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Increased cooperation in stochastic social dilemmas: Can it be explained by risk sharing?

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A R T I C L E I N F O

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A B S T R A C T

A potential mechanism to explain changes in cooperativeness in the presence of risk may be opportunities for informal risk sharing. Using a novel experimental design, we show that the presence of both independent and correlated risk prevents the typical decay of cooperation in a laboratory social dilemma game. Notably, this result seems to rule out risk sharing as a possible mechanism behind the cooperation increase. Exploratory analyses tentatively suggest that behavior consistent with a risk sharing account may emerge late in the game, congruent with previous theorizing of slow learning in stochastic environments.

1. Introduction

Cooperation in social dilemmas has been the focus of extensive research in economics and other disciplines. It, nevertheless, remains unclear how and why cooperative behavior changes under risk. In this paper, we focus on “risk sharing” as a possible mechanism that may facilitate cooperation in social dilemmas under risk. When people’s income or consumption are subject to temporary shocks, such as job loss or unexpected expenditures, they can make use of informal institutions, including loans or gifts from family and friends, to compensate for these shocks, smoothing income and consumption streams despite the occurrence of the shock. When this happens, people are said to “share” the risk stemming from such unforeseen shocks with others. Informal risk sharing has been documented in the field (Fafchamps & Lund, 2003; De Weerdt & Dercon, 2006) and in controlled experiments (Barr & Genicot, 2008; Charness & Genicot, 2009), but little is known about its possible influence on cooperation.

To provide a clean test of risk sharing as a possible influence on cooperation in social dilemmas, we conduct an experiment in which payoffs from both cooperative and selfish actions in a public goods game (PGG) are stochastic. We run one treatment in which payoffs of each subject are determined by independent random draws (Independent risk treatment). Since risk is independent across players, subjects have additional incentives to cooperate as cooperation enables them to share risk. We also run a second treatment in which payoffs are determined by one random draw common to all participants, which rules out risk sharing motives by design (Correlated risk treatment). Finally, we conduct a standard deterministic PGG (No risk treatment).

We find that people cooperate more under risk. Initial cooperation levels are similar across treatments, but there is no evidence for the typical decay in contributions in the Independent risk treatment. In the Correlated risk treatment, even though there is a weak decay towards the end, cooperation remains higher than in the No risk treatment throughout the experiment. Importantly, while risk sharing can explain the high level of cooperation in the Independent risk treatment, it cannot account for the increased cooperation observed in the Correlated risk treatment.

1.1. *Previous research*

Bilancini et al. (2024) conducted an experiment partly similar to ours, in which a portion of each participant’s combined private and group project earnings from a PGG was affected by risk, which was either positively correlated across group members (similar to our Correlated risk treatment) or not correlated across players (similar to our Independent risk treatment). Contributions in the two treatments and in a payoff-equivalent standard game did not differ in their study, thus failing to provide support for what we propose as our risk sharing hypotheses (formulated in Section 2.4 below). Their study relied on one-shot games. Interestingly, their study and ours would provide

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consistent results of no differences in cooperation due to risk, were we to only consider the first period in our repeated games. This might suggest that learning is to some extent necessary for an effect of risk to emerge in social dilemma games. Corazzini and Sugden (2011) also compare treatments partly similar to our Correlated risk and Independent risk treatments, and find higher cooperation in the former. Their results therefore also do not support a risk sharing account.

Several other studies implement PGG treatments in which payoffs from the group project are influenced by risk but payoffs from the private project are not (Dickinson, 1998; Levati et al., 2009; Levati & Morone, 2013; Fischbacher et al., 2014; Théroude & Zylbersztejn, 2020; Freundt & Lange, 2021; Banerjee, 2024; Dorner et al., 2024). These games are thus fundamentally different from our games, in which risk is affecting group project and private project investments equally. In contrast to our setup, the asymmetry in risk between the two projects should motivate risk-averse players to free-ride (Dickinson, 1998). Indeed, these studies find that compared to deterministic PGGs, cooperation levels are typically lower or similar when group project investments, but not individual project investments, are subject to risk.

