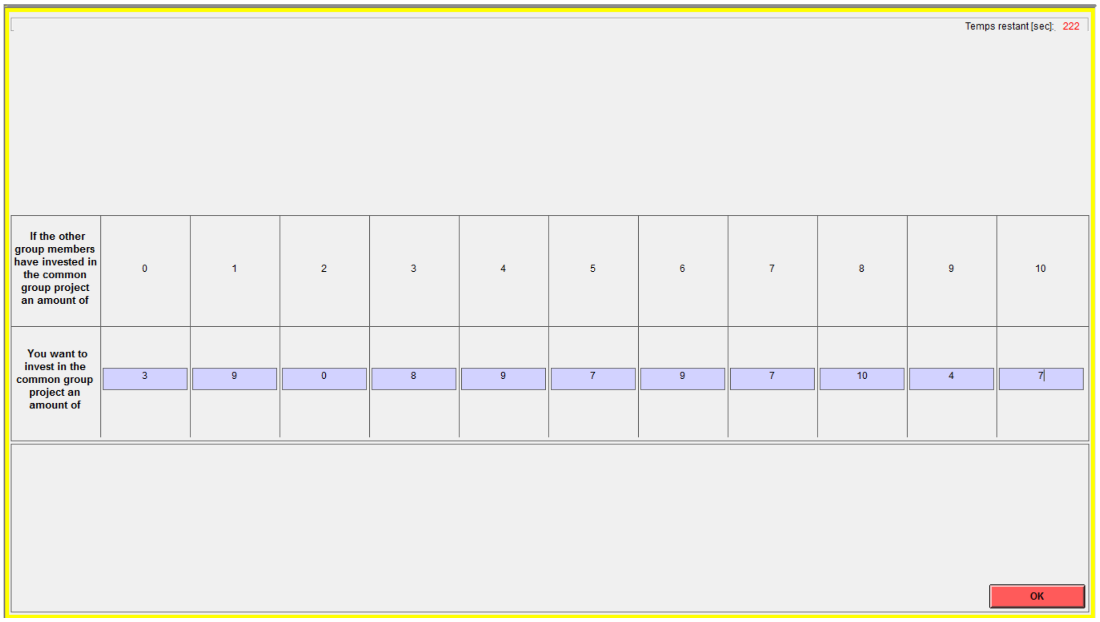
Questionnaire:

1. How many group members do you have?
   - 1
   - 2
   - 3
   - 4
2. The average contribution of your three group members is equal to 5 ECU. Compute your profit if your finale contribution is 7:
   - If the sum of amounts invested in the common project has been multiplied by 1.2
   - If the sum of amounts invested in the common project has been multiplied by 2

   In the following questions, we consider some randomly obtained amounts of a fictional participant.



Screen 1: Unconditional amount



Screen 2: Conditional amounts

Screen 3: Estimation of the contributions

3. Suppose that the participant is randomly selected and that the average contribution of the other members is equal to 6.6 ECU. Which amount will be selected for his/her contribution?

   - 9
   - 7
   - 5
   - 10

4. Suppose that the participant is not randomly selected and that the average contribution of the other group members is equal to 6.6 ECU. Which amount will be selected for his/her contribution?

   - 9
   - 7
   - 5
   - 10

5. The average contribution of the other group members is equal to 6.6 ECU. Did the participant earn the 5 ECU that depend on his/her estimation concerning the average level of contribution of his/her group members?

   - Yes
   - No

Instructions: Heterogeneous Risk Treatment

Thank you for participating to this experiment in economics. Please turn off your phone and do not communicate with the others unless we ask you to. If you have any questions, you can press the red button at the left of your desk at any time, we will come to answer you in private.

During this experiment, you are going to make decisions. These decisions can make you earn money. During the whole experiment, we will not talk about Euros, but about Experimental Currency Units (ECU). Your earnings will be computed in ECU, then converted in Euros at the time of the payment. The conversion rate is the following: 10 ECU = 3 Euro.

At the end of the session, you will receive your payment. You will be paid in Euros, in cash and in private in a separated room.

