

Levati, Maria Vittoria; Morone, Andrea

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by

**M. Vittoria Levati  
Andrea Morone**

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Friedrich Schiller University Jena  
Carl-Zeiss-Str. 3  
D-07743 Jena  
[www.uni-jena.de](http://www.uni-jena.de)

Max Planck Institute of Economics  
Kahlaische Str. 10  
D-07745 Jena  
[www.econ.mpg.de](http://www.econ.mpg.de)

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## Voluntary contributions with risky and uncertain marginal returns: the importance of the minimal value

M. Vittoria Levati, Andrea Morone

**Abstract** Previous research indicates that risky and uncertain marginal returns from the public good significantly lower contributions. This paper presents experimental results illustrating that the effects of risk and uncertainty depend on the employed parameterization. Specifically, if the value of the marginal per capita return under the worst state of nature allows for some efficiency gains, the presence of risk and uncertainty about the public good's value is not detrimental to cooperation. This finding casts doubt on the hypothesis that risk and uncertainty, *per se*, weaken people's willingness to contribute.

**Keywords** Public goods experiments, Voluntary contributions, Risk, Uncertainty

**JEL Classification** C72, C92, D81, H41

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M. V. Levati (Corresponding author)

Max Planck Institute of Economics, Kahlaische Strasse 10, 07745 Jena, Germany

Tel.: +49 3641 686629; fax: +49 3641 686667; e-mail: levati@econ.mpg.de

Andrea Morone

Department of Economics and Mathematics, University of Bari

e-mail: a.morone@dse.uniba.it

## 1 Introduction

There exists a substantial body of evidence showing that in complete information settings individuals contribute voluntarily to public goods even if material self-interest renders free-riding their dominant strategy.<sup>1</sup> Considerably less effort has been devoted to examining whether this result extends to linear voluntary contribution mechanisms where the value of the public good is *ex-ante* unknown to potential contributors.<sup>2</sup> Yet, classic public goods problems like waste recycling, climate change and the extent of individual contribution to work teams do incorporate some degree of uncertainty on the marginal benefit associated with the public good in question.

In the tradition of Frank Knight (1921), situations with “risk” are those where the probabilities of possible future outcomes are known. Instead, situations with “uncertainty” are those where the probabilities are unknown. Waste recycling in Italy may serve as an example of both kinds of situations. A survey conducted in June 2008 by several Italian TV-shows revealed that Southern Italy residents are willing to participate in waste sorting schemes even if they were completely in the dark regarding the fate of their recycled waste. Southern Italians therefore, in deciding on waste recycling, face an uncertain situation. Northern Italians, on the other hand, are better informed about the waste disposal facilities available in their regions: public authorities, industries, and local newspapers not only offer some estimates of the risks that improper recycling habits pose to personal health and the local environment, but also describe the various waste disposal alternatives. Hence, in the North of Italy waste recycling can be characterized as a situation of risk.

The prevailing view holds that both risky and uncertain marginal per capita

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<sup>1</sup>Extensive surveys of experimental studies on voluntary contributions to public goods are presented by Davis and Holt (1993) and Ledyard (1995).

<sup>2</sup>Existing literature has mainly focused on uncertainty in step-level public goods (see, among others, Wit and Wilke 1998; Suleiman et al. 2001; Au 2004) and in common pool resource situations (see, e.g., Rapoport and Suleiman 1992; Budescu et al. 1995; Suleiman et al. 1996).

returns (henceforth, MPCR)<sup>3</sup> diminish contribution levels, either due to risk aversion (as advocated by Dickinson 1998, and Levati et al. 2009) or due to pessimistic beliefs (as suggested by Gangadharan and Nemes 2009).

Dickinson's (1998) experiment is, to the best of our knowledge, the first attempt to deal with a probability of public good provision lower than unity. It considers a 5-person linear public goods game and compares the level of voluntary contributions when the MPCR is fixed at 0.5 to their level when the MPCR takes on values of 0 or 0.714 with probabilities 0.3 and 0.7, respectively. Dickinson detects significantly lower individual contributions when the MPCR is stochastic. Gangadharan and Nemes (2009) use a similar framework in order to distinguish between risk and uncertainty: while in their "environmental risk" treatment subjects are informed that the MPCR takes on values of 0 or 0.6 with equal probabilities, in their "environmental uncertainty" treatment the relevant probabilities are unknown.<sup>4</sup> The authors find that contributions are not different when subjects are faced with uncertainty as compared to risk. Contributions in these two experimental treatments are instead significantly lower than contributions in a baseline treatment with a certain and commonly known MPCR of 0.3.<sup>5</sup> Levati et al. (2009) investigate the effects of imperfect information on contributions in a two-person linear public goods experiment. They run a treatment where the MPCR is fixed at 0.75 and a treatment where the MPCR is, with equal probabilities, either 0.4 or 1.1. In line with the two studies reported above, Levati et al. find that when information about the value

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<sup>3</sup>The MPCR is the return generated for each member of the group when contributions increase by one unit. It can also be seen as the marginal rate of substitution of the private good for the public good.

