Delegation and Public Pressure in a Threshold Public Goods Game

Doruk İriş
Sogang University

Jungmin Lee
Seoul National University and Institute for the Study of Labor (IZA)

Alessandro Tavoni[1]
London School of Economics, Grantham Research Institute on Climate Change and Environment

Abstract

The provision of global public goods, such as climate change mitigation and managing fisheries to avoid overharvesting, requires the coordination of national contributions. The contributions are managed by elected governments who, in turn, are subject to public pressure on the matter. In an experimental setting, we randomly assign subjects into four teams, and ask them to elect a delegate through the mechanism of majority voting. The elected delegates play several variants of a one-shot public goods game in which losses can ensue if the sum of their contributions falls short of a threshold. Earnings are split evenly among the team members, including the delegate. We find that delegation alone causes a small reduction in the group contributions. When delegation is coupled with public pressure, in the form of teammates' messages to their delegate, it has a significantly negative effect on contributions, even though the messages are restricted to payoff-inconsequential suggested contributions (cheap talk). The reason is that delegates appear to give more weight to the least ambitious message: they focus on the lower of the two public good contributions suggested by their teammates.

Keywords: delegation; cooperation; threshold public goods game; climate experiment; regret theory

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[1] Houghton Street, London WC2A 2AE; United Kingdom. a.tavoni@lse.ac.uk

I. Introduction

Much of human activity entails delegation, both at the inter-personal level and at the societal level. Furthermore, while we may have preferences for certain options, we often lack the ability or power to be the decision makers. In addition, given the difficulty of optimal preference aggregation, delegation has the potential to ease decision-making. Hence, in many situations, we rely on an "expert," such as a family member or a politician, depending on the scale of the decision task. At the same time, we express preferences with varying degrees of formality (ranging from voting on candidates or referendum topics in democracies to letting someone choose where to have dinner).

Many group decisions involving the provision of a public good rely on voluntary contributions, which are beneficial for the group, but costly for individuals. Here, we focus on discrete provision, where the public good only has value if enough has been contributed, either because the scale of the project requires a minimum investment, or because of its non-scalability. Examples include the construction of a dam or a bridge, national defense investments, and efforts to mitigate dangerous CO_2 concentration levels. Since delegates often make these decisions, we look at the interplay between threshold public goods provision and delegation. Does this institution improve upon single-actor decisions, or are delegates more prone to pursuing self-interest at the expense of the group?[2] In addition, what role does preference signaling by the constituency play in steering delegates' choices?

In this section we briefly summarize some recent literature pertaining to group decision-making, delegation and threshold effects in influencing cooperation (as measured by private provision of public goods), since these strands are closest to our experiment. We relegate a longer discussion of related literature to Appendix 3.

Commons end in tragedy when institutions fail to control free-riding behavior (Tavoni and Levin, 2014). Field observations and experiments suggest that commons can be managed successfully, even in the absence of governmental regulations or property rights, provided that effective coordination mechanisms, such as communication, are in

[2] Throughout this paper, we simplistically refer to a "group" as a society that consists of "teams." Each team has a "delegate", who acts on behalf of the team and shares the earnings equally with her team members.

place (Ostrom et al., 1994; Dietz et al., 2003). However, even in the presence of a known threshold with the potential to trigger a catastrophe, coordination can be difficult, especially when the parties have different stakes in the game (Tavoni et al., 2011). If instead of financing a standard public good, we are dealing with an uncertain common loss arising from crossing a tipping point, such as a fishery collapse triggered by overharvesting or catastrophic climate change from excessive carbon concentrations, sustaining cooperation is even more problematic. Uncertainty on the location of the tipping point aggravates the coordination task, increasing the tendency to slip into inaction (Barrett and Dannenberg, 2012; Dannenberg et al., 2014).

Much research has studied what facilitates cooperation in experimental settings, notably utilizing the metaphor offered by public goods games and resource dilemmas to capture the conflicting strategic motives behind self- and group-interest. The bulk of the experimental literature on public good provision has focused on the linear case, where choices are dominant strategies and the only equilibrium entails zero contributions to the public good.

While the effect of delegation on this class of games has been studied before (e.g. Hamman, Weber, and Woon, 2011), we are the first to investigate how delegation affects public good provision choices that are strategic substitutes, to the best of our knowledge. We expect the role of delegation to be prominent in this context, where a second equilibrium entailing public good provision exists and players can free-ride on others' provision. Therefore, the constituency may have an incentive to strategically delegate to agents who have a lower valuation for the public good than they have themselves (Habla and Winkler, 2016). In addition to this literature, we contribute to the one on coordination in threshold public good, by interacting two kinds of uncertainty (on the location of the provision threshold and on the magnitude of losses from failure to reach it) with delegation. The combination of the above sources of strategic uncertainty and delegation had yet to be studied experimentally.

Specifically, we investigate whether delegates can reach a collective target, knowing that missing the target may trigger severe losses. To this end, our experimental treatments are designed to assess how the provision of a threshold public good is affected by the type of constituency that delegates are responsible to, and by the degree of public pressure they are exposed to. We tackle these issues in the laboratory, where we randomly assign subjects into four teams, and ask them to elect a delegate through the mechanism of majority voting. The elected delegates play several variants of a one-shot public goods game in which losses can ensue if the sum of their contributions falls short of a threshold. Earnings are split evenly among the team members, including the delegate (in treatments featuring representation).

We find that delegation alone causes a small reduction in the group contributions. When delegation is coupled with public pressure, in the form of teammates' messages to their delegate, it has a significantly negative effect on contributions, despite the fact that the messages are restricted to payoff-inconsequential suggested contributions (cheap talk). The reason is that delegates appear to give more weight to the least ambitious message: they focus on the lower of the two public good contributions suggested by their teammates.

In section II, we briefly present the model underlying the game tested here. Sections III–V are respectively concerned with design, experimental results and discussion, followed by a brief conclusion in Section VI. Additional theoretical results, laboratory materials, literature discussion, as well as additional tables and figures concerning the empirical analysis appear in the four appendices.

II. Threshold Public Goods Game

A. Basic model

There are N teams and each has k members. Each member has initial endowment e and, thus, each team collectively has an endowment of $E = ke$. Each team i decides simultaneously how much to contribute as a team, C_i, to reach a threshold T, and no team can reach the threshold on its own: $E < T$. If the sum of all teams' contributions exceeds the threshold, $\sum_i C_i \geq T$, then they avoid the potential loss, and each team i enjoys the remaining amount, $E - C_i$. Otherwise, each team is left with $q \in [0, 1)$ of the remaining amount with probability p (so that with probability $1 - p$ it still enjoys the entirety of $E - C_i$). There is no rebate. The payoff function with certain threshold is written as follows:

$$g(C_i, C_{-i}) = \begin{cases} E - C_i, if \ \sum_i C_i \geq T \\ pq(E - C_i) \ + \ (1-p)(E - C_i), \ if \ \sum_i C_i < T \end{cases}, \quad (1)$$

where $C_{-i} = (C_1, \dots C_{i-1}, C_{i+1}, \dots, C_N)$. There are two symmetric pure strategy Nash equilibria, namely no contribution (NC) and a symmetric provision contribution (SPC) (i.e., contributing T/N as a team). The second equilibrium exists only if

$$E - T/N \geq pqE + (1-p)\, E \Leftrightarrow pE(1-q) \geq T/N. \quad (2)$$

In this section, we restrict attention to the comparison of these two symmetric pure strategy equilibria, since they are likely to be focal relative to the many asymmetric equilibria in this game (Cadsby and Maynes, 1999, Dannenberg et al., 2014). Thus, teams' choices are expected to coalesce around those points.