This session comprises 2 parts. Your total gain for this session will be the sum of your gains in both parts. The instructions below describe the content of Part 1. The instructions for Part 2 will be distributed at the end of Part 1. During the whole session, your decisions are anonymous.

Preliminary part:

In order to match your answers of the online questionnaire and your answers at this session, please indicate the code we sent you by mail. If you have doubts, please press the red button on the left-hand side of your desk.

Instructions for Part 1:

In this first part, the computer program will randomly form groups of 4 people. At the beginning of the part, each member of the group has 10 ECU. Each group member can invest a part of this amount in a common group project. The amount must be between 0 and 10 ECU. Once every group member has chosen the amount he/she wants to invest in the common project, a random draw determines the return of the project for each group member. Each group member has a 50% chance to receive either the equivalent of 30% of the total amount invested in the common project, or the equivalent of 50% of the total amount invested in the common project. This random draw is individual for each group member. Thus, the outcomes of the random draw may differ across the members of a group.

For all the group members, the amount that is not invested in the common project is stored on a personal account. Thus, if a group member stores X ECU on his/her personal account, he/she will recover exactly X ECU.

Your gain is computed in the following way:

$$\text{Your gain} = [10 - (\text{amount invested})] + p \times \text{sum of amounts invested} \quad (6)$$

where p is worth either 30% or 50% depending on the outcome of the random draw.

Your task consists in (i) choosing successively 2 "types of amount" that you wish to invest in the common project and (ii) estimating the amount invested by the other group members.

- On the first screen, you need to enter an "unconditional amount". This is the amount you want to invest in the common project independently of the amounts invested by the 3 other group members. Once this amount is chosen, confirm by clicking on the OK button.
- On the second screen, you need to enter "conditional amounts". These are the amounts you want to invest for each average amount invested by your group members. Once these amounts are chosen,

confirm by clicking on the OK button.

- On the third screen, you need to estimate what will be the average amount invested in the project by your three group members.

How is your gain computed?
The computer program will randomly select a member of your group:

- If you are not the randomly selected group member, the amount taken into account to compute your gain will be your unconditional amount.
- If you are the randomly selected group member, the amount taken into account to compute your gain will be the conditional amount corresponding to the average of the unconditional amounts of your 3 group members, rounded up to the nearest whole number.

If you estimate exactly the average amount plus or minus 1 ECU, you will receive 5 ECU. Otherwise, you will not receive anything. You will be informed about your earnings for this part at the end of the experiment.
Note that the conditional and unconditional amounts can have an impact on your payment.
The table displayed in these instructions shows your gain in ECU depending on your level of contribution to the project as well as the average level of contribution of your group members.
Before beginning Part 1, you have to reply to a questionnaire that will be distributed.
Please read these instructions again. If you have any questions, please push the red button on the left-hand side of your desk and we will come to answer you in private.

		Average contribution of other group members										
		0	1	2	3	4	5	6	7	8	9	10
Your contribution	0	10	10.9	11.8	12.7	13.6	14.5	15.4	16.3	17.2	18.1	19
	1	9.3	10.2	11.1	12	12.9	13.8	14.7	15.6	16.5	17.4	18.3
	2	8.6	9.5	10.4	11.3	12.2	13.1	14	14.9	15.8	16.7	17.6
	3	7.9	8.8	9.7	10.6	11.5	12.4	13.3	14.2	15.1	16	16.9
	4	7.2	8.1	9	9.9	10.8	11.7	12.6	13.5	14.4	15.3	16.2
	5	6.5	7.4	8.3	9.2	10.1	11	11.9	12.8	13.7	14.6	15.5
	6	5.8	6.7	7.6	8.5	9.4	10.3	11.2	12.1	13	13.9	14.8
	7	5.1	6	6.9	7.8	8.7	9.6	10.5	11.4	12.3	13.2	14.1
	8	4.4	5.3	6.2	7.1	8	8.9	9.8	10.7	11.6	12.5	13.4
	9	3.7	4.6	5.5	6.4	7.3	8.2	9.1	10	10.9	11.8	12.7
	10	3	3.9	4.8	5.7	6.6	7.5	8.4	9.3	10.2	11.1	12