<sup>4</sup>The term "environmental uncertainty" has been introduced by Messick et al. (1988) in reference to variables defining the relevant environment. In public goods experiments, environmental uncertainty may concern the group members' endowment, the threshold for the realization of the public good, the value of the public good, and how the public good will be distributed among the group members. Environmental uncertainty is contrasted to "social (or strategic) uncertainty" which relates to uncertainty about the other players' behavior.

<sup>5</sup>Gangadharan and Nemes (2009) run additional treatments beyond those reported here (namely, their treatments 3 and 5). In some of them, risk and uncertainty are associated with the private good. In others, the probability of provision of the public good is endogenous in the sense that it increases with the subjects' contributions.

of the public good is limited, contribution levels are substantially lower.

In the research referred to, the expected marginal benefit from the public good is held constant across treatments at a value preserving the dilemma structure of the situation. Yet, the employed payoff parameterizations allow for an inefficient supply of positive contributions either because the public good may not be provided (Dickinson 1998; Gangadharan and Nemes 2009) or because the payoff under full contributions of all subjects may not exceed the payoff under overall free-riding (Levati et al. 2009).

Isaac et al. (1984), among others, document the importance of the MPCR to contribution levels in voluntary contribution mechanisms with a full free-riding equilibrium prediction. Thus, it seems crucial, before drawing definite conclusions on the effects of risk and uncertainty on the willingness to contribute, to examine behavior in a linear public goods setting where the occurrence of the worst state of nature does not yield efficiency losses as compared to the free-riding equilibrium.

The primary aim of the experiment reported here is to investigate whether contribution levels are affected by risk and uncertainty about the public good's value when the range of feasible MPCRs (or the MPCR's variance) is smaller than in previous studies and, what is most important, the minimum MPCR still allows for efficiency gains. Drawing on Levati et al. (2009), the workhorse for the analysis is a two-person linear public goods game. In the control treatment (henceforth, *C*-treatment), the MPCR is certain and known to everyone. In the treatments with risk and uncertainty, the MPCR assumes one of two equiprobable values: probabilities are known in the risk treatment (henceforth, *R*-treatment), but unknown in the uncertainty treatment (henceforth, *U*-treatment). The expected MPCR is kept constant throughout the treatments, and its floor value (in the *R* and *U*-treatments) is set just above the value that would make efficiency-oriented players indifferent between full contributions and free-riding. Our findings reveal that, with a parameterization of

this kind, contributions in the  $R$  and  $U$ -treatments are not significantly different from contributions in the  $C$ -treatment. This suggests that, contrary to the prevailing view that the mere presence of risk and uncertainty causes contributions to fall, the minimum MPCR-value is decisive for this fall.

The remainder of the paper is organized as follows. The next section describes in detail the experimental design and procedures. Section 3 presents the results, and Section 4 concludes.

## 2 The experiment

We model our experiment after Levati et al. (2009) to allow for comparison of results. Participants are matched in pairs and interact for 10 periods in a partners design. In every period  $t = 1, \dots, 10$ , each pair member is endowed with 100 ECU (Experimental Currency Unit)<sup>6</sup> which can be either consumed privately or contributed to a group activity. Denote by  $c_{i,t}$  individual  $i$ 's contribution to the public good in  $t$ , where  $c_{i,t} \in \{1, 2, \dots, 99, 100\}$  and  $i = 1, 2$ . The per period monetary payoff of each individual  $i$  is given by

$$\pi_{i,t} = 100 - c_{i,t} + \alpha_t(c_{1,t} + c_{2,t}) \quad (1)$$

where  $\alpha_t$  is the MPCR.

In the  $C$ -treatment subjects know that  $\alpha_t = 0.75$  for all  $t = 1, \dots, 10$ . In the two experimental treatments we introduce risk and uncertainty about the MPCR but retain its expected value at 0.75. More specifically, in the  $R$ -treatment subjects are informed that  $\alpha_t$  can be either  $\underline{\alpha} = 0.6$  or  $\bar{\alpha} = 0.9$ , each with probability  $1/2$ . In the  $U$ -treatment subjects know the two potential values of  $\alpha_t$ , but do not know their exact probabilities. Thus, in comparison to Levati et al. (2009), not only we introduce uncertainty but we also shorten the distance between  $\bar{\alpha}$  and  $\underline{\alpha}$  (recall that Levati et al. specify  $\underline{\alpha} = 0.4$  and  $\bar{\alpha} = 1.1$ ). More importantly, we choose the parameter  $\underline{\alpha}$  so that  $2\underline{\alpha} > 1$ .