We experimentally study this discrete public goods game both in the presence of a certain threshold T, and when the threshold is a random variable $\tilde{T}$. Under uncertainty about the location of the threshold, one of two equally likely thresholds T_1 and T_2 is selected randomly, with mean equal to T (i.e., $E(\tilde{T}) = 0.5T_1 + 0.5T_2 = T$, with $T_1 < T_2$). The payoff function with uncertain threshold is written as follows:

$$\tilde{g}(C_i, C_{-i}) =$$

$$\begin{cases} E - C_i, if \ \sum_i C_i \geq T_2 \\ 0.5(E - C_i) + 0.5\big(pq(E - C_i) + (1-p)(E - C_i)\big), \ if \ T_1 \leq \sum_i C_i < T_2 \\ pq(E - C_i) \ + \ (1-p)(E - C_i), if \ \sum_i C_i < T_1 \end{cases} \quad (3)$$

There are three symmetric pure strategy Nash equilibria with threshold uncertainty: no contribution (NC, as for the certain threshold), and symmetric provisions aiming to reach either T_1 (SPC1) or T_2 (SPC2). In the latter two, each team contributes T_1/N and T_2/N, respectively. The expected payoffs of SPC1 and SPC2 are, respectively:

$$\frac{1}{2}pq\left(E - \frac{T_1}{N}\right) + \frac{1}{2}\left(E - \frac{T_1}{N}\right) \text{ and } E - \frac{T_2}{N}. \quad (4)$$

For the remainder of this section, we focus on the certain threshold case for simplicity. We discuss the implications of threshold uncertainty at the end of the section.

B. Presence of Threshold

No contribution is the unique equilibrium in a standard public goods game because of free-riding incentives. By introducing the threshold, the game is transformed into one involving a choice between NC and SPC, and decision makers face the well-known problem of coordination owing to strategic uncertainty.

Let π_i be the subjective beliefs of team i about reaching the threshold when targeting the SPC (contributing T/N), given the uncertainty about whether total contributions, including those by other teams, will suffice to reach the threshold. We assume that team i believes that if it contributes nothing, the other teams' contributions will not suffice to reach the threshold. Condition (2) can be modified to accommodate subjective beliefs, as follows:

$$u(T/N|\pi_i) \geq u(0|\pi_i) \Leftrightarrow$$

$$\pi_i\left(E-\frac{T}{N}\right)+(1-\pi_i)\left(pq\left(E-\frac{T}{N}\right)+(1-p)\left(E-\frac{T}{N}\right)\right) \geq pqE+(1-p)\,E \qquad (5)$$

$$\Leftrightarrow \pi_i \geq \frac{T\big(1-p(1-q)\big)}{(EN-T)p(1-q)},$$

where $u(C_i|\pi_i)$ is team i's (expected) utility given its subjective beliefs. The threshold will be met provided that $\sum_{j\neq i}^{N} C_j \geq \frac{T(N-1)}{N}$. However, team i places probability $(1-\pi_i)$ on the event that $\sum_{j\neq i}^{N} C_j < \frac{T(N-1)}{N}$. This subjective probability lowers the symmetric provision equilibrium payoff, since coordination is no longer guaranteed. That is, even though team i contributes T/N, the group might still not reach the threshold, in which case the contributions will be wasted.

Note that uncertainty is involved in both symmetric equilibria when π_i is included. While the expected payoff under no contribution depends only on p, the expected payoff under the symmetric provision equilibrium depends on both p and π_i. Thus, in choosing between the two strategies, teams could gravitate towards the "safer" zero contribution strategy.[3] Nevertheless, we expect overall contributions to increase in p, since payoffs decrease in p when following NC, and coordination failure to deepen under threshold uncertainty.

[3] In a sense, this game resembles the stag-hunt game in which players have to decide between socially cooperative and safe strategies. By contributing positive amounts, teams risk becoming the "sucker" of the group, which increases the tendency towards inaction.

We assume that the delegate and her teammates have the same objective function and information. As the team's earnings are shared equally among the members, there is no strategic interaction between them. Under standard models assuming rationality, such as the one discussed above, the delegate's behavior would be the same as that of a self-representing individual player, irrespective of whether communication within teams is allowed.[4]

III. Experimental design

The experiment was conducted offline at Sogang University, Korea, in February 2013. The experiment consists of three treatments, with eight groups in each treatment, and four teams in each group. This gives a total of 96 teams (224 subjects distributed as follows: 32 in Treatment 1, 96 in Treatment 2, and 96 in Treatment 3). In every session, we randomly form $N = 4$ teams of variable size k (either one or three team members), which remain unchanged throughout the session. Each team is endowed with $E = 120$ laboratory dollars for every round.[5] Subjects interact anonymously throughout the experiment by indicating their choices on sheets of paper that are distributed and collected by the experimenters. The collected information is shared with the subjects, when necessary, by means of projectors. In the beginning of the session, subjects are warned that they are not allowed to communicate with others throughout the experiment, with the exception of the structured written communication introduced in treatment 3 (see below). Subjects were always supervised by at least one lab assistant and no attempt of breach of conduct was detected.

A. Game phases

Each session consists of two phases, namely the practice phase (1 round) and the actual game phase, which consists of six rounds that are repeated to feature different values of p and to turn on threshold uncertainty. Subjects are informed about the two phases. However, in the actual game, they are only informed that they play multiple rounds, one of which is chosen randomly to determine the subjects' earnings at the end of

[4] Similarly, as we explain in Section III, we rule out strategic communication between teams.
[5] To keep the earnings and, thus, the monetary incentives unchanged between treatments, we set the exchange rate between the laboratory dollar and the USD in the first treatment at 3 laboratory dollar = 1 USD. In the other treatments, the exchange rate is 1 laboratory dollar = 1 USD.

the session. In each round, the decision makers play a one-shot threshold public goods game. Here, the four teams decide simultaneously on how much to contribute to the public good (in multiples of 1 laboratory dollar) to reach a group threshold $T = 240$ laboratory dollars (or the corresponding uncertain and equally likely thresholds, $T_1 = 190$ or $T_2 = 290$). Subjects are made aware that failing to collectively reach the threshold means losing 90% of their remaining endowment (i.e., $q = 0.1$) with probability p. The degree of loss uncertainty is parameterized with three values of $p \in \{0.55, 0.75, 0.95\}$, hence, ranging from highly uncertain (55% probability) to almost certain (95% probability) losses under non-provision.

Table 1: Main Parameters and Equilibria

	Practice Phase	**Game Phase**					
		Round 1	**Round 2**	**Round 3**	**Round 4**	**Round 5**	**Round 6**
Loss Uncertainty (*p*)	0.55	0.75	0.55	0.95	0.95	0.55	0.75
Threshold Location Uncertainty	Uncertain $\tilde{T}$ (T_1=190 T_2=290)	Certain T (T=240)	Certain T (T=240)	Certain T (T=240)	Uncertain $\tilde{T}$ (T_1=190 T_2=290)	Uncertain $\tilde{T}$ (T_1=190 T_2=290)	Uncertain $\tilde{T}$ (T_1=190 T_2=290)
Damage Rate (1-*q*)	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Highest Expected Payoff Equilibria	NC	SPC	NC=SPC	SPC	SPC2	NC	SPC1

In each of the first three rounds, they play the game with certain threshold T and probabilities p equal to 0.55, 0.75, and 0.95 (randomly drawn only once before the experiment, without replacement, and with the same order of rounds played in every session). In addition to the varying degree of loss uncertainty captured by the three values of p, the following three rounds are characterized by uncertainty over the location of the threshold $\tilde{T}$. Here, T_1 and T_2 have equal probability of materializing, and the mean of the two thresholds is 240, as in the first three rounds featuring threshold certainty.[6] Note that

[6] A widely discussed paper (Rockström et al., 2009) identified a boundary for climate change "to ensure the continued existence of the large polar ice sheets," for which "there is a critical threshold between 350 and 550 ppmv [parts per million by volume]". Simplifying this evidence,

the game phase (i.e., the financially incentivized phase) is designed such that over the course of the six rounds, the teams face each value of p twice, once for certainty and once for uncertainty over the location of the threshold.

Table 1 summarizes the main parameters used in the experiment and the accompanying symmetric pure strategy Nash equilibrium attaining the highest expected payoff. Note that in all rounds, NC is always an equilibrium, but depending on the two types of uncertainty, provision can also be an equilibrium. Round 5 is designed to trigger the least contributions to the public good, as the only equilibrium is the no contribution case. Round 2 is next, as risk neutral players will be indifferent between NC and SPC. In the remaining rounds, public good provision is the Pareto-superior equilibrium. The difference between Rounds 1 and 3 and Rounds 4 and 6 is that, in the latter two, which feature threshold location uncertainty, the highest payoff is attained when the highest and lowest targets are met in Round 4 and 6, respectively.