Table 1: Your gains depending on your contribution and on the average contribution of your three group members if what you receive equals 30% of the value of the group project

		Average contribution of other group members										
		0	1	2	3	4	5	6	7	8	9	10
Your contribution	0	10	11.5	13	14.5	16	17.5	19	20.5	22	23.5	25
	1	9.5	11	12.5	14	15.5	17	18.5	20	21.5	23	24.5
	2	9	10.5	12	13.5	15	16.5	18	19.5	21	22.5	24
	3	8.5	10	11.5	13	14.5	16	17.5	19	20.5	22	23.5
	4	8	9.5	11	12.5	14	15.5	17	18.5	20	21.5	23
	5	7.5	9	10.5	12	13.5	15	16.5	18	19.5	21	22.5
	6	7	8.5	10	11.5	13	14.5	16	17.5	19	20.5	22
	7	6.5	8	9.5	11	12.5	14	15.5	17	18.5	20	21.5
	8	6	7.5	9	10.5	12	13.5	15	16.5	18	19.5	21
	9	5.5	7	8.5	10	11.5	13	14.5	16	17.5	19	20.5
	10	5	6.5	8	9.5	11	12.5	14	15.5	17	18.5	20

Table 2: Your Your gains depending on your contribution and on the average contribution of your three group members if what you receive equals 50% of the value of the group project

Instructions for Part 2: This part lasts 10 periods.

During this whole part, you belong to the same group as in Part 1. At the beginning of each period, each group member has 10 ECU. Each group member can invest a part of this amount in a common group project. The amount must be between 0 and 10 ECU. Once every group member has chosen the amount he/she wants to invest in the common project, a random draw determines the return of the project for each group member. Each group member has a 50% chance to receive either the equivalent of 30% of the total amount invested in the common project, or the equivalent of 50% of the total amount invested in the common project. This random draw is individual for each group member. Thus, the outcomes of the random draw may differ across the members of a group.

For all the group members, the amount that is not invested in the common project is stored on a personal account. Thus, if a group member stores X ECU on his/her personal account, he/she will recover exactly X ECU.

Your gain is computed in the following way:

$$\text{Your gain} = [10 - (\text{amount invested})] + p \times \text{sum of amounts invested} \tag{7}$$

where p is worth either 30% or 50% depending on the outcome of the random draw.

Your task consists in choosing the amount you want to invest in the common project.

At the end of each period, each group member receives information about his/her level of contribution to the project, the total amount invested by the group members, the return of the project, the return of his/her personal account, as well as his/her gain.

How is your gain computed?

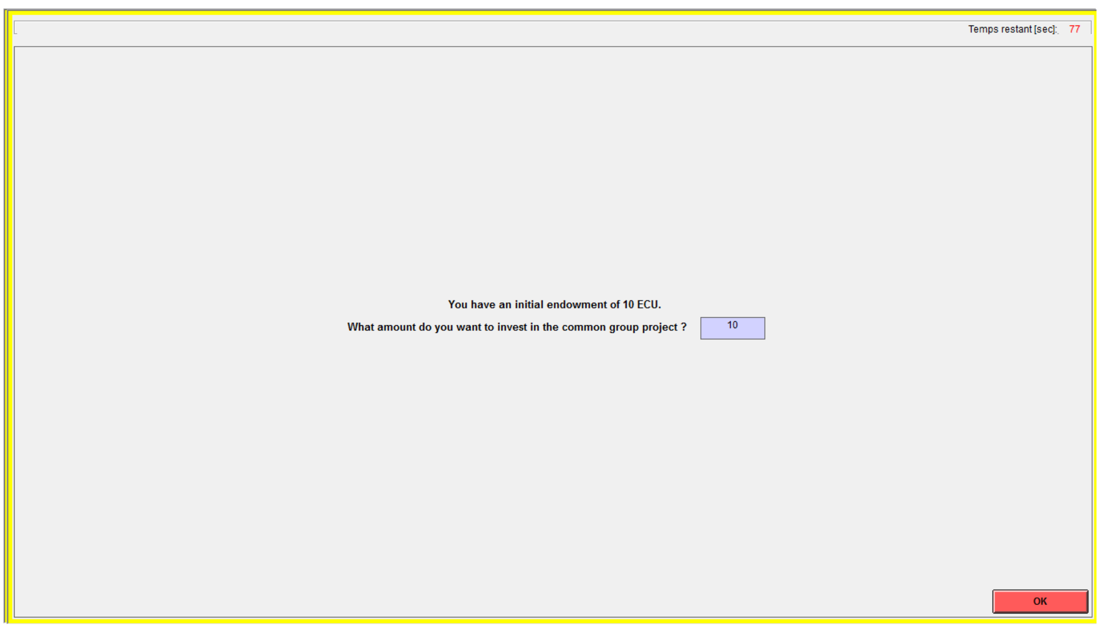
For this part, one period will be randomly selected and gains will be added to the gains of Part 1.