In a similar vein, Gangadharan and Nemes (2009), Cárdenas et al. (2017) and Stoddard (2017) employ PGGs in which the payoffs from either the private or the group project are stochastic. Consistent with a risk aversion account (Dickinson, 1998), participants in Gangadharan and Nemes (2009) invest less to a risky group project when their private project is safe (see also Cárdenas et al., 2017) and they invest more to a safe group project when their private project is risky (see also Stoddard, 2017).

Partly similar to us, Théroude and Zylbersztejn (2020) and Freundt and Lange (2021, treatments "ExtRisk$_{\text{Ind.Level}}$" and "ExtRisk") compare PGGs in which a stochastic component affecting group project investments is independent across subjects and in which it is positively correlated across group members. Cooperation is either similar in the two cases (Freundt & Lange) or lower under independent risk (Théroude & Zylbersztejn). These findings may appear not to support risk sharing as a mechanism underlying cooperation in stochastic PGGs. However, risk-averse subjects in the two studies could have avoided exposure to risk simply by investing in a safe individual project rather than by attempting to share risk, making a clean test of the risk sharing hypothesis not possible (to be clear, such a test was also not among the papers' objectives).

1.2. Alternative accounts

Several other mechanisms besides risk sharing may influence cooperation when risks are introduced, such as risk aversion (Dickinson, 1998; Levati et al., 2009), loss aversion (Levati & Morone, 2013), inequity aversion (Fischbacher et al., 2014; Théroude & Zylbersztejn, 2020), informational externalities (von Essen et al., 2020), and learning (Bereby-Meyer & Roth, 2006). As a final step, we therefore probe the data in further exploratory analyses aiming to identify potential alternative mechanisms behind the treatment differences we observe.

First, we explore whether participants respond differently to others' behavior under risk (following Corazzini & Sugden, 2011; Levati & Morone, 2013; Fischbacher et al., 2014; Théroude & Zylbersztejn, 2020).

We next examine whether behavioral and/or normative beliefs may influence cooperation differently under risk. Levati et al. (2009) report that initial beliefs about others' contributions differ between stochastic and deterministic PGGs and that beliefs about others' current round contributions have a weakly statistically significantly different impact on contributions in the stochastic game (however, no such differences have been detected in one-shot settings, Théroude & Zylbersztejn, 2020; Bilancini et al., 2024).

Third, we explore whether game form understanding may be differentially related to contributions across treatments. This is motivated by the possibility that learning may be slower in stochastic games, which could in turn influence contribution behavior (Bereby-Meyer & Roth, 2006).

We also explore whether risk preferences affect play differently across treatments (as in Levati et al., 2009; Cárdenas et al., 2017; Théroude & Zylbersztejn, 2020; Freundt & Lange, 2021), and whether participants react differently to bad outcomes of risky events across treatments (as in Corazzini & Sugden, 2011; Théroude & Zylbersztejn, 2020). We look separately at how participants react to bad outcomes affecting them personally irrespective of what other group members experience and to bad outcomes affecting all members as a group (as shared adversity can be a potential catalyst for cooperation, De Juan et al., 2020).

2. Method

2.1. The basic decision setting

In all treatments, participants form anonymous groups of four that remain together throughout the experiment (partners matching). Participants play 10 periods of a PGG, followed by a surprise restart game (another 10-period PGG). In each round, each participant is endowed with 20 tokens and has to decide how to distribute the tokens between a Group project and an Individual project (see below for treatment-specific details). In expectation, payoffs and MPCR are the same across treatments. Participants are paid for one round in the pre-restart game and for one round in the restart game randomly selected at the conclusion of the experiment. The exchange rate is 10 points = 2 EUR.[1]

2.2. Treatments

No risk treatment. The first treatment is a standard voluntary contribution linear PGG. One token invested in the Individual project yields 1 token to the investor and 0 tokens to the other three group members. One token invested in the Group project yields 0.5 tokens to all four group members (i.e., 2 tokens shared equally among the four group members).