To facilitate the coordination task, we also introduce a pledge stage before subjects decide their contributions. In the pledge stage, they announce how much they intend to contribute and how much they expect the other teams to contribute. Then, they play the contribution stage, in which they input their actual contributions to the public good.

We announce the other teams' contributions and results of each round at the end of the session to minimize possible income effects owing to performance in a given round.[7] We treat each round as independent observation of a one-shot threshold public goods game. Since subjects learn others' pledges in every round, we control round effects and also provide results using only the observation from the first round. Moreover, we

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we choose T_1 and T_2 such that they resemble the boundaries; for our choice of parameters, they are about 80% and 120% of T, respectively.

[7] After both phases of the game (and the ensuing questionnaire) are completed, each participant drew a number in front of the experimenter using the random number generator available at www.random.org. Participants knew that the draw would determine which of the six rounds would be selected for payment. If the selected round entailed threshold location uncertainty, a further draw determined which of the two thresholds T_1 and T_2 would count. Lastly, when the group's contribution did not exceed the threshold, another draw determined whether the cash after the contribution remained intact or was reduced.

randomly allocate anonymous ID cards to subjects to determine teams and to control reputation effects.[8]

B. Practice phase and voting

After teams are formed, subjects are allocated to their team rooms. The session begins with the unpaid practice phase in which team members play a game *within* the team with uncertain threshold $\tilde{T}$ and probability $p = 0.55$. Each team member decides how much to pledge, as well as how much s/he expects other teams to contribute. This information is projected onto a screen, together with the subjects' IDs. Team members observe their teammates' pledges and expectations from other teams and decide how much to contribute, which is also projected onto the screen with the subjects' IDs. No information (pledges, expectations, and contributions) are revealed to other teams to avoid learning. The purpose of the practice round is subjects to form an opinion about their teammates' willingness to invest in the public good by observing their pledges, expectations from the other teams, as well as how much they eventually contribute. It is particularly important for the treatments with $k = 3$, in which each team elects a delegate after the pledge stage (before the contribution stage; see below). In fact, this is the only information about candidates at the moment of voting.

To elect a delegate, every team member is a candidate and can vote for anyone, including him or herself. The majority voting eliminates ties and guarantees that a delegate is chosen, except in the case in which all subjects have one vote. In this case, another vote takes place to determine the least wanted candidate. Again, majority voting eliminates ties and one team member is chosen to not to be a delegate, except in the case of again all having one vote. In this case, we randomly eliminate one candidate. Majority voting then guarantees a delegate is chosen with two candidates and three votes. Random elimination was only needed 3 times out of 64 elections.

C. Treatments

Table 2 summarizes the main differences across the treatments.

[8] Details about the ID cards and other experimental procedures are in Appendix 2. Additionally, instructions, decision sheets, and survey questions can be found at https://goo.gl/tgSIHr.

Table 2. Treatments

	Loss Uncertainty (p)	**Location Uncertainty** (T_1, T_2)	**Delegation**	**Messages**
NoD ($N = 4$, $k = 1$)	✓	✓ (Rounds 4–6)		
DnoM ($N = 4$, $k = 3$)	✓	✓ (Rounds 4–6)	✓	
DM ($N = 4$, $k = 3$)	✓	✓ (Rounds 4–6)	✓	✓

Treatment 1: No delegation (NoD)

Individual "delegates" represent only themselves, play six rounds, and receive all the team's earnings.

Treatment 2: Delegation, no messages (DnoM)

The elected delegates of the teams move to another room to play all six rounds. The delegates decide how much their team will contribute without communicating with their teammates. The information about the pledge stages in each round is revealed to the non-delegates and they are asked for their opinion on how much their delegate should contribute. Note that teammates know their delegate's pledge and their expectations regarding other teams, but they do not know the identities of the other teams between rounds, as this is controlled via ID cards. The earnings of the team are split evenly among the members.

Table 3. Timing of the Treatments

NoD	DnoM	DM
One-member team	Three-member team	Three-member team
Practice phase in team room	Practice phase in team room	Practice phase in team room
	Team members elect a delegate via majority voting	Team members elect a delegate via majority voting
One-member teams move to common room	Delegates move to common room	Everyone moves to common room Four delegates sit on the front row; teammates sit behind them
Pledge and contribution: The four teams play six rounds	Pledge and contribution: The four teams play six rounds	Pledge and contribution: The four teams play six rounds
	Teammates share their opinion with the experimenter on their team's contribution	Teammates share their opinion on their team's contribution to the delegates via the experimenter

Treatment 3: Delegation and messages (DM)

In contrast to DnoM, in DM, all elected delegates and the non-delegates move to a common room. The delegates are seated in the first rows and their teammates just behind them. Teammates do not see their delegate's decision sheet, but the delegate feels the pressure of his or her teammates sitting behind. All subjects know who the delegates are, since they sit in the front rows. They also know who their teammates are, but do not know which delegate represents each team in any round. Round 1 begins with the pledge stage in which delegates represent their teams and the pledges are declared to all. After the pledge stage, each non-delegate sends his opinion about how much the team should contribute to the team's delegate via the experimenters. The delegate checks the teammates' opinions and freely chooses the team's contribution level. Note that teammates only know their delegate's pledge and their expectations about the other teams. Furthermore, recall that the delegates' contributions are not revealed until the end of the session. The remaining rounds follow the same procedure. Finally, the earnings of the team are split evenly among the members.[9] The main logistical features of the treatments are summarized in Table 3.

IV. Empirical results

A. Random assignments of subjects

Table 4 summarizes the subjects' characteristics across treatments. In total, we have 224 subjects. We have 32 subjects for the noD treatment and 96 (32 delegates and 64 non-delegates) for each of the DnoM and DM treatments. All subjects are undergraduate students at Sogang University, Korea. We collected basic background information, such as age, gender, and major, as well as some attitudinal variables and thoughts about their choices during the experiment via post-experiment surveys. Table 4 shows that 56–62 percent of subjects are male, and the average age is 22–23. On average, they are enrolled for about five semesters, and approximately 60 percent of the students are economics or business majors. The last column presents the p-value of the Chi-square test of equality across treatments. Here, we find no significant differences in any background variable across treatments. This suggests that subjects are assigned randomly to observables across treatments. As mentioned, we also collected attitudinal variables, namely attitudes toward general risk, the lottery, global warming, and recycling. Again, none of these variables showed any difference across treatments.

[9] The show-up fee is 10,000 KRW (about 10 USD). The average earnings are 10,195 KRW, with a maximum of 40,000 and a minimum of 1,000.

Table 4. Subjects' Characteristics across Treatments: Random Assignment

	noD (Baseline)	DnoM	DM	p-value of equality test
Male	0.563	0.563	0.615	0.736
	(0.504)	(0.499)	(0.489)	
Age	22.468	23.156	22.739	0.708
	(2.016)	(6.204)	(2.128)	
Enrolled semesters	5.094	5.125	4.927	0.549
	(2.277)	(2.084)	(2.001)	
ECON/BUS major	0.625	0.583	0.604	0.906
	(0.492)	(0.496)	(0.492)	
General risk (0-10 scale)	4.250	4.885	4.821	0.507
	(1.901)	(2.352)	(2.356)	
Lottery (1-5)	4.469	3.990	4.074	0.543
	(1.244)	(1.326)	(1.331)	
Global warming (0-10)	6.438	6.313	6.358	0.645
	(1.950)	(2.104)	(2.138)	
Recycling (0-10)	7.188	7.500	7.495	0.574
	(2.007)	(1.886)	(2.093)	
Number of subjects	32	96	96	

Notes: noD= Individuals; DnoM = Delegates without non-delegates' messages; DM = Delegates with non-delegates' messages. Standard deviations are in parentheses. The last column present the p-value for the test of mean equality across treatments.

