Final Countdown? An Experimental Collective Risk Dilemma with Horizon Uncertainty*

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Abstract

In this study, we experimentally analyze the incentives to avoid a collective catastrophe when subjects face uncertainty about the exact time at which the loss may occur. We investigate three versions of the Collective Risk Dilemma: (i) a benchmark scenario in which subjects know the ending period by which they have to complete collective efforts to avoid a sure loss of a big portion of their remaining assets; (ii) a risky scenario where subjects do not know the exact ending period but they are at least aware of its probability distribution; and (iii) an ambiguous scenario where subjects do not know the exact ending period nor the probability distribution. Both uncertainty treatments result in significantly larger efforts compared to those found under certainty. However, these additional contributions may not be enough to avoid the collective disaster.

Keywords: collective risk; cooperation; public good; experiment; timing uncertainty; ambiguity.

JEL classification: C72, C92, H41, Q54.

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1 Introduction

In 2018, the United Nations Intergovernmental Panel for Climate Change Special Report on the impacts of global warming of 1.5°C above pre-industrial levels urged for drastic changes for global temperatures to be kept to this maximum raise (UN IPCC, 2018). In October 2018, *The Guardian* highlighted that even half a degree above this threshold might significantly increase the risks of drought, floods, extreme heat and poverty for hundreds of millions of people. In order to reach the maximum increase of 1.5°C, carbon pollution would need to be cut by 45% by 2030 – compared with a 20% cut under the 2°C pathway – and come down to zero by 2050, compared with 2075 for 2°C.[1] One year later, *The New York Times* questioned the precision of these dates. Specifically, the article pointed out that "...society will have to reduce its greenhouse gas emissions by about half by 2030, declining further to net zero by around mid-century. The *about* and *around* typically get dropped in translation, rendering the outcome falsely precise...".[2]

In this paper, we study whether such (im)precisions may have an effect on the incentives to undertake efforts to avoid irreversible damages. Previous literature has experimentally analyzed individual behavior in the presence of risk of disasters when the threshold is not reached or in cases of uncertainty regarding the location of the threshold. These studies have generally concluded that uncertainty harms cooperation. In this study, we analyze experimentally the effects of horizon uncertainty on cooperative action, and we ask ourselves whether horizon uncertainty favors or hurts cooperation. To achieve this, we run a series of laboratory experiments that only differ in the degree of uncertainty regarding the period at which the catastrophe might occur if collective action has not succeeded in reaching a particular threshold. Contrary to previous results on the effects of uncertainty in this type of games, we generally find that horizon uncertainty favors cooperation. However, collective efforts may not be enough to avoid irreversible losses.

The type of game we investigate in this study is known in the literature as Collective Risk Dilemma (CRD), and was first introduced by Milinski et al. (2008). In a CRD, individuals have to make contributions during several periods to avoid a collective catastrophe, such as a climate

[1] Consult "We have 12 years to limit climate change catastrophe, warns UN", at https://www.theguardian.com/environment/2018/oct/08/global-warming-must-not-exceed-15c-warns-landmark-un-report

[2] Consult "Do We Really Have Only 12 Years to Avoid Climate Disaster? The widely recited 12-year deadline is wrong — and right", at https://www.nytimes.com/2019/09/19/opinion/climate-change-12-years.html

disaster. The CRD belongs to a specific category of Public Good Games called Threshold Public Good Games, where the public good is provided if total contributions towards its provision are sufficiently high, that is, if they reach a specific threshold. The distinctive feature of CRD is that it is framed in the domain of losses, that is, reaching the threshold is necessary to avoid a collective disaster (rather than achieving the provision of a public good).

In their seminal work, Milinski et al. (2008) study how the likelihood of suffering a loss in case of failing to reach a known threshold in a known time horizon affects the individual contributions, and the chances of collective success. Specifically, each individual is given an initial endowment of 40 experimental monetary units (EMU) and is assigned to a group of 6 people. The group has 10 rounds to collect 120 EMU, and each individual in the group can contribute 0, 2 or 4 EMU per round to the common account.[3] If the group fails to reach the threshold by round 10, then subjects in that group lose all their remaining assets with some probability (the three scenarios of 90%, 50% and 10% are compared). The main conclusion is that success in avoiding the collective loss is directly related to the likelihood of the losses. Hence, while half of the groups succeed in reaching the target sum (whereas the others only marginally fail) when the likelihood of losing the remaining assets is 90%, the groups generally fail to reach the threshold in the other less dramatic scenarios.

Later on, Dannenberg et al. (2015) study the effects of uncertainty regarding the location of the threshold. To isolate this effect, they slightly vary the framework of Milinski et al. (2008), and consider that group failure results in individuals losing (with probability one) a large percentage of their remaining assets (as opposed to facing a lottery, which may add additional noise to the individual decisions). In particular, they concentrate on the least favorable case, where individuals lose 90% of their remaining assets and analyze three alternative scenarios: certainty, risk and ambiguity regarding the location of the threshold, with a known time horizon of 10 periods. The location of the threshold is erratic in the risk and ambiguity treatments, with the only difference whether individuals know or do not know the probability distribution of the threshold. In the risk treatment, individuals know that the set of possible values for the threshold are equally likely (with an average value of 120 EMU). In the ambiguity treatment, individuals still know the set of possible values for the threshold (these are the same as under the risk treatment), but they are not informed about the

[3]Since subjects are grouped in teams of 6, note that the 2 EMU contribution can be seen as the per period fair share to achieve the threshold of 120 EMU in 10 periods. Alternatively, 0 EMU can be understood as the selfish (or free-riding) contribution, while 4 EMU represents the altruistic cotribution.

exact probability distribution. Their main finding is that introducing uncertainty in the location of the threshold is generally detrimental for avoiding the collective loss, this effect being particularly severe when uncertainty takes the form of ambiguity.

In contrast to Dannenberg et al. (2015), in our experiment the location of the threshold is known, but there is uncertainty regarding the time horizon. We use the same payoff scheme as in Dannenberg et al. (2015) (in case the catastrophe is not avoided, 90% of the remaining assets is lost with certainty) and the same way to introduce uncertainty, namely, risk and ambiguity, but in our case regarding timing. While the target sum of 120 EMU has to be reached by period 10 in the certainty (baseline) treatment, the ending period in the risk treatment can be any from the set {8, 9, 10, 11, 12} all of them being equally likely, which results in an average ending period of 10. In the ambiguity treatment, the ending period can still be any from the same set, but participants are not informed about the probability distribution.

Contrary to the negative effect that threshold uncertainty causes on collective action found in Dannenberg et al. (2015), our results show that both risk and ambiguity regarding the time horizon result in significantly larger individual efforts than certainty. The descriptive statistics show that ambiguity performs slightly better than risk in this aspect, although the differences are not statistically significant between the two treatments.

We get an average individual contribution of about 2 EMU under certainty, and slightly below 2.5 EMU under uncertainty (of any kind). Notice that while an average of 2 EMU guarantees group success under certainty, an average of 2.5 EMU is needed to guarantee group success under uncertainty (since period 8 is the first possible ending period). Our data confirms that individuals in the uncertainty treatments put more weight on the possibility that the disaster occurs earlier than later, regardless of the type of information they have about the probability distribution, which in turn results in increased contributions in these treatments. While the effect of horizon uncertainty is radically opposite to that caused by threshold uncertainty, however, we find that the higher contributions induced by horizon uncertainty may not be enough to avoid the collective loss.

We see a fundamental difference across treatments when we analyze the evolution of average individual contributions over time. In the certainty treatment, individuals contribute less than 2 EMU on average in the first periods, having to compensate for their procrastinating behavior afterwards. However, both uncertainty treatments show early action, slightly decreasing later in the game, especially in the risk treatment (not so under ambiguity). In fact, the success of the groups under uncertainty depends heavily on how they start facing the problem: the earlier, the better. But this early effort must be maintained to guarantee group success, a characteristic that we observe in the successful groups in the ambiguity treatment.

Regarding the distribution of contributions in the different treatments, we observe a big majority of fair sharers (2 EMU contributors) in the certainty treatment, and very few free-riders (0 EMU contributors) and altruists (4 EMU contributors). However, while we observe no significant changes in the proportion of free-riders in both uncertainty treatments (except in the second half of the game in the risk treatment), the proportion of altruists significantly increases. Hence, horizon uncertainty causes some sort of positive polarization, which definitely helps to contribute to group success.

Turning to the average accumulated contributions through time in the different treatments and the probability of success, we confirm that under uncertainty, groups accumulate significantly larger amounts in all periods (starting from period 1) than under certainty. Interestingly, the average group is very close to success in period 8 in both uncertainty treatments, ambiguity performing slightly better than risk. However, the average group under certainty is still very far from success in period 8, due to procrastinating behavior. Indeed, only one (out of 10) group under risk and 4 (out of 10) groups under ambiguity achieve the threshold in period 8, while no group (out of 8) succeeds under certainty in that period. While success for the average group is reached in period 9 in the ambiguity treatment (with 7 groups succeeding), this is still not the case in the certainty treatment (no group collects the target sum for period 9). Success for the average group is achieved in the certainty treatment in period 10.