Please read these instructions again. If you have any questions, please push the red button on the left-hand side of your desk and we will come to answer you in private.

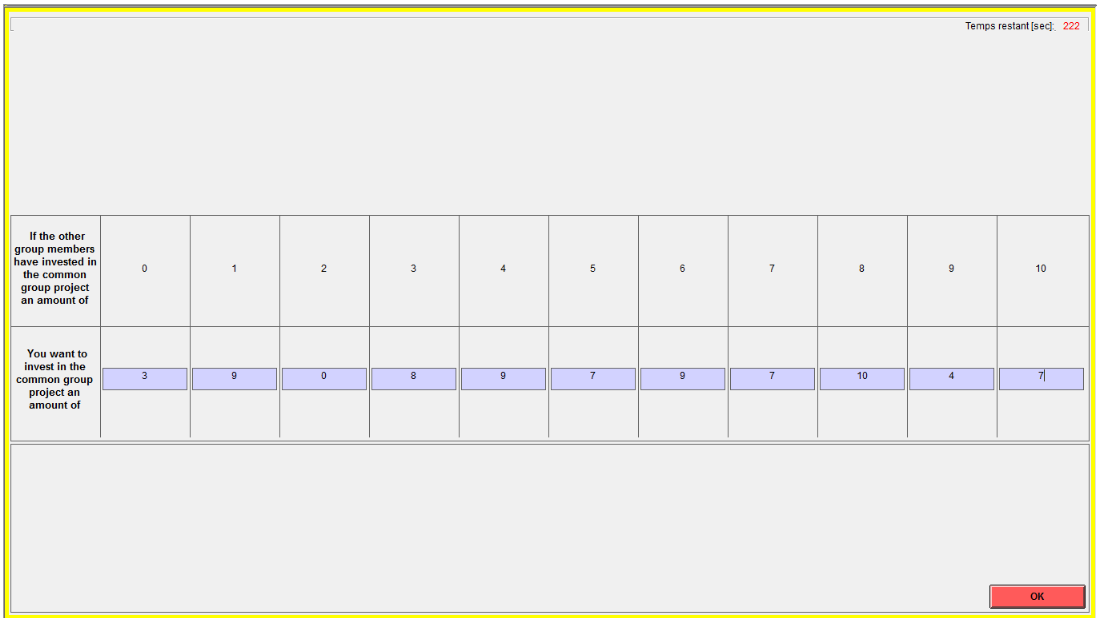
Questionnaire:

1. How many group members do you have?
   - 1
   - 2
   - 3
   - 4
2. After the random draw, every group member will for sure receive the same proportion, p, of the project?
   - Yes
   - No
3. The average contribution of the other group members is equal to 5 ECU. Compute your profit if your finale contribution is 7:
   - If the proportion of the common project that you receive is 30%
   - If the proportion of the common project that you receive is 50%

   In the following questions, we consider some randomly obtained amounts of a fictional participant.



Screen 1: Unconditional amount



Screen 2: Conditional amounts

Screen 3: Estimation of the contributions

4. Suppose that the participant is randomly selected and that the average contribution of the other members is equal to 6.6 ECU. Which amount will be selected for his/her contribution?