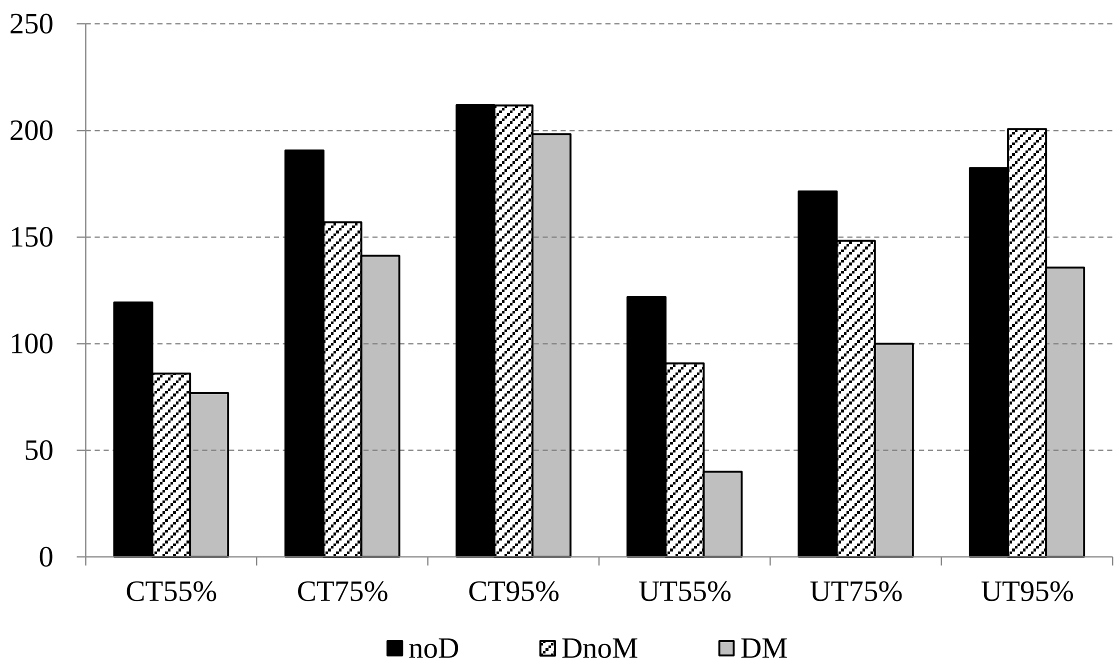
B. Group contribution

For the purpose of our study, a key outcome is the total contribution of a group. Figure 1 shows the average group contribution (there are eight groups per treatment) by treatment, disaster probability, and threshold uncertainty.[10] There are three notable results. First, as the probability of loss increases (from 55% to 95%), the group contribution tends to be larger. This is not surprising, since the incentive to avoid the risk of the loss should be larger when the probability of loss is higher. Second, comparing the average group contribution between CT and UT for each probability and treatment, we find that participants tend to contribute less when they face uncertainty about thresholds. Lastly, we find that the average group contribution is the largest in the baseline treatment

[10] Further results, including contributions in each group, pledges and survey findings are contained in Appendix 4.

(noD), and smallest in the DM. Next, we compare the average group contribution by treatment for each probability and threshold uncertainty setting (CT or UT).

Figure 1. Average Group Contributions across Treatments



Notes: CT55% = Certain threshold with probability of loss 55%; CT75% = Certain threshold with probability of loss 75%; CT95% = Certain threshold with probability of loss 95%; UT55% = Uncertain threshold with probability of loss 55%; UT75% = Uncertain threshold with probability of loss 75%; UT95% = Uncertain threshold with probability of loss 95%.

We confirm the above findings from unconditional mean differences by regression analysis. We run the following regression at the group level:

$$C_{jr} = \beta_0 + \beta_1 DnoM_j + \beta_2 DM_j + \gamma_1 p75_r + \gamma_2 p95_r + \gamma_3 UT_r + \epsilon_{jr},$$

where the dependent variable C_{jr} is the total contribution made by group j in round $r = 1, \ldots, 6$. $DnoM_j$ (or DM_j) indicates whether the group belongs to treatment DnoM (or DM). The omitted treatment is noD. Then, $p75_r$ (or $p95_r$) indicates whether the probability of loss is 75% (or 95%) in round r. The omitted probability is 55%. Lastly, UT_r indicates whether the threshold in round r is uncertain.

The results in Table 5 confirm our findings in Figure 1. Column 1 shows the results for all group-round observations. First, compared to noD, the group contribution in DnoM is lower by about 17 lab $. This gap is not statistically significant. However, the group contribution is significantly lower in DM, by about 51 lab $. This pattern by treatment holds after we separate the sample by the probability of loss, from Columns 2, 3, and 4, although the statistical significance differs.

Table 5. Treatment Effects on Group Contribution

	(1) All	(2) p = 55%	(3) p = 75%	(4) p = 95%	(5) First round
DnoM	-17.146	-32.188	-28.313	9.062	-33.625
	(18.958)	(25.156)	(24.151)	(21.029)	(25.116)
DM	-50.917***	-62.188**	-60.375***	-30.188	-49.375*
	(17.906)	(23.646)	(21.483)	(17.948)	(25.463)
Loss prob. = 75%	62.271***				
	(8.856)				
Loss prob. = 95%	100.979***				
	(10.191)				
Uncertain thresholds	-22.417**	-9.833	-23.042*	-34.375**	
	(8.652)	(9.025)	(11.806)	(13.170)	
Constant	123.062***	125.542***	192.521***	214.375***	190.625***
	(14.041)	(18.663)	(16.831)	(12.450)	(16.241)
Observations	144	48	48	48	24
R-squared	0.471	0.209	0.225	0.193	0.152

Notes: Robust standard errors, clustered by group, are presented in parentheses. Each group played 6 rounds. Significance level: *** 1%, ** 5%, * 10%.

There may be a concern about our experimental design in which subjects play multiple rounds within a fixed group, as there might be learning from repeated plays over rounds or some dynamic interaction between players within a group. To address this concern, in the last column, we use the sample of CT75%, which includes only the first round for each treatment. The number of observations is reduced to 24 (= 8 groups × 3 treatments). However, the group contribution remains significantly lower in DM than in noD.

Second, the group contribution is significantly higher, by 62 lab $, when the loss probability is 75%, and even higher, by 101 lab $, when it is 95%. Lastly, when the threshold is uncertain, the total group contribution is lower. This result is in line with our theoretical finding that threshold uncertainty should deepen the coordination failure. The effect of threshold uncertainty increases with the probability of loss.

C. Team decisions

We find that the total group contribution is lower when decisions are made by delegates (in DnoM and DM), and particularly when delegates are informed of their team members' opinions (in DM). To explain this finding, we examine the individual team decisions, as well as how the experimental and contextual variables affect decision makers in the different treatments. Specifically, we estimate the following equation, which determines the individual team choices:

$$c_{ijr} = \beta_1 Pldg_{-ijr} + \beta_2 Exp_{-ijr} + \gamma_1 p75_r + \gamma_2 p95_r + \gamma_2 UT_r + M_{ijr}\delta + \alpha_{ij} + \tau_r + \epsilon_{jr},$$

where the dependent variable, c_{ijr}, is the contribution of team i in group j in round r, and $Pldg_{-ijr}$ and Exp_{-ijr} represent the average pledge and the expectation presented by the other teams in the same group, respectively. Then, M_{ijr} encapsulates the messages from the team's non-delegates, and, as a value, either takes the average of the two messages, or takes the higher or lower of the two messages.[11] Lastly, we include individual-team fixed effects α_{ij} and round-specific fixed effects τ_r.[12] The individual-team fixed effects control for any effects from each team's time-invariant characteristics, including delegates' demographic characteristics or specific traits, as delegates are fixed once they are determined by voting. In addition, the round-specific fixed effects control for any potential dynamic effects over rounds. Therefore, δ is identified off the variation in teammates' messages round by round.

Table 6 presents the regression results. First, it is notable that there is no effect from average pledges or from the expectations of other decision makers. This appears to suggest that, in accordance with standard economic theory, but in contrast to field and experimental evidence, communication does not facilitate coordination in this game. Second, the probability of loss significantly affects teams' contributions.

[11] Note that M_{ijr} cannot be included for noD since there is no delegation in this treatment. Non-delegates' opinions are not delivered to delegates in DnoM. Therefore, there should be no effect of non-delegates' opinions on delegates' decisions in DnoM. This will serve as a validity test of our experimental design.