Our full data description suggests a clear treatment effect in individual contributions. We then perform a regression analysis to understand the determinants of individual contributions more deeply and find that adding uncertainty has a positive and highly significant effect on individual contributions, with no significant differences between risk and ambiguity. This clear treatment effect becomes even stronger if we control for the period at which the decision is made, the group contribution in the previous period, whether the individual contributes more or less than the average group or the dispersion of contributions. From all these variables, we only find a negative and significant effect in case the individual has contributed less than the group average in the previous period, which hints at the presence of conditional cooperation. Turning to individual characteristics, we find that only better cognitive abilities (measured by the University Admission Score) and loss aversion are significantly correlated with larger individual contributions, *ceteris paribus*. Aspects related to time preferences (such as patience and procrastination), social attitudes (such as negative reciprocity, altruism, trust) or risk tolerance do not prove to be significant in any of the specifications.

To the best of our knowledge, the effects of horizon uncertainty in collective risk dilemmas have only been analyzed previously in Domingos et al. (2020). However, there are several key differences between their approach and ours. The first difference is that their benchmark treatment considers that individuals face a 90% probability of losing all their remaining assets if they fail to achieve the threshold, as in Milinski et al. (2008), while we assume that individuals lose 90% of the remaining assets with probability one in case of group failure, as in the baseline treatment in Dannenberg et al. (2015). Hence, two sources of uncertainty are combined in Domingos et al. (2020) (neither the ending period nor whether the loss in case of failure will actually occur are known), while only horizon uncertainty is present in ours, allowing us to analyze its effect in isolation. This is important because, although the expected loss in case of group failure is the same in the two models, there are well known behavioral differences between facing a sure loss and facing a lottery that may distort the results. This may explain the overall polarization that Domingos et al. (2020) find (more altruism but also more free-riding under uncertainty), while we only obtain more altruism.

The second fundamental difference is that Domingos et al. (2020) consider two alternative scenarios of risk (with lower or larger variance, but known probability distribution in both cases), while we consider risk versus ambiguity (known versus unknown probability distribution). The differences found in Domingos et al. (2020) between the two treatments of uncertainty (especially the likelihood of success) are clearly due to the fact that the ending period may start earlier under large uncertainty (period 6). In fact, they find that introducing horizon uncertainty is detrimental for avoiding the collective loss only in the high uncertainty scenario, while success rates are similar in the certainty and low uncertainty treatments. In our case, we find no significant differences between knowing or not knowing the probability distribution (risk versus ambiguity), although both are clearly superior to the certainty treatment in terms of success, especially considering the first periods where the game could end.

Finally, the third fundamental difference refers to the specific probability distribution considered. While our approach treats the likelihood of the ending period equally in the risk treatment, the approach in Domingos et al. (2020) is biased towards an earlier end.[4] In spite of our unbiased approach, we still have subjects clearly going for early action under uncertainty. Hence, this is the clear effect that uncertainty causes on behavior, regardless of whether probability distributions are biased or not, or whether they are known or not.

Our approach, as well as the other studies presented so far, assumes certainty regarding the amount of losses individuals have to face in case of group failure. This is similar to assume that individuals have the same beliefs regarding the effect of the catastrophe. However, individuals may have different opinions. The literature has widely considered individuals' heterogeneity in several respects: heterogeneity in endowments (wealth differences), heterogeneity in impact (related to the idea of vulnerability), and heterogeneity in available information. The survey by Hurlstone et al. (2017) summarizes the literature on these and other aspects, such as the perceived risk of collective failure, uncertainty surrounding the threshold for catastrophe, intergenerational discounting, and the prospect of reward or punishment based on reputation. Regarding heterogeneity, recent references are, for example, Brown and Kroll (2017), who consider heterogeneity in initial endowments and homogeneity in losses, Mahajan et al. (2022), who study the effects of heterogeneous capacity and vulnerability; Théroude and Zylbersztejn (2020), who analyze heterogeneous risks, or Kumar and Dutt (2019), who deal with differences in available information. Another aspect not considered in our approach is the fact that individual actions may themselves affect the probability distribution (of the location of the threshold, or the ending period, or the amount of the losses). This aspect has been explored in Hagel et al. (2017) or Brown and Kroll (2017), who specifically look at settings where the amount of the loss is contingent on individual actions (or effort).

The remainder of the paper is organized as follows. In section 2, we present the details of our experimental setting. In section 3, we present our results. In section 4, we summarize our main conclusions. The Appendix contains some complementary material.

[4]In Domingos et al. (2020), the experiment lasts on average 10 rounds, but the game can end from round 8 (6) on in the low (high) uncertainty treatment. In the low (high) uncertainty treatment, participants know that the probability that the game ends in period 8 (6) is 1/3 (1/5). If the game continues one additional round, the probability that the game finishes at the end of that period is again 1/3 (1/5), etc... Hence, the probability that the game finishes at period 8 (6) is 1/3 (1/5); the probability that the game finishes at period 9 (7) is $\frac{2}{3} \cdot \frac{1}{3} = \frac{2}{9}$ $\left(\frac{4}{5} \cdot \frac{1}{5} = \frac{4}{25}\right)$; the probability that the game finishes at period 10 (8) is $\frac{2}{3} \cdot \frac{2}{3} \cdot \frac{1}{3} = \frac{4}{27}$ $\left(\frac{4}{5} \cdot \frac{4}{5} \cdot \frac{1}{5} = \frac{16}{125}\right)$; etc.

2 Experimental procedure

We organized three experimental sessions at the Laboratory for Research in Behavioural Experimental Economics of the Universidad de Valencia (LINEEX) in November 2021 with a total of 168 participants without prior experience in public good games. In each session one of the three treatments was implemented, and each subject participated in one session (i.e., treatment) only. Participants were students from different majors of the university, and about 30% of them were Economics or Business students. The experiment was programmed using the z-Tree software (Fischbacher, 2007). At the beginning of each session, instructions were read aloud, and all questions were answered in private. To control the comprehension of the instructions and the decision tasks, subjects had to correctly answer a short quiz before starting the experiment.

Our experimental design follows closely the design of Dannenberg et al. (2015). In the lab, subjects were randomly and anonymously assigned to a group of 6 and played a number of periods in these fixed groups. In the first period subjects were endowed with €40 each and were asked each period to invest €0, €2, or €4 in "a public project whose objective is to avoid damaging everybody". Instructions explained that if the total contributions of the group reached (or surpassed) €120 before the end of the game (i.e., the group managed to avoid a catastrophe that would negatively affect everybody), all group members would receive the money that was left from the endowment at the end of the experiment (i.e., the amount they did not invest in the public project). Subjects were also told that if the group did not manage to reach the €120 threshold, all members would lose 90% of their earnings remaining after the investments in the public project. Note that the experiment is designed such that a contribution of €2 per subject and period ensures group success by the end of period 10. Hence, €2 is referred to as a fair share, while €0 and €4 are referred to as selfish (or free-riding) and altruistic shares, respectively.

At the end of each period, subjets received information on their decision screens about the results, both at the group and invidual levels. On group level, individuals obtained information about the threshold to be reached, the amount collected in the group account (i.e., the accumulated group contribution), as well as the amount to be collected in order to reach the threshold. On an individual basis, subjects received information about the available money (that remained from their endowment after all previous contributions), as well as the actual and all prior inidividual contributions of

	Certainty	Risk	Ambiguity
Subjects	48	60	60
Number of groups	8	10	10
Threshold	€ 120	€ 120	€ 120
Number of periods			
theory	10	8-12	8-12
experiment	10	8	11
Payment			
minimum	€ 6,4	€ 9,4	€ 12
maximum	€ 31	€ 30,3	€ 33
average	€ 20,3	€ 12,04	€ 24,6

Table 1: Overview of the experimental design

all the members in the group (in an anonymous way, using labels for participants). The treatments only differed in the number of periods played. Namely, in the Certainty treatment subjects were informed that they had 10 periods to raise the €120 and avoid the catastrophe. In the Risk treatment subjects were informed that the game would end between periods 8 and 12, with equal probabilities; meaning that the probability that the game finishes in period 8 equals the probability of finishing in period 9, in period 10, in period 11, and in period 12. In the Ambiguity treatment subjects were only told that the game would finish between periods 8 and 12, but no probability distribution was disclosed to the subjects in this case. For logistic reasons, we programmed the experiment to finish exactly at the same period for all groups in the given session (and treatment), and following the above defined ending rules, luck determined that the risk treatment finished at period 8, while the ambiguity treatment finished at period 11. Table 1 resumes the information about the experimental sessions.[5]

After completing the decision tasks, subjects were asked to fill in a short questionnaire, where we extracted a wide set of controls for our regression analysis (to be discussed in the next section in detail). None of the tasks of the questionnaire was incentivized. Besides demographic data (sex, age, studies, etc.), we collected information about subjects' risk tolerance for gains and losses, intertemporal and other-regarding preferences, and cognitive abilities. After finishing, subjects were paid their earnings - including a €5 show-up fee - in private. Sessions lasted for about 60 minutes and the average payments varied between €12 and €24.6, depending on the treatment, see Table 1 for further details.

[5] In Appendix A, we provide the instructions.