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<sup>6</sup>The exchange rate between the ECU and the Euro was 1 to 0.01.

Given our parameter values, the dominant strategy for a risk-neutral opportunistic (i.e., motivated by monetary rewards) player is to contribute nothing in all three treatments. In this equilibrium play the expected per period payoff for each subject would be 100 ECU (or €1). However, the socially efficient outcome (i.e., the outcome that maximizes the sum of  $\pi_{1,t}$  and  $\pi_{2,t}$ ) is achieved when each pair member contributes everything. In this case, each subject would earn an expected per period payoff of 150 ECU (or €1.5).

Numerous experimental studies have shown that in social dilemma situations where the public good's value is commonly known, people cooperate more than what could be expected from rational and selfish individuals (see, e.g., Ledyard 1995 or Gächter 2007 for overviews). Consequently, we anticipate positive contributions in the *C*-treatment. Previous studies have also found that contributions, although positive, are significantly lower when the public good's value is risky than when it is sure (Dickinson 1998; Gangadharan and Nemes 2009; Levati et al. 2009). If this finding is merely due to risk-aversion, then it should be detected in our data as well because the MPCR distribution in the *R*-treatment is a mean-preserving spread of the certain MPCR in the *C*-treatment.<sup>7</sup> On the other hand, risk *per se* may not be the only factor responsible for the significantly lower contributions observed in previous experiments. It is conceivable that this result hinges on the value chosen for  $\underline{\alpha}$ , which so far has been parameterized to eliminate the social dilemma. If this conjecture is true, then the *R*-treatment, where both values of the MPCR render 100% contributions the socially optimal level, might not engender significantly different contributions than the *C*-treatment.

As to the *U*-treatment, according to expected utility theory, individuals' attitude towards uncertainty should be that of neutrality. Risk and uncertainty should be equivalent, provided that the expected probabilities of outcomes un-

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<sup>7</sup>Dickinson (1998, pp. 531–532) provides a formal proof that any agent with a concave utility function would prefer the *C*-treatment, in terms of higher contribution levels, to the *R*-treatment in the sense of second-degree stochastic dominance.



der uncertainty coincide with the known probabilities of those same outcomes under risk. Most individual decision making experiments question this prediction and suggest that individuals regard risk and uncertainty as different (Ellsberg 1961; Camerer and Weber 1992; Tversky and Fox 1995). Yet, the unique linear public goods experiment dealing with the issue (Gangadharan and Nemes 2009) reports that contributions are not significantly different when subjects face uncertainty as compared to risk. On the basis of both the prediction of expected utility theory and Gangadharan and Nemes's results, we therefore conjecture no significant difference in average contributions between the *R*-treatment and the *U*-treatment.

## 2.1 Experimental procedures

We ran two sessions of each of the three treatments, with 24 subjects in each session. Because of the partner design, this yields 24 independent observations for each treatment. All sessions were run computerized, via z-Tree (Fischbacher 2007), at the laboratory of the Max Planck Institute in Jena. Participants (all being students from various fields at the University of Jena) were recruited using the ORSEE software (Greiner 2004). Sessions lasted, on average, an hour. At the end of period 10, subjects were privately paid their earnings from all 10 periods. The average earnings per subject were €15.75 (including a €2.50 show-up fee), ranging from a minimum of €11.73 to a maximum of €17.89.

Upon arrival, participants were randomly seated at visually isolated computer terminals. Written instructions (in German) were then distributed and read aloud to establish public knowledge (see the appendix for an English translation of the instructions). Understanding of the payoff procedure was assured by a series of control questions that all subjects had to answer correctly before the experiment started.

In the *R* and *U*-treatments, an animation of a bingo cage was projected

onto a whiteboard in the laboratory.<sup>8</sup> In addition, the same images of the bingo cage were displayed on the subjects' decision screens. Figure 1 reports a snapshot of the bingo cage. The cage contained 100 balls of two different colors (red and blue) that were constantly blowing. While participants in the *R*-treatment knew that half of the balls were red and the other half were blue, this information was not revealed to participants in the *U*-treatment. Since the balls were in continuous motion, they could be seen but not counted and, in the *U*-treatment, the information available was not sufficient to calculate probabilities. As the probabilities existed but were unknowable, we have created a situation of genuine uncertainty (for a discussion of this issue, see Hey et al. 2008).