Independent risk treatment. In every round, the payoff of investments to the Individual and Group projects is determined for each player by a round- and player-specific independent random event. The random event is "good" with 0.25 probability and "bad" with 0.75 probability.

In case of a "good" event, the payoffs are as follows: One token invested in the Individual project yields 4 tokens to the investor and 0 tokens to the other three group members. One token invested in the Group project yields 2 tokens to all four group members (i.e., 8 tokens shared equally among the four group members).

In case of a "bad" event, the payoffs are as follows: One token invested in the Individual project yields 0 points to all four group members. One token invested in the Group project yields 0 points to all four group members.

Because random events determining the payoffs are not correlated in the group, risk sharing is possible. If, for example, all participants each allocate 15 tokens to the Group project and 5 tokens to their Individual project, and if three participants are faced with a bad event, while the last group member encounters a good event, the first three participants still earn 30 points each (all coming from the last group member's investment to the Group project) and the last group member earns 50 points (30 points from his Group project investment and 20 points from his Individual project investment).

Correlated risk treatment. Payoffs are the same as in the Independent risk treatment, but the payoffs of investments to the Individual and Group projects are determined for all group members jointly by a single

[1] Complete instructions are available in Online Appendix A. In all treatments, participants had to correctly answer a set of control questions before playing the games. When failing to respond correctly, they got new attempts until they got the question(s) right.

round-specific random event common to the whole group. Because risk is perfectly correlated in the group, risk sharing is not possible.

2.3. Additional measures

Game form confusion was measured with a test adapted from Fosgaard et al. (2014) in which participants answered six factual questions about own contribution choices that would maximize either their own or their group's earnings in a given round given certain profiles of other group members' contributions (e.g., how many tokens should one contribute to maximize their own earnings if other group members contributed 10 tokens on average). Participants received 0.6 EUR per correct answer. Game form confusion was measured at the end of 20 rounds of play, since we wanted to explore the possibility that learning may be slower in social dilemmas involving risk.

Risk preferences were measured with a procedure adapted from Eckel and Grossman (2002). Participants were asked to choose one of eight lotteries involving different levels of risk. Responses were incentivized (see p. 28 in Appendix A for details).

Cognitive reflection was measured with an extended five-item version of the Cognitive Reflection Test (CRT, Frederick, 2005).

Initial beliefs about others' contributions. After the first round of the game but before learning about others' contributions and the game's outcome, we elicited incentivized beliefs concerning others' contributions. Participants guessed how many of ten randomly selected participants in their session invested 0–5, 6–10, 11–15, and 16–20 tokens into their Individual project in the first round, receiving 1 EUR per correct guess.[2]

Social norms. We elicited social appropriateness ratings of five possible contributions to the Group project (0, 5, 10, 15, and 20 tokens). Ratings were measured on a 4-point scale (1 = very socially inappropriate, 2 = somewhat socially inappropriate, 3 = somewhat socially appropriate, 4 = very socially appropriate) and were collected after participants completed the 20 rounds of the PGG. Ratings were incentivized using a protocol introduced by Krupka and Weber (2013). Specifically, before submitting their ratings, participants learned that at the end of the experiment, the experimenters would randomly select one of the possible contribution choices being rated. For the selected contribution choice, it would be determined which rating had been selected by the most people in the session. If a participant's rating of the randomly selected contribution choice was the same as the most frequent rating of that choice in the session, the participant would earn 4 EUR.[3]

Social norm certainty. Along with normative ratings, we elicited incentivized estimates of how sure participants were that the appropriateness ratings they submitted would match modal appropriateness ratings in their session. Participants stated their certainty on a scale ranging from 25 % certain to 100 % certain. We used a quadratic scoring rule to incentivize the certainty estimates (see pp. 7–8 and 26 in Appendix A for details). Because norms and norms certainty were measured simultaneously, we cannot rule out hedging and therefore interpret results involving these variables cautiously (see Blanco et al., 2010).

Finally, we collected information on participants' gender, age, and income.