3 Results

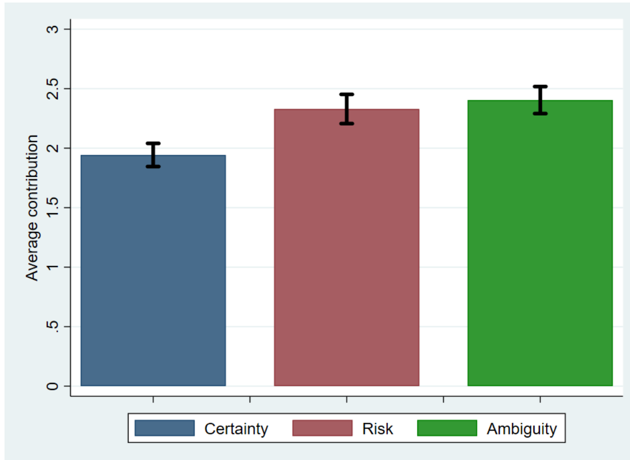
In this section, we present the main results of our experiment. In section 3.1, we describe our data, analyzing the average individual contributions, the types of contributors in the different treatments, average group contributions and success rates. In section 3.2, we perform a regression analysis to understand what is behind the individual decisions. The general conclusion is that horizon uncertainty clearly favors cooperative action, ambiguity being slightly more beneficial for this purpose.

3.1 Data Description

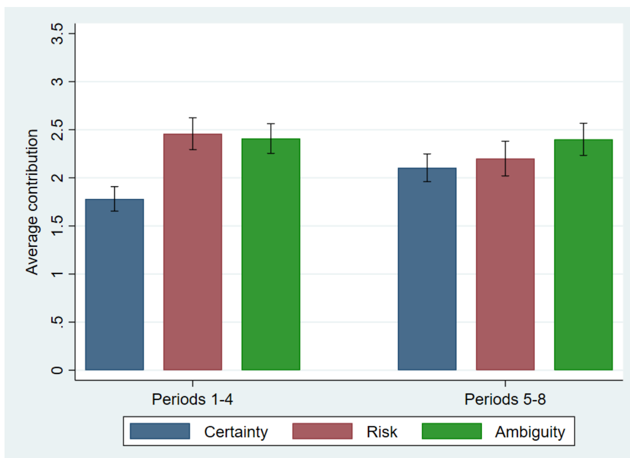
In Figure 1, we present the evolution of average individual contributions until period 8 (the first period when the game can finish, and actually the ending period of the risk treatment) for the three treatments: certainty (baseline), risk and ambiguity. The figure presents a) averages overall; b) evolution of the averages from the first part (periods 1 to 4) to the second part of the time line (periods 5 to 8); and c) evolution per period. In part a) of the figure, we observe a significantly lower average contribution in the certainty treatment (approximately equal to the fair share of €2 per period) than in the risk and ambiguity treatments (here, the average contribution per period is nearly €2.5 in both uncertainty treatments).[6] Note that, while €2 is the individual contribution per period that ensures group success in the baseline treatment (with 10 periods), €2.5 is the contribution per period that guarantees group success by the end of period 8. This target individual contribution lies in the 95% confidence interval in the ambiguity treatment, while it is outside the corresponding confidence interval in the risk treatment.

In part b) of Figure 1, we also see clear differences in the evolution of average individual contributions. In the certainty treatment, individuals contribute less than €2 on average in the first periods, having to compensate for their procrastinating behavior afterwards. However, both uncertainty treatments show early action, slightly decreasing later in the game in the risk treatment. However, we do not observe such a decrease under ambiguity. As we will see later, the success of the groups that face uncertainty depends very much on how they start facing the problem: the

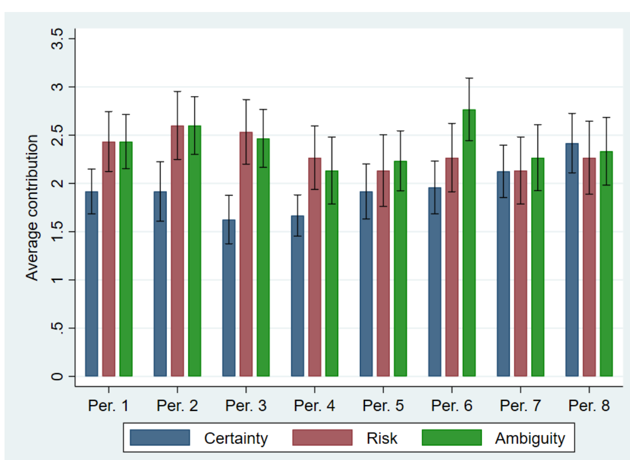
[6] Unless stated differently, throughout the analysis we use the two-sided t-test to test the equality of means. The descriptive statistics and the p-values of the corresponding statistical test are reported in Table 3 in Appendix B.



(a) Overall



(b) Periods 1-4 vs. Periods 5-8



(c) Per period

Figure 1: The evolution of average individual contributions with the 95% confidence interval in the different treatments. Only periods 1-8 shown.

earlier, the better. But it seems that this early effort must be maintained in the second part of the game to guarantee group success.

In part c) of Figure 1, we present the evolution of the average individual contributions per period. If we compare the means or medians in a given period across the treatments, then we see a clear pattern. At the 5% significance level, in periods 1-4 both the means and the medians are higher in the risk and ambiguity treatments than in the certainty treatment. There is no statistically significant difference in contribution between the risk and ambiguity treatments in periods 1-4. In periods 5-8, if we take any period, in general, we do not see significant differences in means or medians in any comparison.[7] Overall, horizon uncertainty implies significantly higher contributions relative to the certain horizon in the first periods, while discernible differences vanish in the second half of the experiment.

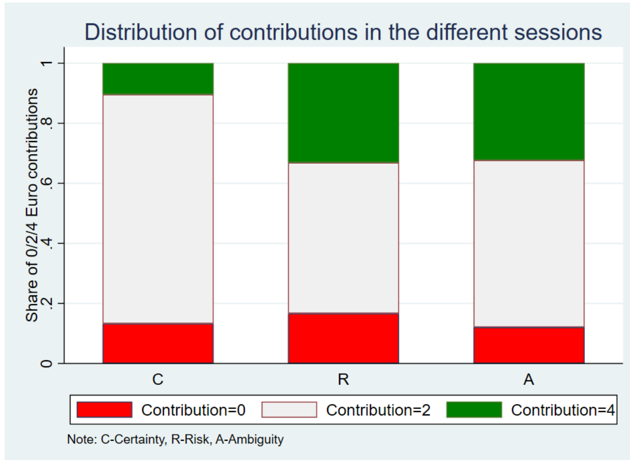
In order to understand what is behind this ”average behavior”, it is important to observe the distribution of the contributions in the different treatments until period 8. Recall that participants can choose only discrete contributions of €0, 2 or 4. The distribution of these possible contributions is presented in Figure 2, which again offers a) overall; b) first part (periods 1 to 4) versus second part (periods 5 to 8); and c) per period results for the three treatments. In part a) of Figure 2, we clearly see that a big majority of subjects selects the fair share of €2 in the baseline treatment. The share of the altruistic contributors (those who contribute €4) is significantly larger in any of the uncertainty treatments, while there are no significant differences between the two.[8] However, there are no significant differences across the three treatments when we look at the proportion of free-riders.[9]

In panel b) of Figure 2, we see a clear change in the distribution of contributions in the certainty treatment between the first and the second parts of the game. We observe an increase in the proportion of altruists and a decrease in the proportion of free-riders, which justifies the procrastinating behavior we have seen before. However, we observe a constant proportion of altruistic contributors

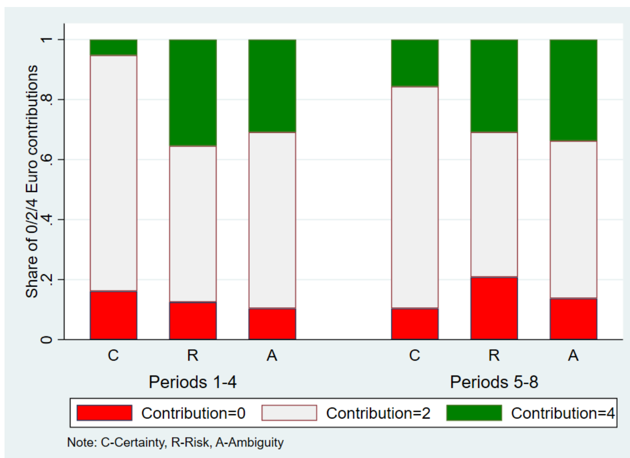
[7] As an exception, in period 6, the contribution in the ambiguity treatment is signficantly larger than the contributions in the other two treatments, both in means and medians.

[8] Table 6 in Appendix C reports the p-values of the Kolmogorov-Smirnov test when we compare the distribution of €0, 2 and 4 contributions in the different treatment. Tables 7, 8 and 9 in Appendix C reports the p-values of the test of proportions when we compare the share of €0, 2 and 4 contributions in the different treatment.

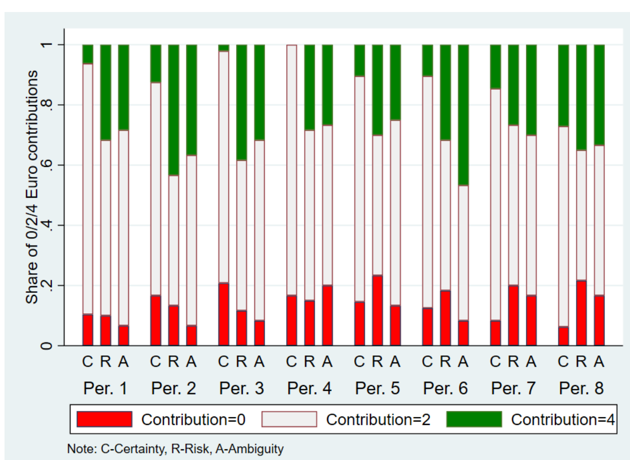
[9] By contrast, Domingos et al. (2020) find a larger share of free-riders under uncertainty. One possible explanation is that, in their setting, subjects face uncertainty on whether the loss will actually occur (besides horizon uncertainty), which may induce some individuals to behave as risk-seekers.