[12] For round-specific fixed effects, although there are six rounds, we can only include three dummies owing to perfect linear collinearity with $p75_r$, $p95_r$, and UT_r.

Table 6. Determinants of Team Contribution: Individual Fixed Effect

Treatment	noD	DnoM			DM			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Avg. pledge by others	-0.040	0.053	0.053	0.051	0.039	0.061	0.065	0.060
	(0.102)	(0.066)	(0.066)	(0.067)	(0.047)	(0.051)	(0.049)	(0.137)
Avg. expectation by others	-0.044	0.319	0.319	0.325	-0.186	-0.169	-0.183	0.187
	(0.213)	(0.235)	(0.237)	(0.231)	(0.137)	(0.166)	(0.163)	(0.328)
75% chance of loss	18.739***	15.068**	15.082***	15.154***	15.084***	8.177*	8.733*	13.595
	(5.353)	(5.541)	(5.440)	(5.487)	(5.336)	(4.733)	(4.734)	(8.665)
95% chance of loss	24.859***	30.286***	30.303***	30.554***	29.065***	16.877***	16.889***	19.470**
	(5.243)	(6.528)	(6.562)	(6.623)	(6.266)	(5.758)	(5.921)	(9.073)
Uncertain thresholds	-3.878	-4.512	-4.508	-4.216	-9.601*	-12.065**	-11.495**	-21.257**
	(5.494)	(5.928)	(5.961)	(5.954)	(5.333)	(4.761)	(4.729)	(9.235)
Team members' opinions								
Average			-0.001			0.483***		
			(0.116)			(0.119)		
Lower				0.025			0.342***	0.411*
				(0.089)			(0.115)	(0.213)
Higher				-0.032			0.136	-0.334
				(0.107)			(0.084)	(0.298)
Constant	38.342*	-4.724	-4.705	-3.931	-15.904	-13.386	-12.074	19.275
	(22.410)	(12.597)	(12.692)	(13.892)	(18.516)	(19.755)	(19.091)	(32.907)
Team FE	Y	Y	Y	Y	Y	Y	Y	Y
Round FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	192	192	192	192	192	192	192	99
R-squared	0.478	0.588	0.588	0.589	0.614	0.672	0.676	0.604

Notes: Robust standard errors, clustered by team, are presented in parentheses. Significance level: *** 1%, ** 5%, * 10%.

Comparing Columns 1, 2, and 5, we find that the effects have similar magnitudes across treatments. Lastly, we find that threshold uncertainty negatively affects the team contribution in DM only. In other words, delegates contribute less when the threshold is uncertain only if they receive their teammates' messages.

Table 7 presents the results without controlling for individual decision maker fixed effects. We run this regression to see how the decision makers' characteristics affect the level of the contribution. Overall, the results for the experimental control variables are similar to those in Table 6. What is interesting in Table 7 is that decision makers' individual characteristics, such as gender, major, and risk aversion, matter in the noD and DnoM treatments, but are statistically insignificant in DM. One interpretation is that with non-delegates' opinions available, delegates behave less as individuals and more as anonymous representatives of a team.[13]

[13] Furthermore, the results about the age effect are intriguing. In noD, age does not matter, while it has a positive effect in DnoM, where older delegates contribute more. However, the effect is opposite in DM; older delegates contribute less after controlling for non-delegates' opinions. While interesting, one should be cautious about inferring from these results, given that there is little age variation among the subjects.

Table 7. Determinants of Team Contribution: OLS controlling for decision-maker's characteristics

Treatment	noD	DnoM			DM		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Avg. pledge by others	-0.005	0.103*	0.101	0.097	0.032	0.066	0.070
	(0.083)	(0.059)	(0.060)	(0.061)	(0.063)	(0.045)	(0.045)
Avg. expectation by others	-0.247	0.003	-0.013	0.010	0.304	0.067	0.034
	(0.203)	(0.238)	(0.234)	(0.226)	(0.224)	(0.221)	(0.209)
75% chance of loss	18.591***	14.649**	14.323**	14.479**	15.974***	5.463	6.502
	(4.859)	(5.468)	(5.646)	(5.665)	(5.378)	(4.669)	(4.524)
95% chance of loss	24.438***	28.705***	28.210***	28.810***	29.543***	11.575**	12.071**
	(5.184)	(6.550)	(6.732)	(6.608)	(6.597)	(5.391)	(5.469)
Uncertain thresholds	-3.557	-4.369	-4.421	-3.807	-11.269**	-13.979***	-13.040***
	(5.270)	(5.516)	(5.503)	(5.604)	(4.906)	(4.348)	(4.377)
Decision-maker's characteristics							
Male	-15.486***	-11.192*	-11.054*	-11.150*	2.366	9.481	10.039
	(4.089)	(6.147)	(6.127)	(6.097)	(8.414)	(6.486)	(6.472)
Age	-0.100	0.318***	0.303**	0.295**	-1.280	-3.155**	-3.335**
	(0.940)	(0.108)	(0.124)	(0.124)	(1.350)	(1.156)	(1.223)
Economics or business major	-9.864**	-11.022**	-11.070**	-11.036**	7.266	4.250	4.739
	(4.068)	(5.237)	(5.238)	(5.212)	(5.632)	(5.538)	(5.664)
Risk averse	10.768**	5.930	5.566	5.271	7.544	7.483	7.289
	(4.242)	(6.246)	(6.381)	(6.336)	(7.572)	(5.305)	(5.176)
Team members' opinions							
Average			0.037			0.705***	
			(0.127)			(0.099)	
Lower				0.073			0.484***
				(0.091)			(0.107)
Higher				-0.052			0.195**
				(0.103)			(0.088)
Constant	57.489*	11.489	12.214	13.700	16.884	49.644	58.578*
	(28.907)	(12.904)	(12.554)	(13.067)	(36.808)	(30.366)	(30.676)
Round FE	Y	Y	Y	Y	Y	Y	Y
Observations	192	192	192	192	192	192	192
R-squared	0.290	0.353	0.353	0.356	0.246	0.468	0.480

Notes: Robust standard errors, clustered by team, are presented in parentheses. Significance level: *** 1%, ** 5%, * 10%.

D. The influence of non-delegates' messages

In Section III, we show that delegates who take into account potential payoffs according to their teammates' messages are more likely to conform to the lowest opinion. In Column 6 of Table 6, we find that delegates tend to follow the average of the non-delegates' opinions. Column 7 shows that the effect is largely driven by the lower value suggested by non-delegates. The higher opinion does not have any significant impact on the delegates' decisions. We find similar results in Table 7, except that the higher opinion is also significant, but matters less than the lower opinion. The results are consistent with our theory's predictions. As expected, in both Table 6 and 7, it turns out that teammates' messages do not matter in DnoM. This is not surprising in that the messages are not delivered to delegates. On the other hand, the result indicates that the significant effects of the messages in DM are not driven by unobservable confounders that could affect both delegates and non-delegates, even with no communication between them.

Figure 2 shows both delegates' contributions and non-delegates' messages for all 192 choices (32 delegates × 6 treatments) in DM. For each choice, the higher vertical bar represents the higher non-delegate message, and the lower bar represents the lower message. Scatter dots represent delegates' choices. There are three types of dots: diamonds denote choices that are closer to the lower message; squares denote those closer to the higher message; and triangles denote choices outside the range. Figure A2 shows that delegates are not only influenced by non-delegates' messages, but are also more inclined to the lower message. Of all 192 choices, 55% are closer to the lower opinion, while only 21% are closer to the higher opinion.

Furthermore, it is notable that delegates are particularly sensitive to non-delegates' zero contribution messages. Panel B of Table 8 shows that in 93 of the 192 choices, at least one non-delegate suggested a zero contribution and, in 63 of the 93 choices (68%), delegates actually contributed zero. Obviously, we find no effect of non-delegates' opinions in DnoM. However, the effect of the lower message is not solely driven by the zero contribution message. In Column 8 of Table 6, we restrict the sample to the cases where the lower message is not zero. We still find that delegates are influenced by the lower message, but not significantly by the higher message.