2.4. Hypotheses

The Independent risk treatment offers risk-sharing opportunities, whereas this is not the case in the Correlated risk treatment. Specifically, for risk-averse subjects, the positive externalities of investments to the Group project are larger in the Independent risk treatment than in the Correlated risk treatment. This is because in addition to the positive externality in terms of expected payoffs (which is constant across treatments), the returns from the Group project are less spread out and less correlated with returns from the Individual project in the Independent risk treatment. That is, risk-averse subjects in the Independent risk treatment can share risk by investing in the Group project.

This leads us to formulate a two-part risk sharing hypothesis: Contributions will be higher in the Independent risk treatment than in the Correlated risk treatment (H1). Contributions will be higher in the Independent risk treatment than in the No risk treatment (H2).

2.5. Participants and sessions

A total of 160 participants (90 women, 70 men; mean age = 25.7 years) took part in the study across 7 sessions, each of which lasted about 2 hours, participants earning 37.6 EUR on average. The experiment was conducted at the Vienna Center for Experimental Economics in 2016. Participants were recruited using ORSEE (Greiner, 2015) and the experiment was computerized using z-Tree (Fischbacher, 2007). Sample size was determined a priori, based on budget constraints. To confirm that the sample would be adequate, we used G*Power (Faul et al., 2007) to calculate that a sample of 44 participants would be required to achieve 80 % power to detect a medium between-subjects effect (Cohen's $d = 0.5$) at the 5 % significance level in a one-tailed mixed ANOVA test of H1 (with 20 repeated measures and assuming a correlation among repeated measures of 0.40). Additional 22 participants would be needed to achieve the same for the purposes of testing H2, for a total sample of 66 participants. A limitation of the study is therefore that it is powered only to detect medium-sized effects.

We conducted 2 sessions in No risk, 2 sessions in Correlated risk, and 3 sessions in Independent risk, for a total of 11 independent groups in No risk, 12 independent groups in Correlated risk, and 17 independent groups in Independent risk (44, 48, and 68 participants, respectively). Balance tests indicate no statistically significant differences across treatments in terms of socio-demographics, cognitive reflection or risk preferences.

3. Results

3.1. Analysis of contribution trends

Fig. 1 provides a first glimpse at our data. In the No risk treatment, the typical pattern of decreasing contributions is apparent over the two 10-period games. We also see the characteristic restart effect after a new 10-period game is announced in round 11.

While contributions start at about the same level across treatments, we observe practically no cooperation decay in the stochastic games (Correlated risk, Independent risk) in the first 10-period game, but there is an indication of cooperation decay in the Correlated risk game after restart.

Models 1 and 2 in Table 1 present statistical support for this reading of Fig. 1. Model 1 is estimated on data from Rounds 1–10 and Model 2 on data from Rounds 11–20. Note that all p-values reported in this paper are from two-sided tests, unless indicated otherwise. Model 1 confirms there is a steeper downward trend in contributions over the course of the first

[2] For analysis purposes, we construct a measure of each guesser's "initial beliefs" by multiplying the mean of each guessed investment category (i.e., 2.5, 8, 13, 18 tokens) by the number of times the guesser said the investment category was represented among the ten randomly selected participants whose contributions they were guessing. For each guesser, we then sum the four products and divide the sum by ten. We then subtract this number from 20, which gives us the guesser's belief of how many tokens ten randomly selected participants in their session contributed on average to the Group project in the first round.

[3] For analysis purposes, we construct a measure of each person's "normative beliefs" by regressing the four appropriateness ratings they submitted on the contributions being rated, and use the regression slope as that person's value of normative beliefs. By construction, positive values of normative beliefs indicate that higher contributions were rated as more appropriate and negative values mean that lower contributions were rated as more appropriate.