(a) Overall



(b) Periods 1-4 vs. Periods 5-8



(c) Per period

Figure 2: The distribution of €0/2/4 contributions in the different treatments

in both uncertainty treatments, and a slight increase of free-riding only in the risk treatment.

In panel c) of Figure 2, we present the evolution of the distribution of contributions per period. We use the Kolmogorov-Smirnov test to assess the equality of distributions. When comparing the certainty treatment with the risk treatment, the test indicates a significant difference at 5% in periods 2,3 and 4. The comparison between the baseline and the ambiguity treatments shows significant difference at 5% in periods 3,4 and 6. Finally, there is no significant difference at the 5% significance level between the risk and ambiguity treatments in any period. By looking at the proportion of zero contributions across treatments, the test of proportions reveals the following. There is a significant difference in the proportion of zero contributions between the certainty and risk treatments only in period 8, however, when it comes to the proportion of €2 contributions, we see a significant difference at the 5% in all periods (up to period 8) between the two treatments. As a consequence, the proportion of €4 contributions also differs significantly at the 5% in periods 1-6 between the baseline and risk treatments. Turning to the certainty vs. ambiguity comparison, we see the following patterns. Similarly to the previous comparison, there is no significant difference in the proportion of zero contributions in periods 1-8. There is a significant difference in €2 contributions at the 5% in only 4 periods (1,4,6 and 7) between these treatments. The proportion of €4 contributions also differs significantly at the 5% in periods 1,2,3,4 and 6 between the baseline and ambiguity treatments. Last, the comparison between the risk and ambiguity treatments reveals no significant difference at the 5% significance level in any of the first 8 periods when we consider €0 / 2 / 4 contributions. Overall, it seems that the larger average contributions in the risk and ambiguity treatments relative to the certainty treatment are mainly due to the fact that under uncertainty the €4 contribution is more frequent than the €2 contribution. This sort of positive polarization contrasts with the general polarization (more altruism but also more free-riding) found in Domingos et al. (2020). We believe this difference may be due to the fact that loses are sure in our experiment, but they are treated as a lottery in Domingos et al. (2020).

We now turn to analyze group results both on average contributions and success rates. In Figure 3, we present the evolution of the average group contributions over the periods across the treatments. We see a clear delay in cumulative contributions in the certainty treatment, as compared to any of the two uncertainty treatments.[10] Even though we do not observe significant per-period

[10]The descriptive statistics of group contributions and the p-values of the corresponding statistical test are reported

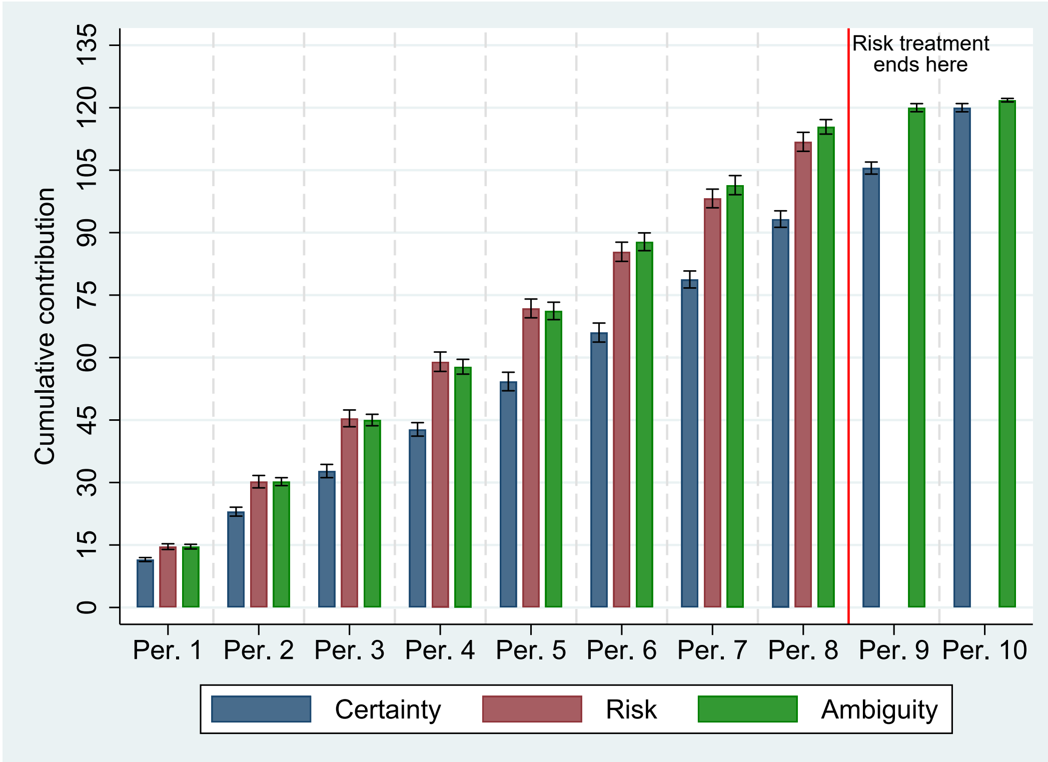


Figure 3: The evolution of group contributions with the 95% confidence interval in the different treatments

differences in contributions in periods 5-8, due to the significant differences in periods 1-4, cumulative group contributions are significantly larger in the risk and ambiguity treatments than those in the certainty treatment over all periods. When comparing cumulative group contributions in the risk and ambiguity treatments, there are no significant differences neither in means, nor in medians.

Even though we find significantly larger cumulative contributions in both uncertainty treatments when compared with certainty, however, these additional contributions may not be enough to avoid the collective loss. This can be seen by noticing that the confidence interval for both the risk and ambiguity treatments in period 8 does not include the target 120, which means that the average group would fail if the ending period was 8 in both uncertainty treatments. If we now look at period 9, we see that success is guaranteed for the average group under ambiguity, while subjects have not collected the target sum under certainty yet (recall that our risk treatment finished at period 8 in the experiment).

Figure 4 shows the proportion of surviving groups across treatments in the possible ending

in Tables 4 and 5 in Appendix B.

periods. In period 8, only 1 group (out of 10) reached the target sum under risk. By that period, however, 4 groups (out of 10) had collected the target sum in the ambiguity treatment, while no group had succeeded in the certainty treatment yet. In period 9, the difference was even larger: 7 successful groups (out of 10) in the ambiguity treatment, while no successful groups yet under certainty. By period 10, 9 (out of 10) groups succeeded in the ambiguity treatment, while 6 groups (out of 8) succeeded under certainty. Finally, in period 11 (the ending period in the uncertainty treatment), all the groups succeeded in avoiding the collective loss.

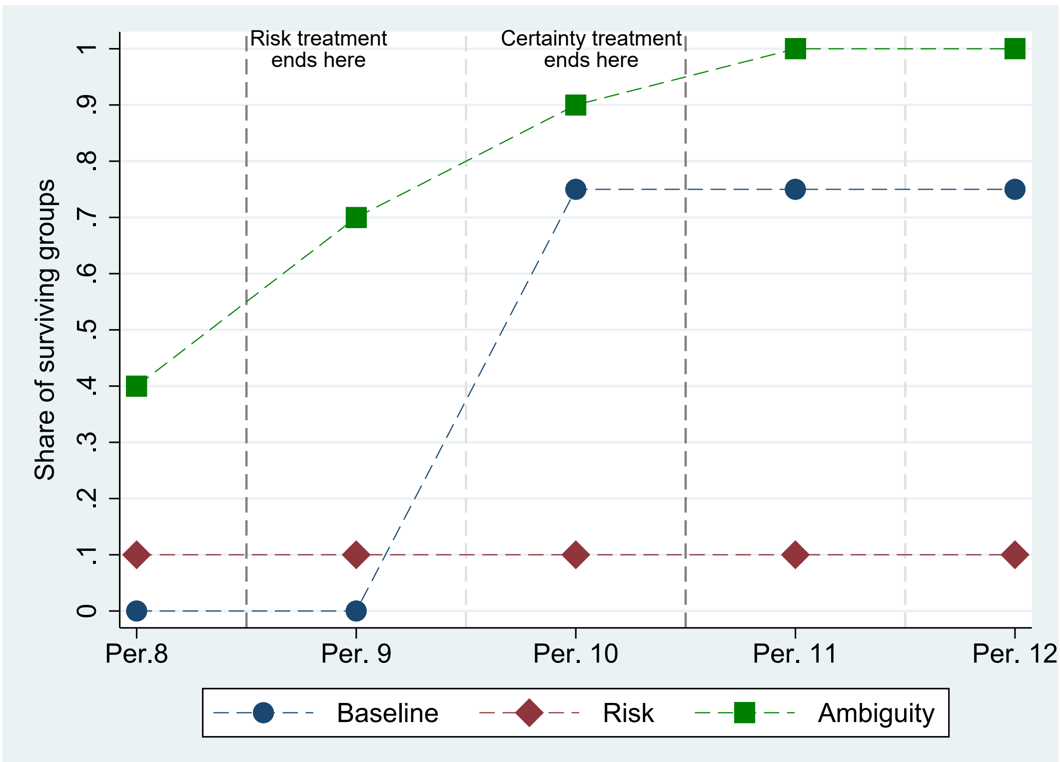


Figure 4: Surviving groups in the different treatments

Next, we are interested in analyzing whether there are patterns that help distinguishing the groups that fail from those that reach the threshold in period 8 (hence those that ensure groups success under uncertainty). We illustrate the main differences in Figures 5 to 8. Specifically, we look at the evolution of the average individual contributions under risk and ambiguity (Figures 5 and 6, respectively), as well as the distribution of the contributions in the first and second parts of the game under risk and ambiguity (Figures 7 and 8, respectively).