Insert Figure 1 about here

At the end of each period  $t$ , a ball was randomly drawn from the bingo cage. Participants were aware that the color of the drawn ball would determine the value of  $\alpha_t$ : if the drawn ball was red, then  $\alpha_t$  would be 0.6; otherwise, it would be 0.9. To avoid confounding effects due to asymmetric marginal benefits, in any period  $t$  the random value of  $\alpha_t$  was determined simultaneously for both pair members. Subjects were aware of this procedure. Moreover, as behavior might vary according to the MPCRs the subjects encounter, the sequence of 120  $\alpha_t$ -values (12 pairs  $\times$  10 periods) displayed to the subjects remained identical in all sessions employing the two experimental treatments.<sup>9</sup>

In all three treatments, at the end of each period, participants got feedback on their partner's contribution and their private payoff. In the *R* and *U*-treatments, they were also informed about the randomly chosen  $\alpha_t$ -value in their own pair.

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<sup>8</sup>We decided to show the bingo cage in both experimental treatments because we wanted them to differ only in one respect (namely, awareness of the probabilities).

<sup>9</sup>The sequence was randomly generated in the first experimental session of the *R*-treatment and used in all subsequent sessions.

### 3 Experimental results

Table 1 (panel A) summarizes the results under our three treatments. As expected, the Nash-equilibrium free riding prediction is clearly rejected: on average, all players, independently of the treatment, contribute positive amounts. Moreover, risky and uncertainty about the public good's value do not affect behavior significantly: although mean (and median) contributions are lower in the  $R$  and  $U$ -treatments than in the  $C$ -treatment, the differences are not significant ( $p = 0.893$  for  $C$  vs.  $R$ ;  $p = 0.386$  for  $C$  vs.  $U$ ;  $p = 0.918$  for  $R$  vs.  $U$ ; two-sided Wilcoxon rank-sum tests with continuity correction).<sup>10</sup>

Insert Table 1 about here

For the reader's convenience, we have included in panel B of Table 1 the main results of Levati et al. (2009). Average contributions are the lowest in their  $II$  (risk)-treatment. Wilcoxon rank-sum tests with continuity correction show that the difference between  $II$  and each of our treatments is statistically significant ( $p \leq 0.013$  for all three comparisons).<sup>11</sup> Thus, the conclusions of this nonparametric analysis are in accordance with our conjecture that the parameterization of the marginal payoffs (in particular, the value chosen for  $\underline{\alpha}$ ) is a decisive factor in significantly weakening the willingness to contribute to a risky and uncertain public good. The analysis is also supportive of our hypothesis that risk and uncertainty would not trigger different contributions.

The average (over the 10 periods) standard deviation of contributions for individual subjects is 20.84 in  $C$ , 18.85 in  $R$  and 16.47 in  $U$ . Figure 2 displays the standard deviation of contributions per subject, separately for the three treatments. Almost 70% of the participants in the  $U$ -treatment have a standard

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<sup>10</sup>Unless otherwise stated, all statistical tests rely on independent group observations and are two-sided. Recall that, due to our matching procedure, the number of independent observations is 24 for all treatments.

<sup>11</sup>A similar rank-sum test fails to reject the null hypothesis of equality between our control and Levati et al.'s  $PI$ -treatment ( $p = 0.376$ ), even if some of the design features of Levati et al.'s experiment (such as elicitation of participants' beliefs and risk preferences) were not implemented in the current experiment. This corroborates the robustness of previous findings.

deviation less than 20. The corresponding percentage is lower (about 50%) in both the other two treatments. According to the Wilcoxon rank-sum test with continuity correction, the variances of contributions between  $C$  and  $U$  are weakly significantly different ( $p = 0.08$ ); in contrast, there are no significant differences in the variances between  $C$  and  $R$  as well as between  $U$  and  $R$  (the  $p$ -values are 0.516 and 0.274, respectively). It seems, therefore, that the presence of “environmental” uncertainty (see Messick et al. 1988) renders contributions relatively more stable compared to sure situations.

Insert Figure 2 about here

Figure 3 illustrates the time path of contribution levels in the  $C$ ,  $R$  and  $U$ -treatments, averaged over the 24 groups that make up each treatment. The figure reveals that at least in the first three periods, risk and uncertainty about the public good’s value trigger lower contributions than the control. To check whether the difference is significant, we performed Wilcoxon rank-sum tests using data from the first three periods. We find that the difference between  $R$  and  $C$  is not significant ( $p = 0.112$ ) whereas the difference between  $U$  and  $C$  is weakly significant ( $p = 0.06$ ). In the remaining 7 periods, we fail to reject the null hypothesis that mean contributions are the same in  $C$  and  $U$  ( $p = 0.592$ ). In fact, Figure 3 shows that average contributions are quite similar across treatments in periods 4–10.