Table 8. Zero Messages and Zero Contribution

A. DnoM

		Delegate's contribution		
		Positive	Zero	Total
Any team member proposed zero?	No	78	22	100
		(78.0)	(22.0)	(52.1)
	Yes	57	35	92
		(62.0)	(38.0)	(47.9)
	Total	135	57	192
		(70.3)	(29.7)	(100.0)

B. DM

		Delegate's contribution		
		Positive	Zero	Total
Any team member proposed zero?	No	78	21	99
		(78.8)	(21.2)	(51.6)
	Yes	30	63	93
		(32.3)	(67.7)	(48.4)
	Total	108	84	192
		(56.3)	(43.8)	(100.0)

Notes: There are 192 choices in each treatment, DnoM and DM. We present the number of choices corresponding to each cell. Percentages are presented in parentheses. In each panel, the percentages in the first two columns and two rows are the conditional probabilities given whether any team member proposed zero contribution.

Lastly, in Table 9, we check the robustness of the finding that delegates are more sensitive to the lower contribution message across various subsamples. Overall, we find that the result is robust. We find that delegates are more inclined to the lower message when they do not know anyone in the session or in their team. The asymmetric effect is also evident, regardless of whether they understand the game rules well and regardless of gender. The asymmetric effect is not affected by the average pledge or the expectation presented by the other delegates. An interesting finding is that the sensitivity to the lower suggestion is not statistically significant when the threshold is uncertain, although the effect of the lower suggestion is much larger than that of the higher one.

Table 9. Sensitivity to Lower Message: Robustness across Subsamples

	Lower message	Higher message	N	R-squared
All strangers in experiment	0.344**	0.214*	126	0.732
	(0.137)	(0.106)		
All strangers in team	0.313**	0.149	168	0.714
	(0.116)	(0.091)		
Understood game rules very well	0.407**	0.030	114	0.651
	(0.169)	(0.099)		
Understood game rules not very well	0.331***	0.291**	78	0.789
	(0.107)	(0.124)		
Male delegate	0.285**	0.090	126	0.659
	(0.123)	(0.114)		
Female delegate	0.334*	0.192	66	0.791
	(0.170)	(0.134)		
Single certain threshold	0.571***	0.269*	96	0.812
	(0.172)	(0.155)		
Double uncertain thresholds	0.136	0.005	96	0.705
	(0.159)	(0.141)		
Higher pledges by others	0.404**	0.370***	91	0.774
	(0.163)	(0.123)		
Lower pledges by others	0.310**	0.152	101	0.730
	(0.147)	(0.124)		
Higher expectation by others	0.314*	0.127	114	0.683
	(0.159)	(0.130)		
Lower expectation by others	0.418**	0.253	78	0.815
	(0.200)	(0.273)		

Notes: In all regressions, all control variables and fixed effects in Table 3 are controlled for. Robust standard errors, clustered by team, are presented in parentheses. Significance level: *** 1%, ** 5%, * 10%.

Table 10 summarizes the non-delegates' opinions in DnoM and DM by round. The results for DnoM are quite surprising. Although the non-delegates' contribution decision is payoff-irrelevant, we find little difference between non-delegates and delegates. Non-delegates appear to be willing to contribute more, but that is not always the case.[14]

[14] Recall that, unlike in DnoM, non-delegates in DM can signal their preferred contributions to their delegates. However the results in Table 10 show that non-delegates in DM did not behave differently from those in DnoM. Indeed, the last column shows that we cannot reject the null that non-delegates in DM are the same as those in DnoM. This means that the lower public good contributions by the delegates in DM are attributable to the fact that they responded to the messages sent by their constituency.

Table 10. Average Contributions of Delegates and Non-delegates

	DnoM		DM		
	Non-delegates	Delegates	Non-delegates	Delegates	Non-delegates DnoM = DM
CT55%	27.94	21.50	25.47	19.22	0.744
	(25.81)	(25.17)	(26.97)	(25.12)	
CT75%	40.45	39.25	38.95	35.31	0.598
	(25.58)	(25.22)	(26.28)	(26.94)	
CT95%	42.97	52.94	49.30	49.56	0.205
	(31.67)	(20.08)	(24.05)	(23.62)	
UT55%	26.02	22.72	26.61	10.00	0.998
	(25.69)	(28.38)	(28.90)	(20.32)	
UT75%	45.05	37.09	44.03	25.00	0.902
	(30.18)	(28.82)	(30.08)	(28.30)	
UT95%	52.97	50.19	52.95	33.94	0.849
	(30.01)	(25.12)	(27.69)	(30.11)	

Notes: Standard deviations are presented in parentheses. P-values of equality tests are presented in the last column.

V. Discussion

Our finding that delegates contribute less than self-representing individuals, especially when non-delegates' messages are close to zero, is puzzling from the perspective of standard economic theory, given that in our setting the delegates and their teammates have the same objective function and there should be no strategic interaction between them. In this section we discuss some possible explanations for our findings about the behavior of delegates. Among others, we focus on three explanations; a) strategic selection of delegates, b) responsibility towards teammates, and 3) social regret.

A. Selection of delegates

A recent, mostly theoretical literature, has investigated the role of strategic delegation in collective decision-making (Harstad, 2008), including when dealing with international externalities (Siqueira, 2003) and international environmental agreements (Bucholz, 2005). The common finding is that the constituency may have an incentive to strategically delegate to agents who have a lower valuation for the project than they have themselves, in order to increase the bargaining power with the other parties. In our setting, this would translate to the following logic, from the perspective of the voters: elect the candidate that is least likely to invest in the public good, so that the other delegates will (hopefully) shoulder most of the burden and the threshold will still be reached. As mentioned in the introduction, there is scope for strategic delegation because in our game public good provision choices are strategic substitutes.

However, given that strategic delegation is not the focus of this experiment, we took deliberate steps to preempt it. Specifically (see Section IIIA for more details), the teams' decisions (elections, pledges and contributions in each round) are not communicated to other teams until the end of the experimental sessions. Hence, the case for strategic delegation is substantially weakened, since signaling the election of a hard-nosed negotiator is not possible.

Nevertheless, to check whether strategic delegation took place, we examine whether delegates are selectively chosen with the aim of decreasing the amount of contribution to the public good. Specifically, using subjective-level data, we estimate a Probit model where the dependent variable is whether a subject is elected as a delegate. Table 11 presents the results.

Columns 1 and 2 present the results for the DnoM treatment and 3 and 4 those for the DM treatment. We include the amounts of pledge and expectation at the practice round because the information was revealed prior to voting. In fact, any other information besides those two numbers and ballot orders was not revealed. Since voting selects one delegate in a three-member team, we try to include the amounts of pledge and expectation in the relative term compared to the team average in Columns 2 and 4.

Table 11. Voting Results

	DnoM		DM	
	(1)	(2)	(3)	(4)
	Absolute	Relative	Absolute	Relative
Pledge	-0.002	-0.003	-0.002	-0.004
	(0.003)	(0.004)	(0.002)	(0.003)
Expectation	-0.000	-0.002	-0.005**	-0.007*
	(0.002)	(0.005)	(0.002)	(0.004)
Male	0.064	0.064	0.107	0.113
	(0.096)	(0.091)	(0.124)	(0.115)
Age	0.022	0.020	-0.030	-0.039
	(0.017)	(0.012)	(0.049)	(0.043)
Semesters	-0.006	-0.005	0.054	0.065
	(0.025)	(0.024)	(0.050)	(0.043)
ECON/BUS major	-0.020	-0.019	0.151	0.133
	(0.105)	(0.106)	(0.103)	(0.100)
General risk preference	0.001	-0.000	0.029	0.028
	(0.020)	(0.019)	(0.026)	(0.025)
Middle ballot order	0.207	0.204	0.168	0.194
	(0.137)	(0.137)	(0.144)	(0.148)
Observations	96	96	95	95
Pseudo R squared	0.0722	0.0782	0.1131	0.1402

Notes: Marginal effects from Probit models. The dependent variable is the indicator for whether the subject is elected as delegate. One subject in DM is dropped because of missing risk preference. Robust standard errors, clustered by team, are in parentheses.

The results show that most variables are not statistically significant. That is, there is no selection into delegates on observables. This is not surprising given that not much information about candidates was available for voters.