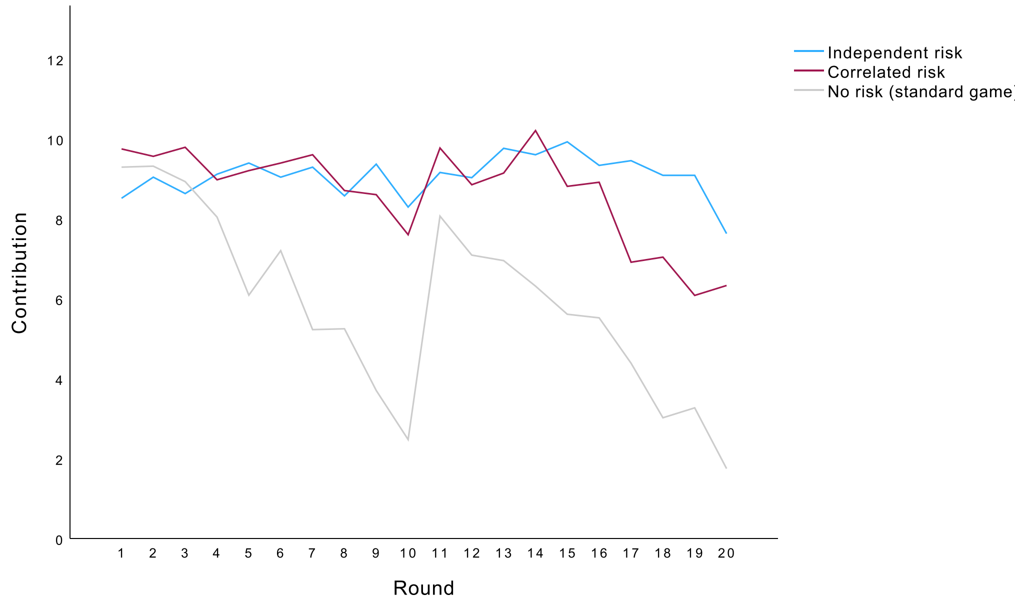

Fig. 1. Average contributions to the public good.

Table 1
Analysis of contribution trends (Models 1 and 2) and tests of risk sharing hypotheses (Models 3 and 4).

	Model 1	Model 2	Model 3	Model 4
Correlated risk treatment	1.18 (1.31)	3.97 (2.53)	−0.40 (1.20)	−0.54 (1.25)
No risk treatment	1.85 (1.28)	4.57 (3.32)	−3.19** (1.10)	−3.72** (1.18)
Round	0.00 (0.12)	−0.11 (0.07)		
Round * Correlated risk treatment	−0.18 (0.16)	−0.32** (0.12)		
Round * No risk treatment	−0.77*** (0.16)	−0.55** (0.18)		
Age				0.01 (0.07)
Female				1.06 (0.63)
Confusion score				0.26 (0.21)
Risk preference				0.32 (0.17)
CRT score				0.66** (0.25)
Constant	8.92*** (0.83)	10.88*** (1.34)	10.10*** (0.77)	6.50** (2.38)
Period fixed effects	No	No	Yes	Yes
Observations	1600	1600	3200	2720
Subjects	160	160	160	136
Clusters	40	40	40	34

Notes: Linear random effects panel regressions with standard errors (in brackets) clustered at the matching group level and with contribution to the Group project as the dependent variable. Model 1 estimated on data from rounds 1–10 and Model 2 on data from rounds 11–20. Independent risk treatment serves as the reference category. Confusion score denotes the number of incorrect answers in a game form understanding test. Risk preference indicates preferred gamble, with higher values indicating less risk aversion. CRT score is the number of correct answers in the CRT. $^*p < .05$, $^{**}p < .01$, $^{***}p < .001$ (two-sided).

ten periods in the No risk treatment than in the Independent risk treatment and the Correlated risk treatment ($p < .001$ in the latter case, based on comparison of margins). Contribution trends in the Independent risk and Correlated risk treatments are statistically the same. Model 2 confirms contributions remain largely stable in the Independent risk treatment but fall off over the course of the ten periods of the restart game in both the Correlated risk treatment and the No risk treatment. Contribution declines in the Correlated risk and No risk treatments are statistically indistinguishable ($p > .10$, based on comparison of margins).[4]