Insert Figure 3 about here

Figure 3 indicates that average contributions stay roughly constant from the first until the last but one period in all three treatments. To support this observation statistically as well as to investigate what drives contribution decisions, we estimated, separately for each treatment, a linear mixed effect regression on individual  $i$ ’s contribution decision in period  $t$  ( $c_{i,t}$ ). Regressors are *Period* (taking values 1 to 10), the dummy *Last Period* (which equals 0 for periods 1-9 and 1 for period 10), the one-period lagged contribution of  $i$ ’s

partner ( $c_{-i,t-1}$ ), and, in the model for the  $R$  and  $U$ -treatments, the one-period lagged value of the MPCR ( $\alpha_{t-1}$ ). The ex-ante logic of this last variable is that a higher marginal incentive to contribute may affect psychologically individuals and make them contribute more even though free-riding remains their dominant strategy. The lagged contribution of  $i$ 's partner may explain  $i$ 's behavior if people are conditionally cooperative, i.e., they try to match the contributions of their counterpart. In the theory of conditional cooperation, one wants to contribute if others contribute, while one does not want to contribute if others free-ride.<sup>12</sup> The models have random effects at two levels: the effects for the 24 independent matching groups and the effects for the individual participant within each group. The estimation accounts for first-order autocorrelation in the within-(matching) group residuals. The regression results are presented in Table 2.

Insert Table 2 about here

No time trend is detected in any of the treatments. The coefficient of *Last Period* is always negative and significant, capturing the decline of contributions in the last period of each treatment.<sup>13</sup> The parameter estimate for the partner's lagged contribution is positive and significant in all three regressions, meaning that the amount most recently contributed by  $i$ 's partner predicts  $i$ 's current contribution decision. Thus, conditional cooperation appears to be a likely explanation of behavior in each treatment. Finally, in the model for the  $R$  and  $U$ -treatments the lagged value of the MPCR is positive but not significant, suggesting that individuals tend to increase contributions when they observe  $\alpha_{t-1} = 0.9$ , but not significantly so.

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<sup>12</sup>Evidence of conditional cooperation has been found both in controlled laboratory experiments (see, e.g., Keser and van Winden 2000; Fischbacher et al. 2001; Levati and Neugebauer 2004; Levati and Zultan 2009; Fischbacher and Gächter forthcoming) and outside the laboratory (e.g., Frey and Meier 2004).

<sup>13</sup>The absence of a time trend and the significant end effect confirm the results of Levati et al. (2009).

At last, we examine whether the lack of significant difference in contribution levels across treatments, detected at the independent group level, persists at the individual level.<sup>14</sup> For this purpose we estimate the following random-effects equation using all individual choices stratified by group and subject:

$$c_{i,t} = \beta_0 + \beta_1 Risk + \beta_2 Uncertain + \beta_3 Period + \beta_4 Last\ Period + \beta_5 c_{-i,t-1} + \eta_j + \eta_{j,i} + \epsilon_{j,i,t} \quad (2)$$

where  $j = 1, \dots, 72$ ,  $i = 1, \dots, 144$ ,  $t = 2, \dots, 10$ ,  $\eta_j$  and  $\eta_{j,i}$  are, respectively, the level-1 and level-2 random effect terms (which are assumed to be independent and identically distributed over the groups  $j$  and the individuals  $i$ , and independent of the errors  $\epsilon_{j,i,t}$  for each  $j$ , each  $i$  and over all periods  $t$ ). Eq. (2) includes the same independent variables as the models in Table 2, but adds the treatment dummies *Risk* and *Uncertainty* (the *C*-treatment is the baseline). *Risk* takes value 1 for the *R*-treatment and 0 otherwise. *Uncertainty* takes value 1 for the *U*-treatment and 0 otherwise. The estimation results of the equation specified in (2) are recorded in Model 1 of Table 3. In comparison to Model 1, the specification of Model 2 contains additional terms representing the interaction of the two experimental treatments with each of the other three explanatory variables. The number of useable observations for this analysis is 1296 (48 persons  $\times$  9 periods  $\times$  3 treatments).

Insert Table 3 about here

In both models, the coefficients of the two treatment dummies are not significant, implying that, also at the individual level, neither risk nor uncertainty have a substantial impact on contribution decisions. Table 3 shows again that there is no time effect (the coefficient of *Period* is not significant in both models), with the exception of the last period where contributions decline significantly. In line with the regressions in Table 2,  $i$ 's own contributions depend positively and significantly on the lagged partner's contributions. All the in-

<sup>14</sup>In Dickinson's (1998) experiment, risk regarding the return from the public good significantly lowers contributions at the individual, but not at the group, level.

teraction terms in Model 2 are not significant, meaning that the effects of the various variables do not depend on the treatment.

#### 4 Conclusions

Previous empirical research has indicated that the presence of risk and uncertainty about the public good's value significantly lowers contributions. This evidence is based on linear voluntary contribution mechanisms with a positive probability of inefficient contributions. In the present study, we have demonstrated that both risky and uncertain returns from the public good are not necessarily detrimental to cooperation and that their effects depend on the employed parameterization. In particular, the value chosen for the minimum marginal per capita return appears to be decisive for the significant decline in contributions observed so far.