Regarding the evolution of average contributions under risk and ambiguity (Figures 5 and 6, respectively), the success of the only successful group in the risk treatment is clearly due to a

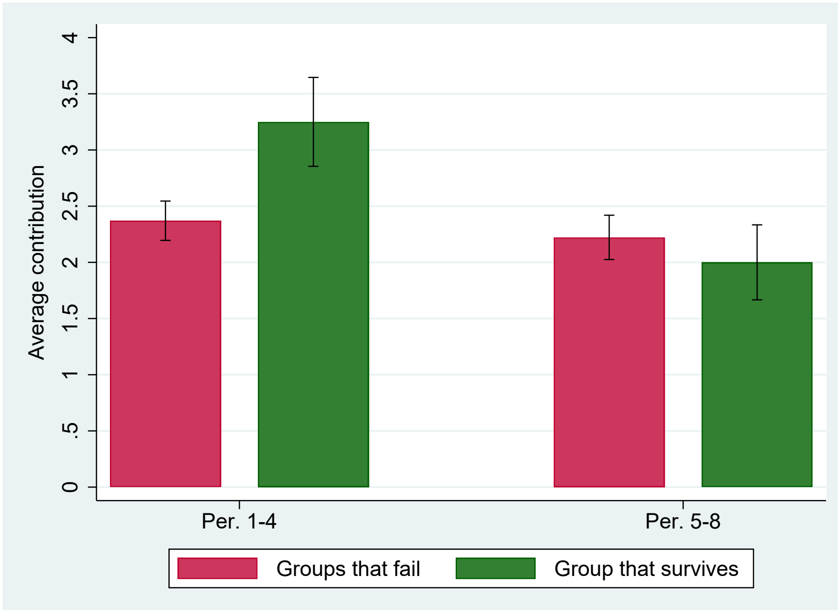


Figure 5: Comparing the contribution of surviving and failing groups in the risk treatment

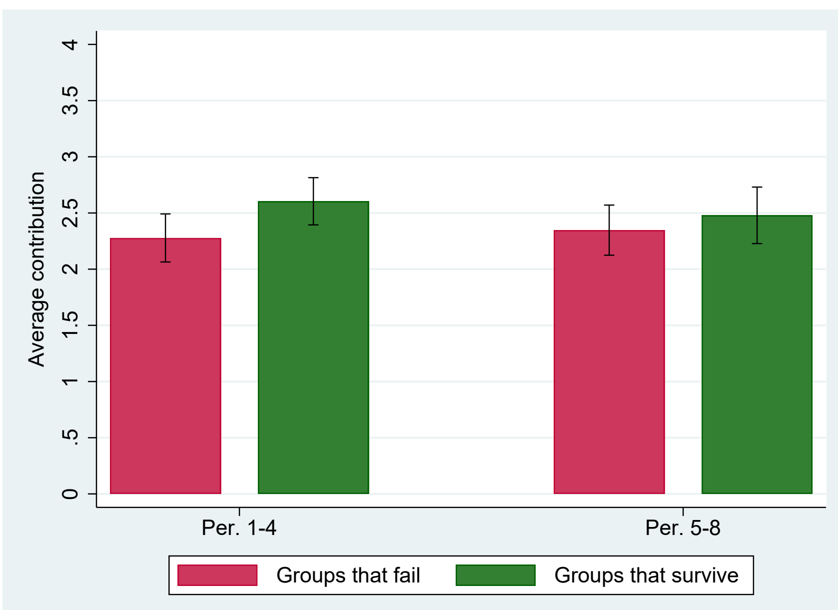


Figure 6: Comparing the contribution of surviving and failing groups in the ambiguity treatment

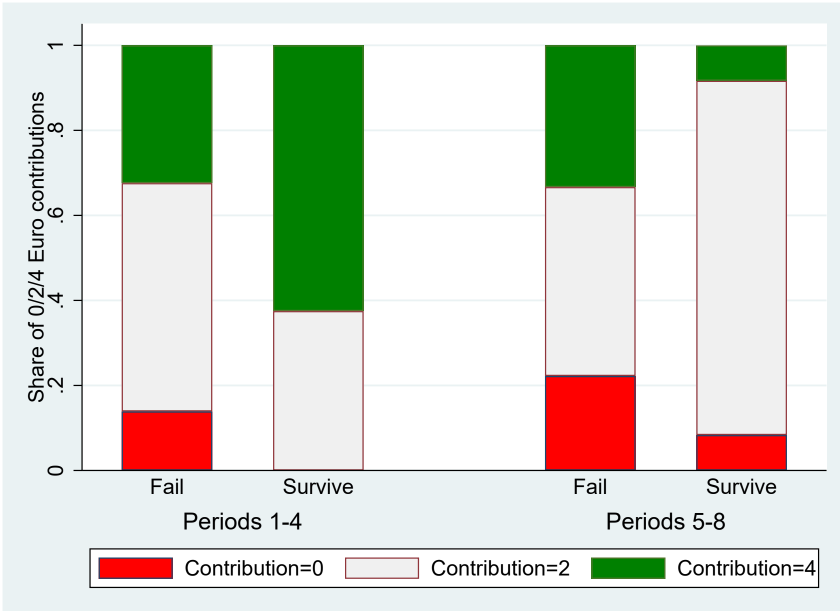


Figure 7: Comparing the share of €0,2 and 4 contributions of surviving and failing groups in the risk treatment

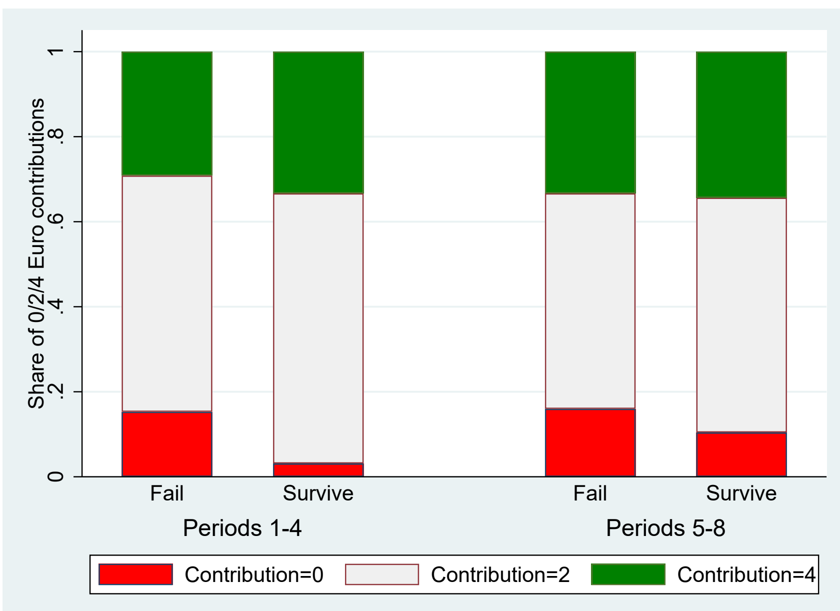


Figure 8: Comparing the share of €0,2 and 4 contributions of surviving and failing groups in the ambiguity treatment

great start, but we do not think we can extrapolate conclusions from here precisely because there is only one successful group. In the ambiguity treatment (where 4 groups succeed in reaching the threshold by the end of period 8), the performance of the average successful group in the first part of the game is slightly better than that of the groups that fail. This seems not to be enough for group success, which requires continuous effort to reach the target sum. However, there are no significant differences between the two cases (in fact, groups that do not reach the threshold in period 8 under ambiguity only fail marginally).

With regards to the comparison of the distribution of contributions between the groups that succeed and fail under risk and ambiguity (Figures 7 and 8, respectively), we clearly see a larger proportion of altruistic contributers and no free riders in the first part of the game in the only successful group under risk, while the most popular choice in the second part is the fair share. Again, we do not think we can extrapolate conclusions since there is only one successful group. Turning to ambiguity (Figure 8), the key difference between groups that succeed and fail is the lower proportion of free riders under success, especially in the first part of the game (periods 1-4).

3.2 Regression analysis

All the previous descriptive analysis indicates a clear treatment effect. In this subsection we perform a regression analysis to corroborate our initial impression and gain a deeper understanding of the determinants of individual contributions.