3.2. Main results

Models 3 and 4 in Table 1 present estimates from linear random effects models with contributions to the public good regressed on treatment dummy variables, with controls added in Model 4. We do not find support for H1, as contributions are not statistically significantly higher in the Independent risk treatment than in the Correlated risk treatment ($p > .10$, one-sided). In support of H2, contributions are higher in the Independent risk treatment than in the No risk treatment ($p < .01$, one-sided). Comparisons of marginal means in addition indicate that contributions are higher in the Correlated risk treatment than in the No risk treatment ($p < .05$, in both Models 3 and 4). While these results show that the mere presence of risk affects cooperation, the pattern of behavior across treatments is not consistent with the two-part risk sharing hypothesis (which requires supporting H1 as well).[5]

[4] Mann-Whitney rank-sum tests applied to group-level contributions in the first and last round of each 10-period game complement this analysis. Consistent with the visual impression from Fig. 1, there are no pairwise differences between treatments in first-round contributions in either the first 10-period game or the restart game (all $ps > .10$). Contributions in the 10th and 20th round are lower in the No risk treatment than in both the Independent risk (both $ps < .001$) and Correlated risk treatments (both $ps < .01$). Contributions are similar in Correlated risk and Independent risk in both the 10th round and the 20th round (both $ps > .10$).

[5] Mann-Whitney rank-sum tests provide results consistent with the parametric analysis. Contributions, aggregated over all rounds and over players in a matching group, are lower in No risk than in both Independent risk ($p < .01$) and Correlated risk ($p = .051$), while contributions are statistically indistinguishable when comparing Correlated risk and Independent risk ($p > .10$).

3.3. Exploratory analyses

Since the observed pattern of behavior cannot be rationalized with the two-part risk sharing hypothesis, we decided to perform additional exploratory analyses to see whether other potential explanations might emerge from the data. We find that neither reciprocal preferences, risk preferences, beliefs, norms, nor game form misperception can account for treatment differences in contribution behavior, as described below.

3.3.1. Reciprocity

Contributions are positively correlated with other group members' contributions in the previous round ($p < .001$ in a model without interaction terms otherwise identical to Model 5, not shown). More importantly, however, there is no evidence for a differential impact of reciprocal preferences across treatments (see non-significant interaction terms in Model 5; see Levati & Morone, 2013 for a similar result). Treatment also does not influence how participants reciprocate cumulative contributions from previous two, three, four or five rounds (while controlling for their own cumulative contributions in those rounds, results not shown).

3.3.2. Beliefs

Initial beliefs about others' contributions are positively correlated with one's contributions throughout the game (see Model 6). There is, however, no evidence for a differential impact of initial beliefs across treatments (see non-significant interaction terms in Model 6).

Descriptively speaking, participants' initial beliefs are similar in the three treatments, with $M_{\text{Independent}} = 8.58$, $SD_{\text{Independent}} = 2.97$; $M_{\text{Correlated}} = 8.79$, $SD_{\text{Correlated}} = 2.78$; $M_{\text{No risk}} = 8.68$, $SD_{\text{No risk}} = 3.61$. The means are not statistically significantly different from each other according to a linear model regressing beliefs on treatment indicators ($p > .10$ in the omnibus test).

3.3.3. Norms

Normative beliefs are unrelated to contributions and do not differentially impact contributions across treatments, as can be seen from

Table 2
Exploratory analyses.