It is however notable that in the voting for selecting delegates in treatment DM, the level of expectation about other teams' contribution turns out to be significant in both the absolute and relative terms. The magnitude of the effect is also not ignorable. A one-standard deviation increase in the amount of expectation (which is 17.6 in the absolute term and 15.1 in the relative term) decreases the probability of being elected as delegate by about 10 percentage points. This result is somewhat indicative of strategic delegation; more pessimistic members are more likely to be elected as delegates.

However, it should be noted that our results in Section V are not driven by selective choice of delegates. Recall that in our team-decision regression analyses, we controlled for team-specific fixed effects, which should absorb any effects from team delegates' time-invariant traits, including propensity for cooperation and belief about others' contribution. Although it is still possible that those delegates who trust other teams less respond to less cooperative messages from teammates more sensitively, it is unlikely that selection into delegates itself, or strategic delegation, explains our findings.

B. Responsibility effects induced by delegation

Differently from the case of self-representation, a delegate may feel responsible towards her teammates, since her decision affects not only her own payoff but also theirs. We speculate about three reasons why such responsibility could push delegates to contribute less than self-representing individuals. First, delegates may fear to let teammates down and this could induce them to become more cautious, i.e. minimize the risk of being the sucker by gravitating towards NC. Such fear of being blamed for wasting positive contributions could deter investments in the public good even in the absence of communication. Second, in the treatment featuring messages, delegates may feel the need to conform to the suggestions of their constituency, even if the messages are non-binding, possibly due to a sense of responsibility for having been voted "into office" (in most cases by at least one of the teammates). Combining the two lines of thought above, one would expect the delegate to give more weight to the lower of the two messages about preferred contributions. Third, if a delegate expects other delegates to contribute little to the public good, again due to the above arguments, then she would have an additional incentive not to contribute. Bolton et al. (2015), Charness and Jackson (2009), and Song (2008) suggest similar implications for responsibility and show that delegates trust and cooperate less in trust and stag-hunt games, and choose safer lotteries.

Although we observe a similar tendency, the gap between group contributions in DnoM and NoD was not statistically significant. Messages appear to be determinant in triggering significant reductions in contributions. We thus come back to the interesting case where the delegate receives asymmetric contribution suggestions, e.g. one high and one low message in our setting, and elaborate on its implications. We focus on two reasons why delegates may be more likely to follow low contribution suggestions than high ones. First, the anticipated pain of regret for making the wrong choice is strengthened if people are aware of the foregone choice (Zeelenberg, 1999). Thus, the above responsibility effects are more salient when the delegates receive the teammates' messages. Second, a delegate who receives a low contribution suggestion could easily anticipate that the other delegates also receive and follow such suggestions. Thus, she would also contribute nothing, anticipating that the group would fail to reach the threshold regardless of her contribution. In a lottery choice setup, Bolton et al. (2015) show that delegates tend to conform to both teammates suggesting safe and risky options, but that only the "safe" suggestions have a significant effect. Our experimental data aligns with this finding, in the sense that delegates selectively listen to the message suggesting low or zero contributions (and avoid the risk of wasting contributions, not reaching the target and being the "sucker"). Thus, we argue that some combination of these forces drives the delegates to contribute less than self-representing individuals.[15]

C. Social Regret Model

In order to understand the delegate's behavior both in the presence and in the absence of the teammates' messages in the threshold public goods game that we tested experimentally here, we sketch the results of an application of social regret model (İriş, 2017). The latter theory modifies Loomes and Sugden's (1982) individual regret-aversion model. As detailed in Appendix 1, we extend İriş (2017) by studying binary choice environments with more than two states of nature. Specifically, this model departs from standard preferences by allowing the delegate to experience regret (or rejoice) for not having followed a teammate's message if the suggested contribution would have secured a higher (lower) payoff. We assume that regret and rejoice are greater for larger utility differences (in an increasing fashion) between what a team receives based on the delegate's contribution and what the same team would have received from another action

[15] Note that, due to the experimental design, we cannot attribute the difference between the DM and DnoM treatments to messages alone. The reason is that while non-delegates were also present in the decision room in DM, they sat in a different room in DnoM. For this reason, we can only conclude that public pressure from the constituency, in the form of a combination of messages and passive auditing in the decision room, induces the delegates to decrease group contributions to the public good.

suggested by the teammates. When the utility difference increases linearly, the delegate is social regret-neutral and acts as if she was maximizing her expected utility. On the other hand, if the utility difference increases convexly, the delegate is social regret-averse.[16] Social regret-averse delegates value the states with larger utility differences more. In the case of a certain threshold, we have three possible states: reaching the threshold and avoiding the potential loss (*RT*), not reaching the threshold and suffering the ensuing loss (*NTL*), and not reaching the threshold, but getting lucky as the loss does not happen (*NTNL*). Our main result shows that if the utility difference is larger in *NTL* or *NTNL* than *RT*, which is satisfied by the parameters chosen in the experiment, then social regret-averse delegates follow low contribution suggestions more than messages calling for high contributions. Thus, social regret-aversion rationalizes the main finding of our experiment.

VI. Conclusion

We analyzed the provision of a discrete public good, which only has value if enough has been contributed collectively, either because the scale of the project requires a minimum investment, or owing to its non-scalability. To mimic the challenges to cooperation faced by parties deciding on effort coordination in the presence of uncertainty, all treatments feature both uncertainty on the location of the threshold and on the consequences of non-provision. We test the impact of delegation and peer pressure in the form of payoff-immaterial messages to the delegate by comparing provision levels to a baseline treatment in which subjects self-represent and directly decide on the contribution to the public good.

As mentioned in the previous section, there are behavioral and theoretical arguments to expect that, relative to the baseline case where decision makers act independently, a delegate who receives contrasting signals by the constituency will place more weight on the non-cooperative messages. In line with this expectation, we find that, while delegation of the investment decision to an appointed leader has little effect when decoupled from the peer pressure of non-delegates, it does influence delegate behavior in

[16] This assumption for individual regret-aversion is confirmed by experimental data. See Bleichrodt and Wakker (2015) for more about this evidence and applications of regret theory.

the treatment featuring public pressure from the constituency. Here the contribution to the public good drops significantly, even if the messages do not alter the delegate's incentives. The empirical analysis confirms that this drop is attributable to the fact that delegates tend to focus on the lowest contribution level suggested by non-delegates. Hence, negative examples can be detrimental to cooperation.

The simple setup utilized here, while arguably more conducive to cooperation than the more complex real-world task of avoiding dangerous climate change, provides stark implications for climate policy. For example, consider the parallel between the experimental setting and the emissions reduction problem. Reaching an agreement on emission trajectories that are compatible with safe levels of global warming requires collaboration between negotiators (acting on behalf of their national constituencies) and their foreign counterparts. The stakes are indisputably high according to the scientific evidence on the losses associated with substantial warming, such that the collectively rational decision would be to coordinate efforts to avert abrupt future changes in the climate. In the terminology of our game, this is the provision equilibrium, and if all parties do their part, the cost of reducing emissions, relative to business as usual, is more than compensated for by the expected future savings from avoiding dangerous climate changes.

However, as in the game, individual free-riding incentives mean that unilateral deviations from the provision strategy can quickly destabilize cooperation: once a (sufficiently large) country defects, reaching the target may be unfeasible or uneconomical. We can think of this as strategic uncertainty about co-players' actions. The game also captures another feature that has the potential to jeopardize climate cooperation, namely scientific uncertainty on the location and impact of crossing the threshold. As expected, we find that scientific uncertainty reduces the contributions to the public good and, consequently, the probability of coordination on the cautious equilibrium. Lastly, the negative effect of signaling by the constituency points to the dark side of leading by words: delegates appear to be quick to follow suggestions only when these entail pursuing a risky gamble on the climate commons.

As mentioned above, the real "climate game" is likely to be more complicated. Here we focused on a simple implementation of the complex political economy context that surrounds negotiations; further work may contribute to this nascent strand, for instance by disentangling the effect of different forms of public pressure on delegates' contributions to a threshold public goods game. Furthermore, the present setup restricts attention to small groups of symmetric subjects in terms of expected payoffs. Asymmetries entail different stakes for different parties, and a larger group size amplifies the problem of deterring unilateral deviations from the provision strategy. Thus, it appears that, in the face of uncertainty, without a strong call for action at the sub-national level, negotiators may be reluctant to commit to sizeable emission reductions and may selectively listen to those who suggest staying with the status quo.