This finding casts doubt on the hypothesis that risk aversion, *per se*, causes this decline. If this hypothesis were correct, risk aversion should have affected the level of contributions also in our experimental treatments where, compared to the control, subjects are confronted with a mean preserving spread on the distribution of possible marginal per capita returns.

In view of our data, a more likely explanation of the significant difference in contribution behavior between certain public goods on the one hand and risky and uncertain public goods on the other hand may be *loss aversion*. In their prospect theory, Kahneman and Tversky (1979) propose that people evaluate risky alternatives on the basis of a reference point (or status quo). Outcomes lower than the reference point are considered as losses. Outcomes larger than the reference point are regarded as gains. Loss aversion refers to people's tendency to strongly prefer avoiding losses to acquiring gains.

Public goods problems require that individuals decide how much to give from their own endowment to a common resource. The reference point is what one possesses and, therefore, contribution decisions involve an immediate loss in

order to possibly obtain a future benefit (McCusker and Carnevale 1995). In all previous experimental studies of public goods games with risky and uncertain marginal payoffs, there exists a positive probability that in case of full contributions by all group members, each individual does not obtain any benefit, but rather incurs a loss as compared to overall free-riding. Thus, if people are motivated to minimize losses more than they are motivated to maximize gains (Kahneman and Tversky 1984, Tversky and Kahneman 1991, Taylor 1991), it is harder to cooperate in these settings than in a setting (like the one implemented here) where all possible values of the marginal per capita return guarantee efficiency gains.

Our experiment shows also evidence of relatively more stable contributions when subjects are faced with an uncertain, rather than sure, marginal benefit from the public good. This suggests that if “strategic” uncertainty is coupled with “environmental” uncertainty, people tend not to try out new strategies if they somehow succeeded in coordinating with their partner. Furthermore, the regression results reveal that conditional cooperation is a viable determinant of behavior in all three treatments.

To conclude, this study has contributed to shed a new light on the effects of risk and uncertainty about the public good’s value on people’s willingness to contribute. Our results indicates that if politicians and firms involved in privately financed public projects cannot warrant perfect information about their marginal benefits, they should at least ensure that potential contributors do face a social dilemma under the worst state of nature.



## Appendix: Experimental instructions

This appendix reports the instructions (originally in German) we used for the uncertainty ( $U$ )-treatment. The instructions for the control ( $C$ )- and the risk ( $R$ )-treatments were adapted accordingly.

**General instructions.** Welcome and thanks for participating in this experiment. Please remain quiet and switch off your mobile phone. You will receive 2.50 euros for having shown up on time. If you read these instructions carefully, you can make profitable decisions and earn more money. The show-up fee of 2.50 euros and any additional amount of money you earn will be paid to you in cash and privately (i.e., without the other participants knowing your earnings) at the end of the experiment.

During the experiment, we shall not speak of euros but rather of ECU (Experimental Currency Unit). ECU are converted to euros at the following exchange rate: 100 ECU = €1.

It is strictly forbidden to communicate with the other participants during the experiment. Communication between participants will lead to the automatic end of the session with no payment to anyone. Whenever you have a question, please raise your hand and one of the experimenters will come to your place.

**Detailed information on the experiment.** The experiment consists of 10 separate periods, in which you will interact with another participant. The two of you form a pair that will remain the same in all 10 periods. You will never know which of the other participants is in your pair.

At the beginning of each period, each participant receives 100 ECU. In the following, we shall refer to this amount as *your endowment*.

Your task (as well as the task of the other member of your pair) is to decide how much of your endowment you want to contribute to a project. Your contribution decision must be an integer number between 0 and 100 ECU. Whatever you do not contribute, you keep for yourself (“ECU you keep”).

In every period, your earnings consist of two parts

1. the “ECU you keep”; i.e.: your endowment *minus* your contribution;
2. the “income from the project”.

$$\text{Your period-earnings} = \text{ECU you keep} + \text{Income from the project}$$

The “income from the project” is determined as follows:

$$\text{Income from the project} = \alpha \times (\text{sum of your pair's contributions})$$

In words, your contribution and the contribution of the other member of your pair are added up, and the resulting sum is multiplied by a number that we call  $\alpha$ . The multiplier  $\alpha$  can be either 0.6 or 0.9, where the actual value will be randomly determined. You have to decide about your contribution without knowing the value of  $\alpha$ .