    - 9
    - 7
    - 5
    - 10

5. Suppose that the participant is not randomly selected and that the average contribution of the other group members is equal to 6.6 ECU. Which amount will be selected for his/her contribution?

    - 9
    - 7
    - 5
    - 10

6. The average contribution of the other group members is equal to 6.6 ECU. Did the participant earn the 5 ECU that depend on his/her estimation concerning the average level of contribution of his/her group members?

    - Yes
    - No

B Non-parametric analysis

B.1 Non-parametric results on the randomization of risk preferences and other-regarding preferences across treatments

Figure 4: Gneezy Potters risk preferences distributions by treatment

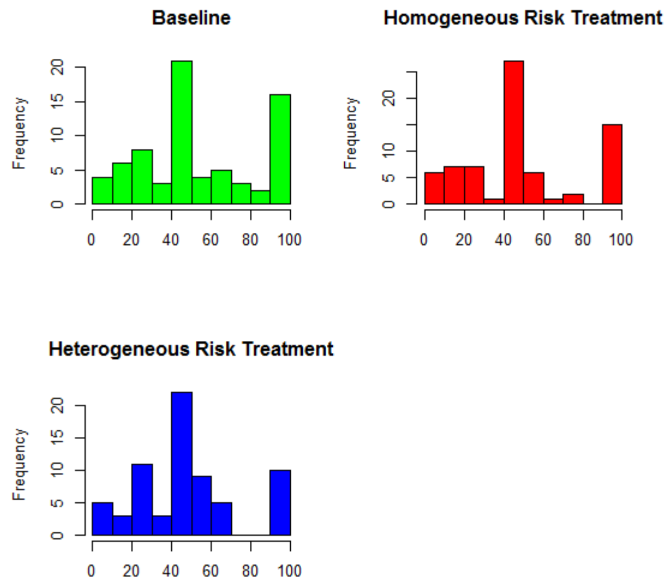
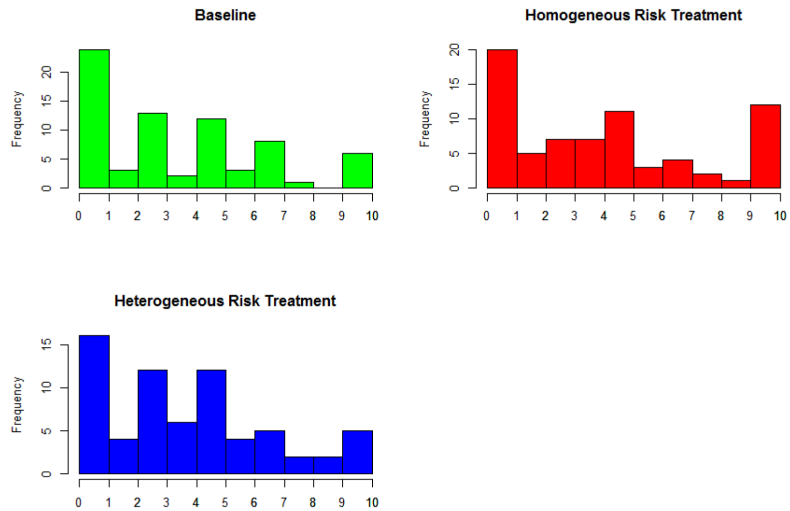


Figure 4 presents the distributions of investment choices in the Gneezy-Potters test across the three treatments. Kruskal-Wallis test does not reject the null hypothesis that these outcomes come from the same distribution ($p = 0.661$).

B.2 Non-parametric support for Result 1: conditional cooperation

Kruskal-Wallis test is used to check if conditional contributions across treatments come from the same distribution. We replicate the results of the parametric F-test with a one slight difference: the p associated with the average contribution of other members equal to 1 becomes weakly significant. Altogether, we reject the null hypothesis that the conditional contributions come from the same distribution for three values of the other players' average contribution: the value of 1 ($p = 0.055$), the value of 2 ($p = 0.030$) and the value of 4 ($p = 0.034$); neither result remains significant once we apply the Bonferroni correction for multiple comparisons. These results hold after excluding pure free-riders from the analyzed sample (with $p = 0.062$, $p = 0.024$, and $p = 0.019$, respectively).