	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11
Correlated risk treatment	−1.09 (0.80)	2.41 (3.53)	−0.56 (1.81)	0.14 (1.74)	−2.35 (1.78)	−1.08 (1.52)	−0.60 (1.48)
No risk treatment	−2.18** (0.64)	−2.76 (2.42)	−3.30* (1.61)	−3.44* (1.56)	−5.19* (2.31)		
Lagged average contribution other group members * Correlated risk treatment	0.10 (0.08)						
Lagged average contribution other group members * No risk treatment	0.13 (0.08)						
Initial beliefs * Correlated risk treatment		−0.33 (0.37)					
Initial beliefs * No risk treatment		−0.09 (0.25)					
Normative beliefs * Correlated risk treatment			0.26 (11.14)				
Normative beliefs * No risk treatment			−3.83 (10.14)				
Confusion score * Correlated risk treatment				−0.31 (0.44)			
Confusion score * No risk treatment				−0.11 (0.47)			
Risk preference * Correlated risk treatment					0.44 (0.36)		
Risk preference * No risk treatment					0.34 (0.43)		
Lagged bad event * Correlated risk treatment						0.77 (0.50)	
Lagged shared adversity * Correlated risk treatment							0.45 (0.58)
Lagged own contribution	0.62*** (0.04)						
Lagged average contribution other group members	0.07 (0.07)						
Initial beliefs		0.64** (0.24)					
Normative beliefs			0.48 (8.63)				
Lagged bad event						−0.90** (0.31)	
Lagged shared adversity							−0.57 (0.35)
Age	0.00 (0.03)	0.04 (0.05)	0.01 (0.07)	0.00 (0.07)	0.00 (0.07)	−0.01 (0.09)	−0.01 (0.09)
Female	0.40 (0.28)	0.59 (0.63)	1.11 (0.63)	0.95 (0.64)	1.18* (0.60)	0.50 (0.88)	0.49 (0.88)
Confusion score	0.12 (0.08)	0.19 (0.17)	0.26 (0.21)	0.40 (0.32)	0.27 (0.21)	0.32 (0.25)	0.32 (0.25)
Risk preference	0.11 (0.07)	0.33* (0.16)	0.32 (0.17)	0.31 (0.18)	0.07 (0.28)	0.28 (0.21)	0.28 (0.21)
CRT score	0.26* (0.11)	0.63* (0.25)	0.65* (0.26)	0.65* (0.25)	0.67** (0.24)	0.82** (0.32)	0.83** (0.32)
Constant	1.39 (1.01)	0.48 (3.09)	6.38** (2.29)	6.36* (2.49)	7.62** (2.48)	6.36* (2.95)	5.85* (2.97)
Period fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2584	2720	2720	2720	2720	1748	1748
Subjects	136	136	136	136	136	92	92
Clusters	34	34	34	34	34	23	23

Notes: Linear random effects panel regressions with standard errors (in brackets) clustered at the matching group level and with contribution to the Group project as the dependent variable. Models 10 and 11 are estimated on risk treatment data. Independent risk treatment serves as the reference category. Confusion score denotes the number of incorrect answers in a game form understanding test. Risk preference indicates preferred gamble, with higher values indicating less risk aversion. CRT score is the number of correct answers in the CRT. All "lagged" variables refer to variable values from the previous round. * $p < .05$, ** $p < .01$, *** $p < .001$ (two-sided).

Model 7. Normative beliefs are also not statistically significantly different across treatments according to a linear model regressing beliefs on treatment indicators ($p > .10$ in the omnibus test). Across treatments, a 10-token increase in contribution to the Group project was rated as 1.01 points more socially appropriate on average ($SD = 0.93$), a finding similar to what Kimbrough and Vostroknutov (2016) report.

Adding a three-way interaction between treatment indicators, normative beliefs, and average certainty of norm ratings (and all lower-order interactions) does not change the conclusion from Model 7 – norms are not predictive of contributions in any of the treatments, whether or not we take certainty of norm ratings into account or not (all $ps > 0.10$, results not shown).

As noted in Section 2.3, we are not able to rule out misreporting of social norm perceptions due to hedging. If hedging took place, this could have attenuated the correlation between norms and contributions in Model 7.

3.3.4. Confusion

Game form confusion is not associated with contributions (see Model 2 in Table 1). Non-significant interactions with treatment indicators suggest that confusion does not drive contributions in any of the treatments (see Model 8 in Table 2).

3.3.5. Risk preferences

Risk preferences have a weak, marginally statistically significant positive association with contributions ($p < .10$, see Model 2 in Table 1). However, their influence does not differ across treatments, as can be seen from non-significant interactions with treatment indicators in Model 9 in Table 2.

3.3.6. Bad events

In the Independent risk treatment, encountering a bad event causes participants to decrease their contributions by 0.90 tokens in the following round (see Model 10). Participants' contributions in the Correlated risk treatment do not respond to previous round bad events (the sum of the "lagged bad event" and "lagged bad event * Correlated risk" coefficients from Model 10 is not statistically significantly different from zero according to a chi-square test, $p > .10$). We do not find statistically significant treatment differences in how participants respond to the cumulative number of bad events encountered in previous two to five rounds (results not shown).