The results of our regression analysis are presented in Table 2. Since the game ended in different periods depending on the treatment, we restrict our attention to periods 1-8 to obtain meaningful results. We provide six specifications of the individual contribution per period. Using the certainty treatment as the control group, all the specifications contain the treatment dummies (risk and ambiguity). In subsequent specifications, we progressively include variables that may shape the individual contributions. In specification (2), we add Period, that stands for the period in which the subject made the decision. In specification (3), we include total group contribution in the previous period (denoted as Group Contr. (t-1)), that is, the amount that the group accumulated until the end of the previous period, which is informative about how much is needed to reach the target sum of €120. In specification (4), we add two variables related to whether and to which extent the subject contributed more or less in the previous period. Hence, the variable Overcontr.(t-1) equals the difference of the individual and the average contribution in the previous period if the individual contribution is larger, and is zero otherwise. Similarly, Undercontr.(t-1) measures the difference between the individual and the average contribution in the previous period if the individual contribution is smaller, and is zero otherwise. Remember that at the end of each period subjects receive information about their own and the group contribution, so they can figure out if they contributed more or less than the average. We have created two variables to capture the deviation from the average contribution, as deviating positively (that is, contributing more) may have a different influence than deviating negatively. Moreover, these variables may capture conditional cooperation that has been shown to be a relevant factor in group situations when subjects have to cooperate, e.g. the public goods game (Fischbacher et al., 2001) or group contests (Kiss et al., 2020). In specification (5), we add the standard deviation in contributions in the previous period (SD Contr.(t-1)) as polarized contributions may affect subjects' behavior (Domingos et al., 2020). Finally, in specification (6) we include a wide set of controls that indicate individual characteristics, measured in the questionnaire at the end of the sessions.

We now provide a detailed description of the questionnaire. We collected information on some demographic data and cognitive abilities, as well as individual and social preferences. Regarding demographic data, we collected information on gender, age, nationality, whether the subject studies, and the field of study.[11] Based on the field of study, we created a dummy variable that indicates if the subject studies Economics or Business, and 31% of the subjects falls into this category. We also collected information about subjects' cognitive abilities by asking their university admission score.[12]. We hypothesized that individual preferences may also shape subjects' decisions. Hence, we measured intertemporal preferences as the game played in the experiment and the issue of climate change requires efforts and costs earlier to enjoy benefits (or the absence of a catastrophe) later. To measure two aspects of intertemporal preferences, we used two items from the Global Preference Survey (Falk et al., 2018). The first question, related to *patience*, was "How willing are you to give up something that is beneficial for you today in order to benefit more from that in the

[11]Since 95% of the subjects is Spanish, and 98% studies, these variables are not very informative. However, we include them in the regression, but we do not report the coefficients.

[12]Participants also completed the cognitive reflection test (CRT) (Frederick, 2005) Since the university admission score significantly correlates with the CRT, we decided to include the former as it is based on a more thorough measurement. Results do not change qualitatively if we use the CRT instead of the university admission score, or we use them both.

future?". Subjects could indicate their willingness on an 11-point Likert-scale. The second item was related to *procrastination*. Subjects could express on an 11-point Likert-scale to what extent they agreed with it the statement "I tend to postpone tasks even if I know it would be better to do them right away.". We also conjectured that social preferences could play a role as subjects made their decisions in groups. Hence, altruism, reciprocity or trust may influence behavior. To measure these preferences, we again used items from the Global Preference Survey. *Altruism* was assessed on an 11-point Likert-scale by measuring the willingness to be generous to good causes ("How willing are you to give to good causes without expecting anything in return?"). We measured two aspects of reciprocity. Willingness to punish someone after being treated unfairly ("How willing are you to punish someone who treats you unfairly, even if there may be costs for you?") on an 11-point Likert-scale is a proxy for *negative reciprocity*. Agreement on an 11-point Likert-scale with the statement "When someone does me a favor, I am willing to return it." captures *positive reciprocity*.[13] The extent to which subjects agreed with the statement "I assume that people have only the best intentions." on an 11-point Likert-scale is our *trust* measure. Our proxy for risk tolerance is the *bomb risk* elicitation task by Crosetto and Filippin (2013).[14] Since experiencing the catastrophe may be perceived as a loss, we speculated that loss aversion may also be an important factor. Hence, we used the task by Gächter et al. (2022) to measure loss aversion.[15]

In line with the previous findings, we confirm a strong treatment effect that does not vanish even as we include additional controls. Specification (1) reflects Figure 1a, indicating that in the Certainty treatment average individual contribution per round is €1.943, and the dummy variables show that in the Risk / Ambiguity treatments average individual contributions are €0.386 / 0.461 larger. If anything, the effect seems to become stronger in later specifications. Hence, individual

[13]Since altruism and positive reciprocity are positively correlated at the 1% (Table 11 in Appendix D), we dropped positive reciprocity. Our findings do not change qualitatively if we use positive reciprocity and drop altruism, or use both of them.

[14]We also measured risk by using self-assessment ("how willing or unwilling you are to take risks?") also employed in the Global Preference Survey, and a simple choice task (choosing either €1000 for sure, or a gamble in which the subject receives €2000 if heads comes up, and €0 if tails.). All these variables correlate positively. We use the bomb risk elicitation task as it provides the most nuanced measure. Using a different proxy for risk preferences, or including them all does not change our findings.

[15]Randomization into treatments was fairly successful. Table 10 in Appendix D indicates that there are only two significant differences across treatments at the 5%. First, the share of those studying Economics or Business was significantly higher in the Ambiguity treatment than in the Certainty treatment. Second, subjects in the Ambiguity treatment were significantly more patient than in the Risk treatment. However, these variables turned out to be not significant in the regression analysis to explain contributions. Since the variables collected in the questionnaire do not show very high correlations.

	Dependent variable: Individual contribution					
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Risk	0.386***	0.386***	0.484**	0.536***	0.549***	0.587**
	(0.077)	(0.077)	(0.165)	(0.157)	(0.161)	(0.194)
Ambiguity	0.461***	0.461***	0.574***	0.620***	0.632***	0.652***
	(0.071)	(0.071)	(0.153)	(0.160)	(0.166)	(0.188)
Period		-0.005	0.111	0.124	0.128	0.137
		(0.025)	(0.084)	(0.086)	(0.090)	(0.093)
Group Contr.(t-1)			-0.009	-0.009	-0.010	-0.010
			(0.006)	(0.006)	(0.006)	(0.007)
Overcontr.(t-1)				-0.117*	-0.112*	-0.113
				(0.060)	(0.058)	(0.063)
Undercontr.(t-1)				0.032	0.027	0.014
				(0.062)	(0.060)	(0.064)
SD Contr.(t-1)					-0.024	-0.022
					(0.064)	(0.067)
Age						0.009
						(0.014)
Female						-0.002
						(0.078)
EconBus						-0.019
						(0.092)
Univ.Adm.Score						0.019*
						(0.009)
Patience						-0.016
						(0.026)
Procrastination						0.001
						(0.015)
Neg.Recip.						0.005
						(0.012)
Altruism						0.014
						(0.013)
Trust						0.006
						(0.012)
Risk						-0.001
						(0.002)
Loss Aversion						0.107*
						(0.047)
Constant	1.943***	1.965***	1.767***	1.790***	1.796***	1.514**
	(0.054)	(0.142)	(0.232)	(0.232)	(0.226)	(0.559)
Observations	1,344	1,344	1,176	1,176	1,176	1,176
R^2	0.024	0.024	0.025	0.029	0.029	0.038

Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

In the last specification, we also control for being Spanish and being a student.

Table 2: Individual contribution. OLS regression

contributions are €0.39-0.59 larger in the Risk treatment, and €0.46-0.65 larger in the Ambiguity treatment, on average, as compared with the Certainty treatment. We cannot reject the equality of the Risk and Ambiguity coefficients in any of the specifications (we always find p-values larger than 0.26).

The variable Period does not prove to be significant in any specification. Total group contribution in the previous period has a consistent negative coefficient throughout the specifications, suggesting that the closer the target contribution is, the less subjects contribute, but the coefficient fails to be significant in any specification. Overcontr.(t-1) has a consistently negative coefficient (that is marginally significant in specifications (4) and (5)), indicating that those who contributed more than the average in the previous period decrease their contribution. This effect, however, dissapears once we add the controls (see specification (6)). Similarly, those who contributed less than the average in the previous period tend to increase their contribution, as the coefficient of Undercontr.(t-1) is consistently positive (but never significant). These coefficients are indicative of conditional cooperation. The coefficient of Overcontr.(t-1) is considerably larger in each specification than the coefficient of Undercontr.(t-1).[16] The standard deviation of contributions in the previous period does not prove to be significant.

Turning to individual characteristics, overall they do not seem to be important factors to understand individual contributions. There are only two characteristics that are at least marginally significant. The University Admission Score is positive, indicating that better cognitive abilities go hand in hand with larger contributions. Loss aversion also has a positive coefficient, suggesting that more loss averse subjects tend to contribute more, *ceteris paribus*.

Overall, the treatment effects are clearly the most consistent and significant determinants of individual contributions.

4 Conclusions

In this paper, we have presented an experimental study to analyze the effects of horizon uncertainty, considering a variation of the Collective Risk Dilemma first presented in Milinski et al. (2008). We have considered three treatments with different degrees of uncertainty regarding the

[16] If we test if the coefficient of Undercontr.(t-1) is equal in magnitude than the coefficient of Overcontr.(t-1), then we reject the equality at the 10% in the last three specifications.

period at which a catastrophe might occur if collective action has not succeeded in reaching a particular threshold. In particular, we have analyzed a baseline treatment without uncertainty regarding the ending period, and two uncertainty treatments: a risk treatment with known probability distribution regarding the ending period, and an ambiguity treatment with unknown probability distribution. Previous literature has analyzed the effects of uncertainty regarding the loss in case of failure to reach the target sum, or uncertainty regarding the target sum itself, leading to the conclusion that uncertainty generally hinders cooperation.