Figure 5: Distributions of unconditional contributions by treatment



B.3 Non-parametric support for Result 2: unconditional contributions and beliefs

Figure 5 shows the distributions of unconditional contributions across the three treatments. Kruskal-Wallis test does not reject the null hypothesis that these outcomes come from the same distribution ($p = 0.519$).

Figure 6 presents the distributions of beliefs about the group members' average contribution to the public good. Kruskal-Wallis test does not reject the null hypothesis that these outcomes come from the same distribution ($p = 0.484$).

Spearman's correlation coefficients for these two variables are all significant at the 1% level and given as follows. Baseline treatment: 0.531; HetR treatment: 0.584; HomR treatment: 0.677.

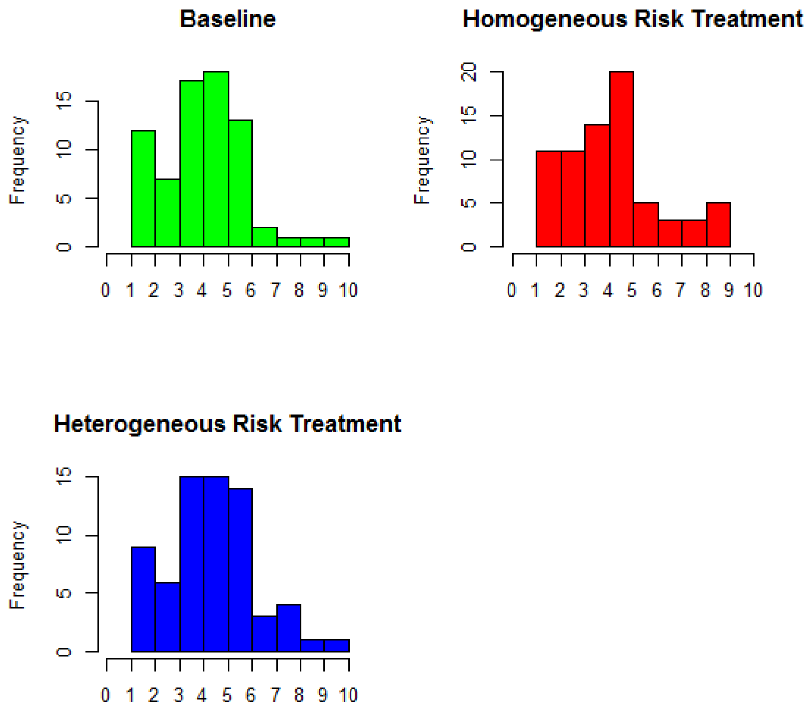
B.4 Non-parametric support for Result 3: round 1 and round 10 contributions

For the repeated VCM game, Kruskal-Wallis test does not reject the null hypothesis that the contributions in the repeated VCM game are drawn from the same distribution in round 1 ($p = 0.316$, individual contribution used as an independent observation unit) and in round 10 ($p = 0.665$, group average contribution used as an independent observation unit).

B.5 Non-parametric support for Result 4: average group contributions

Kruskal-Wallis test rejects the null hypothesis that the average group contributions in the repeated VCM game come from the same distribution ($p = 0.015$). Pairwise comparisons based on ranksum tests yield the following results. Comparing the baseline treatment and the HetR treatment, we do not reject the null hypothesis that the average group contributions come from the same distributions ($p = 0.137$). However,

Figure 6: Distributions of beliefs by treatment



the distribution of the average group contributions in the HomR treatment is (weakly) significantly different than in either of the remaining treatments (baseline: $p = 0.008$, HetR: $p = 0.077$).