Each ECU you keep raises your period-earnings by one ECU. Each ECU that you contribute to the project raises “*sum of your pair's contributions*” by one ECU. As a consequence, “*income from the project*” increases by  $\alpha$  ECU. Since “*income from the project*” is the same for both members of a pair (i.e., both you and your fellow member receive the same income from the project), each ECU that you contribute to the project raises your period-earnings as well as the period-earnings of your fellow member by  $\alpha$  ECU. The same holds for the contributions of your fellow member: each ECU that (s)he contributes increases “*income from the project*” and, therefore, your period-earnings by  $\alpha$  ECU.

*Example:* Suppose that you contribute 60 ECU to the project and the other member of your pair contributes 40 ECU. Then “*sum of your pair's contributions*” is  $60 + 40 = 100$  ECU, and both you and your fellow member receive an “*income from the project*” of either  $0.6 \times 100 = 60$  ECU or  $0.9 \times 100 = 90$  ECU. The “*ECU you keep*” are  $100 - 60 = 40$ . Hence, your “*period-earnings*” are either  $40 + 60 = 100$  ECU or  $40 + 90 = 130$  ECU.

### **The bingo cage**

You will have noticed an animation of a bingo cage projected on the whiteboard. The same bingo cage will be displayed on your decision screen. This cage contains 100 balls of two different colors: red and blue. The balls are constantly blowing in the cage. At the end of each period, a ball will be randomly drawn from this bingo cage.

- If the drawn ball is red, the multiplier  $\alpha$  will be 0.6.
- If the drawn ball is blue, the multiplier  $\alpha$  will be 0.9.

The randomly determined value of  $\alpha$  will be the same for the two members of a pair.

### **The information you receive at the end of each period**

At the end of each period, you will receive information about 1) the number of ECU contributed by the other member of your pair, 2) the income from the project, 3) the randomly drawn multiplier  $\alpha$ , and 4) your corresponding period-earnings.

**Your final earnings**

Your final earnings will be calculated by adding up your period-earnings in each of the 10 periods. The resulting sum will be converted to euros and paid out to you in cash, together with the show-up fee of 2.50 euros.

Before the experiment starts, you will have to answer some control questions to verify your understanding of the rules of the experiment.

*Please remain seated quietly until the experiment starts. If you have any questions please raise your hand now.*

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Table 1: Summary statistics on contributions by treatment

Treatment	Mean	Median	Std. dev
<i>A) Current experiment</i>			
<i>C</i> (control)	70.20	72.25	23.44
<i>R</i> (risk)	68.82	70.88	20.51
<i>U</i> (uncertainty)	65.50	68.04	17.76
<i>B) Levati et al. (2009)</i>			
<i>PI</i> (control) <sup>a</sup>	78.08	100.00	35.33
<i>II</i> (risk) <sup>b</sup>	40.75	40.00	35.30

<sup>a</sup> *PI* stands for “perfect information”.

<sup>b</sup> *II* stands for “imperfect information” ( $\underline{\alpha} = 0.4$  and  $\bar{\alpha} = 1.1$ ).



Table 2: Mixed-effects regressions on contribution decisions in each treatment (number of observations per model: 432)

Independent variable	Coefficient	Std. error	<i>p</i> -value
<i>C</i> -treatment			
<i>Constant</i>	50.666	6.336	0.000
<i>Period</i>	-1.288	0.682	0.108
<i>Last Period</i>	-18.244	3.774	0.000
$c_{-i,t-1}$	0.396	0.051	0.000
<i>R</i> -treatment			
<i>Constant</i>	52.323	7.787	0.000
<i>Period</i>	0.054	0.612	0.929
<i>Last Period</i>	-13.172	3.624	0.000
$c_{-i,t-1}$	0.247	0.052	0.000
$\alpha_{t-1}$	1.478	6.298	0.815
<i>U</i> -treatment			
<i>Constant</i>	29.776	6.667	0.000
<i>Period</i>	0.135	0.479	0.778
<i>Last Period</i>	-12.621	3.048	0.000
$c_{-i,t-1}$	0.458	0.051	0.000
$\alpha_{t-1}$	8.873	5.393	0.101

Table 3: Linear mixed-effects regressions on individual contribution decisions (number of observations: 1296)

Independent variables	Model 1		Model 2	
	Coefficient	Std. error	Coefficient	Std. error
<i>Constant</i>	47.341***	4.538	52.654***	6.103
<i>Risk</i>	1.169	5.046	-0.081	8.381
<i>Uncertainty</i>	-1.232	5.048	-15.721	8.489
<i>Period</i>	-0.407	0.350	-1.296	0.594
<i>Last Period</i>	-14.827***	2.024	-18.432***	3.488
$c_{-i,t-1}$	0.361***	0.029	0.370***	0.048
<i>Risk</i> × <i>Period</i>			1.313	0.842
<i>Risk</i> × <i>Last Period</i>			5.287	4.935
<i>Risk</i> × $c_{-i,t-1}$			-0.108	0.069
<i>Uncertainty</i> × <i>Period</i>			1.358	0.845
<i>Uncertainty</i> × <i>Last Period</i>			5.509	4.939
<i>Uncertainty</i> × $c_{-i,t-1}$			0.083	0.075
Information Criteria:				
Akaike		11587.58		11578.16
Bayesian		11639.21		11660.69

*Note:* The stars indicate significance at the 1% level.