Our analysis suggests a radical opposite result. Under horizon uncertainty (of any kind), we find significantly larger individual contributions than those found in the baseline treatment, which (almost) guarantees group success of the average group under uncertainty. These larger contributions are especially noticeable at the beginning of the game, although continuous efforts are needed to achieve group success. By contrast, and in line with the related literature, the certainty treatment exhibits a very different pattern, with procrastination in the first periods, followed by the need to compensate afterwards to succeed. Our regression analysis confirms that the treatment effect (either risk or ambiguity) is the most noticeable effect of larger individual contributions. Regardig individual charasteristics, only better cognitive abilities (measured by the University Admission Score) and loss aversion induce significantly larger individual contributions, *ceteris paribus*. Demographic characteristics or aspects related to time (such as patience and procrastination), risk tolerance, or social aspects (such as negative reciprocity, altruism, trust) do not prove to be significant in affecting individual contributions.

Our analysis clearly shows that horizon uncertainty favors individual contributions, and the key to succeed relies on early and continuous action. However, we have relied on a number of simplifications. Interesting extensions might include the possibility to combine several uncertainties (such as threshold and horizon uncertainty), or some heterogeneity aspect regarding perceptions of losses, due to informational gaps, for example. We think all these issues deserve further investigation.

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A Instructions

This appendix contains the English translation of the original instruction (which was in Spanish). We reproduce the instructions of the certainty treatment below, indicating in parentheses where the wording of the instructions differed in the other two treatments.[17]

INSTRUCTIONS

Thank you for participating in this experiment on decision making. We are not interested in your behavior in particular, but in knowing how individuals act on average. Therefore, all your data will be treated anonymously. That is, the other participants will not be informed about your identity, they will not be able to identify you with your decisions, nor will you receive information about the identity of any other participant during or after the experiment.

Decisions are made on the computer. Read carefully these instructions and the instructions displayed on the screen throughout the experiment before making a decision.

Next, you will see a series of instructions explaining how the experiment works. These instructions are the same for all participants and it is very important that you understand them well, since the money you earn will depend on your decisions and those of the other participants. If you have any questions during the experiment, raise your hand and one of the experimenters will assist you. Remember not to talk to any other participant during the experiment. Please turn off your cell phone now.

Description of the experiment

During the experiment your earnings will be calculated in euros. In addition to the money earned in the game, you will also receive €5 just for participating.

Each participant will be assigned anonymously and randomly to a group of 6 people. To ensure anonymity, at the beginning of the experiment each member of a group will be assigned an alias ("Player A, B, C, D, E or F"). Your alias will not change and will be visible to you on the screen throughout the experiment. This means that neither you nor any other participant will be able to relate and identify the members of your group with the participants in the room.

[17] We do not include the questionnaire here as it contains standard measures as described in section 3.2. It is available upon request.

The experiment will consist of 10 periods. At the top of the screen you will be able to see during the experiment the period in which you are playing.

(In the risk treatment, instead of the previous paragraph, we had the following one: The experiment will consist of between 8 and 12 periods, depending on chance. The exact period in which the experiment will end is unknown, but the probability of playing 8, 9, 10, 11 or 12 periods is the same. That is, there is a 20% chance that the game will end in period 8, a 20% chance that it will end in period 9, etc... At the top of the screen you will be able to see during the experiment the period in which you are playing, but you will not be given information about the number of periods chosen by the computer.)

(In the uncertainty treatment, we had the following text: The experiment will consist of between 8 and 12 periods, depending on chance. The number of periods is determined by the computer randomly. The exact period in which the experiment will end is unknown, as well as the probability of playing 8, 9, 10, 11 or 12 periods. At the top of the screen you will be able to see during the experiment the period in which you are playing, but you will not be given information about the number of periods chosen by the computer.)

Each participant will make a decision in each period. The members of a group remain the same during all periods.

At the beginning of the experiment, i.e. in the first period, each participant will receive an endowment of €40 in a private account, and this is the amount of money you will have to manage during the experiment. In each period you will have the possibility to contribute to a public account, the aim of which is to avoid a catastrophe that - if it happens - will cause damage to all members of your group. In each period you will be asked whether you want to invest €0, 2 or 4 in the public account from the money you have left in that moment in the private account.

Your profit from the experiment will depend on the one hand, on whether your group has managed to avoid the catastrophe, and on the other hand, on the money you have left in your private account at the end of the experiment. To avoid the catastrophe, your group must have accumulated at least €120 in the public account, and in this case each member of the group will receive the money left in his private account. In case your group does not avoid the catastrophe, i.e. if it has accumulated less than €120 in the public account at the end of the experiment, each group member will lose 90% of his private account balance and will receive the remaining 10% as gains from the experiment.

In summary, your earnings from the game will be:

(1) If the catastrophe has been avoided (your group has accumulated at least €120 in the public account at the end of the experiment): Gains = Money in your private account

(2) If the catastrophe has not been avoided (your group has accumulated less than €120 in the public account at the end of the experiment):

Gains = 10%*Money in your private account

Remember, in both cases, the money in your private account is: €40 - your total contribution to the public account during all periods.

Example 1: Imagine that throughout the experiment you have contributed a total of €18 to the public account (and therefore you have €22 left in your private account) and your group's total contribution to the public account is €130. In this case, your group has enough balance to avoid the catastrophe (130¿120), therefore, your gain from the experiment is the balance of your private account, €22.

(In the risk and uncertainty treatments, we had the following example 1: **Example 1**: Imagine that the experiment ends in period 10 and throughout the experiment you have contributed a total of €18 to the public account (and therefore you have €22 left in your private account) and the total contribution of your group to the public account is €130. In this case, your group does have enough balance to avoid catastrophe (130¿120), therefore, your profit from the experiment is the balance of your private account, €22.)

Example 2: Now suppose that your contribution to the public account has been €18 in total (so you have €22 left in your private account), but your group has collected a total of €115 in the public account until the end of the experiment. In this case **your group does not have enough money to avoid the catastrophe** (115¡120). As a consequence, all members of your group lose 90% of the money in their private account and keep the remaining 10%. In your case, this means that your gain from the experiment is 10%*€22=€2.2.

(In the risk and uncertainty treatments, we had the following example 2: **Example 2**: Now suppose the experiment ends in period 8 and your contribution to the public account has been €18 in total (therefore, you have €22 left in your private account), but your group has collected a total of €115 in the public account until the end of the experiment. In this case **your group does not**

have enough money to avoid catastrophe (115¡120). As a result, all members of your group lose 90% of the money in their private account and keep the remaining 10%. In your case, this means that your profit from the experiment is 10%*€22=€2.2.)

Decisions in each period are made simultaneously, so when you decide whether to contribute €0, 2 or 4 to the public account you will not know the decisions of the other members of your group, and they will not know your decision at this time. However, at the end of each period we will inform you anonymously (using the aliases of each member) about the contribution of each member of your group to the public account in each period (including the current period), the amount of money accumulated by your group in the public account in each period and in total up to the current period, and you will also be informed of the balance of your private account in the current period.

At the end of the experiment, you will be informed about the results of the game: the money your group has collected in total in the public account, the balance of your private account, whether your group has managed to avoid the catastrophe, and your gains from the experiment. At the end of the session you will be paid the gains of the experiment in euros together with the €5 you receive for your participation.

Before we start, we will ask you to answer some questions to check that you have understood the instructions. When all participants have answered these questions correctly, we will start the experiment.

B Individual and group contributions - statistical comparison

	Mean ind. contributions			Wilcoxon ranksum test			t-test		
	Certainty	Risk	Ambiguity	C-R	C-A	R-A	C-R	C-A	R-A
Overall	1.943	2.329	2.404	0.000	0.000	0.481	0.000	0.000	0.380
Period 1-4	1.781	2.458	2.408	0.000	0.000	0.570	0.000	0.000	0.665
Period 5-8	2.104	2.200	2.400	0.325	0.005	0.134	0.433	0.011	0.112
Period 1	1.917	2.433	2.433	0.008	0.006	0.958	0.014	0.008	1.000
Period 2	1.917	2.600	2.600	0.004	0.003	0.876	0.006	0.003	1.000
Period 3	1.625	2.533	2.467	0.000	0.000	0.705	0.000	0.000	0.772
Period 4	1.667	2.267	2.133	0.009	0.054	0.644	0.006	0.037	0.586
Period 5	1.917	2.133	2.233	0.307	0.124	0.783	0.385	0.152	0.686
Period 6	1.958	2.267	2.767	0.147	0.000	0.052	0.197	0.000	0.044
Period 7	2.125	2.133	2.267	0.848	0.441	0.627	0.972	0.541	0.593
Period 8	2.417	2.267	2.333	0.678	0.866	0.876	0.561	0.734	0.800

Table 3: Mean individual contributions in the treatments. Comparison of medians using the Wilcoxon ranksum test, and compariosn of means using the t-test (p-values reported).