C Additional tobit regressions

Table 5: The patterns of cooperation over time and across treatments: tobit regressions

	Tobit			
	Dep. variable: contribution in round t			
Model:	M1	M2	M3	M4
Observations:	$t = 1$	$t = 10$	$t \in \{1; 10\}$	$t \in \{1; 10\}$
Intercept (β_0)	3.056^a	-4.856^a	-0.271	2.963^a
	(0.568)	(1.391)	(0.612)	(0.535)
$1[HomR]$ (β_1)	1.171	1.226	2.734^a	1.226
	(0.799)	(1.856)	(0.953)	(0.835)
$1[HetR]$ (β_2)	0.397	0.225	0.995	0.428
	(0.806)	(2.012)	(0.808)	(0.656)
$1[round2-3]$ (β_3)				-1.353^b
				(0.633)
$1[round4-5]$ (β_4)				-2.583^a
				(0.687)
$1[round6-7]$(β_5)				-4.145^a
				(0.892)
$1[round8-9]$ (β_6)				-5.232^a
				(0.985)
$1[round10]$ (β_7)				-6.010^a
				(1.080)
$1[round2-3] \times 1[HomR]$ (β_8)				1.864^b
				(0.792)
$1[round4-5] \times 1[HomR]$ (β_9)				1.672
				(1.071)
$1[round6-7] \times 1[HomR]$ (β_{10})				2.337
				(1.279)
$1[round8-9] \times 1[HomR]$ (β_{11})				1.726
				(1.391)
$1[round10] \times 1[HomR]$ (β_{12})				-0.241
				(1.626)
$1[round2-3] \times 1[HetR]$ (β_{13})				0.264
				(0.769)
$1[round4-5] \times 1[HetR]$ (β_{14})				0.646
				(0.880)
$1[round6-7] \times 1[HetR]$ (β_{15})				1.056
				(1.151)
$1[round8-9] \times 1[HetR]$ (β_{16})				0.986
				(1.205)
$1[round10] \times 1[HetR]$ (β_{17})				-0.270
				(1.530)
$sigma$	4.597	7.224	5.515	5.208
	(0.306)	(0.921)	(0.301)	(0.277)
N	212	212	2120	2120
$Prob > F$	0.330	0.793	0.022	< 0.001

Note. Estimates from double-censored tobit regressions. a/b indicate statistical significance at the 1%/5% level. In all models, the set of explanatory variables includes treatment dummies. In M4, it also includes (pairwise) round dummies and their interactions with treatment dummies. In M2-M4, residuals are clustered at the group level (53 clusters), standard errors are computed using the leave-one-out jackknife procedure.

Table 6: The patterns of cooperation over time and across treatments: tobit marginal effects

	Dep. variable: contribution in round t			
Model:	M1	M2	M3	M4
Observations:	$t = 1$	$t = 10$	$t \in \{1; 10\}$	$t \in \{1; 10\}$
$1[HomR]$ (β_1)	0.818	0.306	1.405^a	0.627
	(0.554)	(0.472)	(0.487)	(0.427)
$1[HetR]$ (β_2)	0.277	0.056	0.512	0.219
	(0.562)	(0.504)	(0.415)	(0.337)
$1[round2-3]$ (β_3)				-0.692^b
				(0.318)
$1[round4-5]$ (β_4)				-1.322^a
				(0.327)
$1[round6-7]$(β_5)				-2.122^a
				(0.406)
$1[round8-9]$ (β_6)				-2.678^a
				(0.449)
$1[round10]$ (β_7)				-3.077^a
				(0.533)
$1[round2-3] \times 1[HomR]$ (β_8)				0.954^b
				(0.407)
$1[round4-5] \times 1[HomR]$ (β_9)				0.856
				(0.545)
$1[round6-7] \times 1[HomR]$ (β_{10})				1.196
				(0.648)
$1[round8-9] \times 1[HomR]$ (β_{11})				0.884
				(0.713)
$1[round10] \times 1[HomR]$ (β_{12})				-0.123
				(0.832)
$1[round2-3] \times 1[HetR]$ (β_{13})				0.135
				(0.393)
$1[round4-5] \times 1[HetR]$ (β_{14})				0.330
				(0.449)
$1[round6-7] \times 1[HetR]$ (β_{15})				0.540
				(0.585)
$1[round8-9] \times 1[HetR]$ (β_{16})				0.505
				(0.614)
$1[round10] \times 1[HetR]$ (β_{17})				-0.138
				(0.782)
N	212	212	2120	2120

Note. Average marginal effects from double-censored tobit regressions. a/b indicate statistical significance at the 1%/5% level. In all models, the set of explanatory variables includes treatment dummies. In M4, it also includes (pairwise) round dummies and their interactions with treatment dummies. In M2-M4, residuals are clustered at the group level (53 clusters), standard errors are computed using the leave-one-out jackknife procedure.