The preceding analysis focused on how participants responded to being affected by bad events, irrespective of whether other group members were affected. We additionally construct a measure of "shared adversity", which takes the value 1 if all group members encountered a bad event in a given round and 0 otherwise. From Model 11, we see that participants do not respond to previous round shared adversity in either treatment (in neither treatment do they, similarly, respond to cumulative instances of shared adversity occurring in previous two to five rounds, results not shown).

4. Concluding remarks

We found that people cooperate more in social dilemmas in the presence of risk. At the beginning of a repeated interaction, people behave similarly in stochastic and deterministic public good games. Cooperation level, however, remains stable in the stochastic games, while it gradually declines in the deterministic game.

We find that differences between stochastic and deterministic games cannot be attributed to risk sharing: cooperation is higher both in the treatment with independent risks (where risk sharing is feasible) and in the treatment with perfectly correlated risks (where risk sharing is ruled out by design) compared to the standard game. At the same time, cooperation is similar when comparing the two risk treatments.

Risk sharing alone cannot explain these differences, but one might speculate that learning in combination with risk sharing could have more bite. If we restrict our attention to the very last rounds of the restart game, there appears to be a tendency for cooperation levels in the Independent risk treatment to surpass those in the No risk treatment and the Correlated risk treatment (which would be consistent with risk sharing). One might speculate that at this point in the game, participants in the Correlated risk treatment might have come to realize that opportunities for risk sharing are truly non-existent whereas they may have failed to fully internalize this fact until then. Subsequent research could explore this possibility further (e.g., by running longer games and by collecting explicit measures of understanding of risk sharing opportunities).

Alternative explanations – including reciprocal preferences, risk preferences, social norms or game form understanding having differential impact across treatments – did not receive support in exploratory analyses. The present study was not designed to test these explanations, and more targeted tests would likely be possible. For this reason, we interpret the present (lack of) evidence for the tested belief- and preference-driven explanations for differences in cooperative behavior under risk cautiously. For example, to study the effect of game form understanding and learning in more detail in subsequent studies, one could measure game form understanding repeatedly over the course of play and also collect indicators of understanding of repeated-play incentives (see discussion in Andreoni, 1988).

Our exploratory analyses uncovered a possible difference in how participants react to bad outcomes in the Independent risk treatment (where it leads to less cooperation in the next round) and the Correlated risk treatment (where it has no impact). However, this finding needs to be replicated due to its exploratory nature, especially since it is not consistent with a previous report of no differences in how cooperation responds to stochastic outcomes that are either positively correlated or uncorrelated across players (Corazzini & Sugden, 2011).

A limitation of this study that needs to be acknowledged is that it has not been preregistered. A second limitation is that sessions rather than matching groups within session were randomized to treatments.

The study does not provide definitive answers regarding risk sharing as a possible driver of cooperation, but in its general form the risk hypothesis can be rejected. Exploratory analyses, nevertheless, tentatively suggest that behavior more clearly consistent with risk sharing may emerge after extensive game play, which is a promising direction for subsequent research. The study usefully complements previous work which mainly focused on settings in which usually only cooperative choices were affected by risk. A cursory reading of the literature, reviewed in Section 1.1, could therefore create the impression that risk affects cooperation negatively or that it leaves it unaffected. However, this experiment clearly shows that the opposite can be true when both cooperation and non-cooperation are subject to risk. From a policy perspective, then, it could be possible to encourage cooperation through managing risk or risk perceptions associated with cooperative and non-cooperative options. For example, if technologies contributing to climate change mitigation become less risky or come to be perceived as less risky, these options may garner greater consumer interest and voter support. Similarly, highlighting risks of environmentally harmful technologies and behaviors could steer consumer preferences away from choices contributing to climate change.

CRediT authorship contribution statement

Stepan Vesely: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Erik Wengström:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.socec.2024.102309.

Data availability

Data will be made available on request.

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