	Mean group contributions			Wilcoxon ranksum test			t-test		
	Certainty	Risk	Ambiguity	C-R	C-A	R-A	C-R	C-A	R-A
Overall	11.656	13.975	14.425	0.001	0.000	0.491	0.000	0.000	0.349
Period 1-4	10.688	14.750	14.450	0.000	0.000	0.874	0.000	0.000	0.681
Period 5-8	12.625	13.200	14.400	0.449	0.004	0.130	0.429	0.013	0.114
Period 1	11.500	14.600	14.600	0.019	0.008	0.946	0.016	0.007	1.000
Period 2	11.500	15.600	15.600	0.032	0.009	0.967	0.028	0.006	1.000
Period 3	9.750	15.200	14.800	0.008	0.006	0.857	0.006	0.003	0.819
Period 4	10.000	13.600	12.800	0.010	0.026	0.715	0.009	0.014	0.556
Period 5	11.500	12.800	13.400	0.302	0.218	0.963	0.410	0.119	0.668
Period 6	11.750	13.600	16.600	0.198	0.001	0.063	0.119	0.001	0.041
Period 7	12.750	12.800	13.600	1.000	0.356	0.493	0.966	0.208	0.449
Period 8	14.500	13.600	14.000	0.548	0.946	0.688	0.634	0.801	0.847

Table 4: Mean group contributions in the treatments. Comparison of medians using the Wilcoxon ranksum test, and compariosn of means using the t-test (p-values reported).

	Mean group cumulative contributions			Wilcoxon ranksum test			t-test		
	Certainty	Risk	Ambiguity	C-R	C-A	R-A	C-R	C-A	R-A
Period 1	11.500	14.600	14.6	0.019	0.008	0.946	0.016	0.007	1.000
Period 2	23.000	30.200	30.200	0.004	0.002	0.805	0.011	0.002	1.000
Period 3	32.750	45.400	45.000	0.004	0.000	0.724	0.002	0.000	0.902
Period 4	42.750	59.000	57.800	0.001	0.000	0.726	0.001	0.000	0.757
Period 5	54.250	71.800	71.200	0.001	0.000	0.751	0.001	0.001	0.883
Period 6	66.000	85.400	87.800	0.0002	0.000	0.443	0.000	0.000	0.566
Period 7	78.750	98.200	101.400	0.000	0.000	0.361	0.000	0.000	0.455
Period 8	93.250	111.800	115.400	0.001	0.000	0.491	0.000	0.000	0.349

Table 5: Mean group cumulative contributions in the treatments. Comparison of medians using the Wilcoxon ranksum test, and compariosn of means using the t-test (p-values reported).

C Comparison of €0,2,4 contributions

	Certainty-Risk	Certainty-Ambiguity	Risk-Ambiguity
Overall	0.000	0.000	0.695
Period 1-4	0.000	0.000	0.963
Period 5-8	0.013	0.002	0.585
Period 1	0.054	0.129	1.000
Period 2	0.010	0.075	0.999
Period 3	0.001	0.015	0.999
Period 4	0.022	0.037	1.000
Period 5	0.228	0.574	0.928
Period 6	0.157	0.001	0.513
Period 7	0.788	0.504	1.000
Period 8	0.504	0.906	1.000

Table 6: Comparing the distribution of €0,2,4 contributions using the Kolmogorov-Smirnov test. P-values reported.

	Certainty-Risk	Certainty-Ambiguity	Risk-Ambiguity
Overall	0.168	0.598	0.043
Period 1-4	0.280	0.078	0.474
Period 5-8	0.004	0.294	0.040
Period 1	0.943	0.484	0.509
Period 2	0.628	0.100	0.224
Period 3	0.194	0.062	0.543
Period 4	0.813	0.658	0.471
Period 5	0.254	0.852	0.157
Period 6	0.408	0.478	0.107
Period 7	0.089	0.200	0.637
Period 8	0.025	0.098	0.487

Table 7: Comparing the proportion of €0 contributions using the two-sided test of proportions. P-values reported.

	Certainty-Risk	Certainty-Ambiguity	Risk-Ambiguity
Overall	0.000	0.000	0.093
Period 1-4	0.000	0.000	0.142
Period 5-8	0.000	0.000	0.361
Period 1	0.005	0.033	0.453
Period 2	0.004	0.130	0.144
Period 3	0.004	0.059	0.271
Period 4	0.003	0.001	0.714
Period 5	0.003	0.141	0.099
Period 6	0.004	0.001	0.583
Period 7	0.011	0.011	1.000
Period 8	0.016	0.082	0.464

Table 8: Comparing the proportion of €2 contributions using the two-sided test of proportions. P-values reported.

	Certainty-Risk	Certainty-Ambiguity	Risk-Ambiguity
Overall	0.000	0.000	0.783
Period 1-4	0.000	0.000	0.286
Period 5-8	0.000	0.000	0.494
Period 1	0.001	0.003	0.690
Period 2	0.001	0.004	0.456
Period 3	0.000	0.000	0.444
Period 4	0.000	0.000	0.838
Period 5	0.014	0.053	0.540
Period 6	0.008	0.000	0.092
Period 7	0.128	0.059	0.685
Period 8	0.379	0.484	0.847

Table 9: Comparing the proportion of €4 contributions using the two-sided test of proportions. P-values reported.

D Randomization and correlations

The first column shows the variables. Section 2 contains the description of the variables. Columns Certainty, Risk and Ambiguity contain the averages in the given treatment. The last three columns indicate the p-values of statistical tests that compare the treatments. C-R denotes the comparison between the Certainty and the Risk treatment, C-A and R-A represent the Certainty vs Ambiguity, and the Risk vs Ambiguity comparisons. We used the two-sided t-test for Age, University Admission Score, Cognitive Reflection Test, Patience, Procrastination, Negative Reciprocity, Positive Reciprocity, Altruism, Trust, Self-assessed Risk Attitude, Bomb Risk, and Loss Aversion. The rest of the variables are binary, so we applied the two-sided test of proportions.

	Certainty (N=48)	Risk (N=60)	Ambiguity (N=60)	C-R	C-A	R-A
Age	20.35	20.20	20.07	0.67	0.52	0.72
Female	0.58	0.60	0.65	0.86	0.48	0.57
Spanish	0.96	0.95	0.93	0.84	0.57	0.70
Studies	0.96	0.97	1	0.82	0.11	0.15
Economics&Business	0.21	0.32	0.38	0.21	0.05	0.44
University Admission Score	10.51	10.67	10.87	0.76	0.48	0.58
Cognitive Reflection Test	0.71	0.83	0.73	0.53	0.90	0.59
Patience	7.06	7.55	6.77	0.25	0.44	0.04
Procrastination	6.19	6.2	6.367	0.98	0.73	0.72
Negative Reciprocity	5.19	4.97	5.02	0.69	0.74	0.92
Positive Reciprocity	9.44	9.45	9.32	0.96	0.62	0.41
Altruism	6.60	6.68	6.82	0.87	0.64	0.76
Trust	4.58	4.53	4.78	0.93	0.70	0.60
Self-assessed Risk Attitude	5.96	6.10	6.02	0.68	0.85	0.79
Choice Risk Attitude	0.06	0.07	0.10	0.93	0.48	0.51
Bomb Risk	33.92	32.87	35.55	0.73	0.60	0.31
Loss Aversion	2.75	2.5	2.53	0.13	0.19	0.84

Table 10: Demographic date, cognitive measures and preferences in the different treatments

	Age	Female	Spanish	Studies	Econ&Bus	Univ. Adm. Score	Cogn. Refl. Test	Patience	Procrast.	Neg. Recip.	Pos. Recip.	Altruism	Trust	Self-ass. Risk	Choice Risk	Bomb Risk
Female	0.08	-														
Spanish	-0.39***	0.03	-													
Studies	-0.21***	-0.04	-0.03	-												
Econ&Bus	-0.13	-0.10	-0.07	0.10	-											
Univ. Adm. Score	-0.48***	-0.07	0.53***	0.17**	0.08	-										
Cogn. Refl. Test	-0.05	-0.34***	0.13	0.04	-0.03	0.17**	-									
Patience	0.03	-0.19**	-0.10	-0.03	0.21***	-0.05	0.05	-								
Procrast.	-0.05	0.12	0.06	0.10	-0.08	0.08	-0.03	-0.04	-							
Neg. Recip.	-0.02	-0.14*	0.10	-0.03	-0.03	0.02	0.02	0.00	0.09	-						
Pos. Recip.	-0.17**	-0.05	0.11	0.30***	0.05	0.29***	-0.00	0.02	-0.04	0.00	-					
Altruism	0.01	0.14*	-0.14*	0.16**	-0.11	-0.01	-0.14*	0.06	0.02	0.09	0.24***	-				
Trust	0.04	-0.03	0.07	-0.05	-0.16**	-0.04	0.10	-0.03	0.05	0.03	-0.02	0.16**	-			
Self-ass. Risk	-0.01	0.01	-0.08	0.07	0.06	-0.10	-0.14*	0.13	-0.06	0.07	0.18**	0.23***	0.01	-		
Choice Risk	0.11	-0.14*	-0.03	-0.10	0.14*	-0.11	0.02	-0.06	-0.09	0.08	0.02	-0.03	0.07	0.13*	-	
Bomb Risk	0.04	-0.12	0.01	0.05	0.10	-0.03	-0.06	0.13	0.09	0.10	-0.01	0.03	-0.04	0.24***	0.18**	-
Loss Aversion	-0.15**	0.04	0.07	0.11	-0.15**	0.06	-0.02	-0.06	0.15**	-0.06	-0.08	-0.07	0.01	-0.32***	-0.14*	-0.16**

Table 11: Pairwise correlations between the variables of interest (*** p<0.01, ** p<0.05, * p<0.1)