Table 7: Present contributions and random MPCR in the past: tobit regressions

	Tobit	
	Dep. variable: contribution in round t	
Treatment:	HetR	HomR
Intercept (γ_0)	0.767	4.538^a
	(1.024)	(2.000)
$1[\bar{\alpha}_{t-1}]$ (γ_1)	0.617	-1.018
	(0.841)	(1.479)
$Freq(\bar{\alpha})_{(1;t-2)}$ (γ_2)	1.102	0.637
	(1.167)	(2.502)
$1[\bar{\alpha}_{t-1}] \times Freq(\bar{\alpha})_{(1;t-2)}$ (γ_3)	0.932	0.381
	(1.481)	(3.123)
Round (dummy variables):		
4 (γ_4)	-0.109	-0.800
	(0.486)	(0.726)
5 (γ_5)	-0.641	-1.968
	(0.531)	(0.980)
6 (γ_6)	-1.126	-1.972
	(0.757)	(1.030)
7 (γ_7)	-1.741	-2.972^b
	(0.859)	(1.213)
8 (γ_8)	-2.604^a	-3.505^a
	(0.866)	(1.204)
9 (γ_9)	-2.403^a	-4.982^a
	(0.536)	(1.678)
10 (γ_{10})	-4.446^a	7.300^a
	(0.742)	(1.838)
$sigma$	4.826	6.227
	(0.387)	(0.753)
N	544	576
$Prob > F$	0.001	0.037

Note. Estimates from double-censored tobit regressions. a/b indicate statistical significance at the 1%/5% level. In all models, the set of explanatory variables includes treatment dummies. In M4, it also includes (pairwise) round dummies and their interactions with treatment dummies. In M2-M4, residuals are clustered at the group level (53 clusters), standard errors are computed using the leave-one-out jackknife procedure.

Table 8: Present contributions and random MPCR in the past: tobit marginal effects

	Tobit: Marginal Effects	
	Dep. variable: contribution in round t	
Treatment:	HetR	HomR
$1[\bar{\alpha}_{t-1}]$ (γ_1)	0.304	-0.503
	(0.413)	(0.713)
$Freq(\bar{\alpha})_{(1;t-2)}$ (γ_2)	0.543	0.315
	(0.562)	(1.252)
$1[\bar{\alpha}_{t-1}] \times Freq(\bar{\alpha})_{(1;t-2)}$ (γ_3)	0.460	0.188
	(0.737)	(1.538)
Round (dummy variables):		
4 (γ_4)	-0.065	-0.457
	(0.292)	(0.415)
5 (γ_5)	-0.374	-1.107^b
	(0.305)	(0.541)
6 (γ_6)	-0.640	-1.109
	(0.419)	(0.573)
7 (γ_7)	-0.955^b	-1.636^a
	(0.460)	(0.632)
8 (γ_8)	-1.351^a	-1.902^a
	(0.418)	(0.592)
9 (γ_9)	-1.263^a	-2.578^a
	(0.274)	(0.720)
10 (γ_{10})	-2.015^a	-3.426^a
	(0.270)	(0.694)
N	544	576

Note. Average marginal effects from double-censored tobit regressions. a/b indicate statistical significance at the 1%/5% level. In all models, the set of explanatory variables includes treatment dummies. In M4, it also includes (pairwise) round dummies and their interactions with treatment dummies. In M2-M4, residuals are clustered at the group level (53 clusters), standard errors are computed using the leave-one-out jackknife procedure.