Figure 1: Snapshot of the bingo cage employed in the experiment

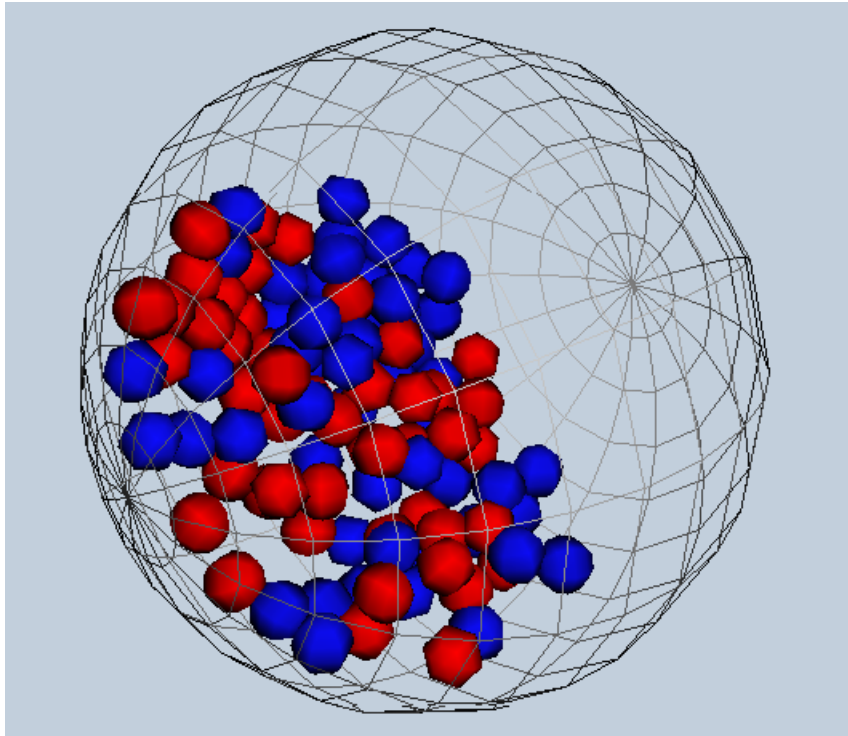


Figure 2: Standard deviations of contributions of individual subjects across periods in each treatment (the number on top of bars is the total number of subjects in the interval)

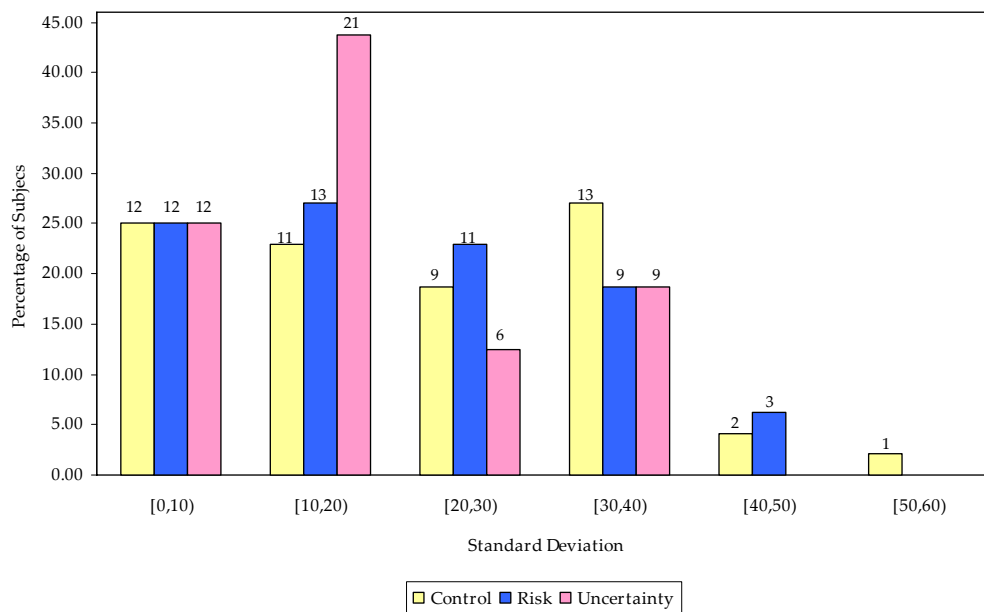


Figure 3: Average contributions in each period, separately for the *C*, the *R*, and the *U*-treatment