Appendix 1: Social regret model

In our model, the delegate experiences regret (or rejoice) by not following a teammate's contribution suggestion if the suggested contribution would have secured a higher (lower) payoff. The utility function then depends on both the contributions and the messages from the delegate's teammates. We refer to this as *regret-augmented utility*, and express it as follows:

$$V(C_d|m,\pi_i) \equiv u(C_d|\pi_i) + \eta(C_d|m,\pi_i), \qquad (6)$$

where C_d is the delegate's contribution decision and $m \equiv (m_1, \dots, m_{k-1})$ is the vector of teammates' messages to the delegate suggesting contributions, ranging from the lower bound m_l to the higher bound m_h. The first term $u(C_d|\pi_i)$ is the *standard expected utility* appearing in (5), which we assume to be continuous. The second term is the *regret utility*, which is the sum of the delegate's regrets and/or rejoices experienced by not following teammate j's message under possible states of the world $s \in S$, where S is the set of states:

$$\eta(C_d|m,\pi_i) \equiv \sum_{j=1}^{k-1} \sum_{s\in S} \mathbb{P}_s\, R\left(f_s(C_d) - f_s(m_j)\right). \qquad (7)$$

Following Loomes and Sugden (1982), the delegates believe that each state $s \in S$ occurs with probability $\mathbb{P}_s$. Then, $f_s: [0, E] \to \Re$, a linear choiceless utility function evaluates the consequences of either the delegate's chosen contribution or a teammate's message at a particular state $s \in S$. In the case of certain threshold, there are three states that occur, with the following probabilities: reaching the threshold and avoiding the potential loss (*RT*) and $\mathbb{P}_{RT} = \begin{cases} \pi_i, & C_d = T/N \\ 0, & C_d = 0 \end{cases}$; not reaching the threshold and the loss happens (*NTL*) and $\mathbb{P}_{NTL} = p(1 - \mathbb{P}_{RT})$; and not reaching the threshold, but the loss does not happen (*NTNL*) and $\mathbb{P}_{NTNL} = (1-p)(1 - \mathbb{P}_{RT})$. When negative, the function $R: \mathbb{R} \to \mathbb{R}$ captures the delegate's regret for not having followed the teammates' messages. Conversely, a positive value of $R(\cdot)$ indicates rejoice.

Assumption 1: We assume that $R(\cdot)$ is continuous, strictly increasing with $R(0) = 0$, and three times differentiable.

To understand the implications of the teammates' messages for the delegate, we focus on the scenario in which team i's delegate receives messages $m^* = (m_h = T/N, m_l = 0)$ from two teammates. Note that delegates have two teammates in our experiment and this setup allows us to examine how a delegate with regret may perceive high (m_h) and low (m_l) messages asymmetrically. We discuss the case of unanimous messages later. A delegate who receives m^* and contributes zero will experience non-negative regret utility $\eta(0|m^*, \pi_i) \geq 0$ if the following holds:

$$\pi_i R\left(\underbrace{f_{RT}(0) - f_{RT}(m_h)}_{Regret:\, pqE+(1-p)E-\left(E-\frac{T}{N}\right)<0}\right) + p(1-\pi_i)R\left(\underbrace{f_{NTL}(0) - f_{NTL}(m_h)}_{Rejoice:\, qE-q\left(E-\frac{T}{N}\right)>0}\right) +$$

$$+(1-p)(1-\pi_i)R\left(\underbrace{f_{NTNL}(0) - f_{NTNL}(m_h)}_{Rejoice:\, E-\left(E-\frac{T}{N}\right)>0}\right) \geq 0. \qquad (8)$$

The first term shows that the delegate feels regret by contributing 0 in the scenario in which the threshold would have been reached if she contributed T/N. In this case, each team would have received a higher payoff than the current expected payoff from (2). The second and third terms capture the delegate's rejoice from having contributed 0 when this turns out to be advantageous, namely when contributing positive amounts is wasteful as the threshold is out of reach. That is, in this scenario the delegate cannot be pivotal as the group would still fail to reach the threshold. In addition, regardless of whether the actual loss is suffered (NTL) or not ($NTNL$), the payoff will be lower than that under the public good provision. In other words, $q(E - T/N) < qE$ and $(E - T/N) < E$, respectively. Note that if the delegate contributes T/N instead of nothing, the domain of the $R(\cdot)$ functions in (8) will take the opposite sign. Then, the regret state will be replaced by rejoice, while the rejoice states will be replaced by regret.

For convenience, we define a function $\Psi(.)$ such that for all ε,

$$\Psi(\varepsilon) = \varepsilon + R(\varepsilon) - R(-\varepsilon), \qquad (9)$$

where $\Psi(.)$ is an increasing function and skew symmetric, that is, $\Psi(\varepsilon) = -\Psi(-\varepsilon)$. Given m^* and π_i, delegate prefers to contribute nothing over contributing T/N, $V(0|m^*, \pi_i) \geq V(T/N|m^*, \pi_i)$ if and only if:

$$\textstyle\sum_{s \in S} \mathbb{P}_s\left[\Psi\left(f_s(0) - f_s(T/N)\right)\right] \geq 0. \qquad (10)$$

We state the implications of having the second term in (6) and the specification under (7) in Lemma 1 and Proposition 1.

Lemma 1: If the delegate's subjective beliefs on reaching the threshold T by contributing T/N is lower than a critical level ($\pi_i < \pi_i^R$), the regret utility $\eta(C_d|m^*, \pi_i)$ belonging to team i's delegate is higher when contributing $C_d = 0$ than when contributing $C_d = T/N$. Conversely, if $\pi_i > \pi_i^R$, the opposite holds: $\eta(C_d|m^*, \pi_i)$ is higher when contributing $C_d = T/N$.

Proof of Lemma 1

Let us call $x_{RT} = f_{RT}(T/N) - f_{RT}(0)$, $x_{NTL} = f_{NTL}(0) - f_{NTL}(T/N)$, and $x_{NTNL} = f_{NTNL}(0) - f_{NTNL}(T/N)$, and note that $x_i > 0$ for all $i \in \{RT, NTL, NTNL\}$. The condition below shows that $\eta(0|m^*, \pi_i) \geq \eta(T/N|m^*, \pi_i)$:

$$\pi_i R(-x_{RT}) + p(1-\pi_i)R(x_{NTL}) + (1-p)(1-\pi_i)R(x_{NTNL}) \geq$$
$$\pi_i R(x_{RT}) + p(1-\pi_i)R(-x_{NTL}) + (1-p)(1-\pi_i)R(-x_{NTNL}), \tag{11}$$

which can be rewritten as:

$$\pi_i\big(R(-x_{RT}) - R(x_{RT})\big) + p(1-\pi_i)\big(R(x_{NTL}) - R(-x_{NTL})\big) +$$
$$+(1-p)(1-\pi_i)\big(R(x_{NTNL}) - R(-x_{NTNL})\big) \geq 0. \tag{12}$$

While the first term favors contributing T/N owing to the belief in reaching the threshold, the second and third terms favor no contribution. Given the parameters of the model (p, q, N, T, E), there is a unique π_i^R such that (12) holds with equality. Thus, for any $\pi_i < \pi_i^R$, the inequality (12) holds strictly, since it increases the weights for the positive rejoice terms and decreases the negative regret terms, completing the proof.

Lemma 1 shows that the delegate's subjective belief about reaching the threshold T by contributing T/N determines how she evaluates the regret utility. While a subjective belief above a critical level favors targeting the provision equilibrium, a sufficiently low subjective belief favors shirking.

Next, we investigate the implications of social regret-neutrality and aversion. First, we assume $R(\cdot)$ to be linear, which also implies $\Psi(.)$ to be linear; that is, for all $\varepsilon > 0, R''(\varepsilon) = R''(-\varepsilon)$, which captures social regret-neutrality. Second, we assume $\Psi(.)$ to be convex in $\mathbb{R}^+$ (thus, concave in $\mathbb{R}^-$); that is, for all $\varepsilon > 0, R''(\varepsilon) > R''(-\varepsilon)$, which captures regret-aversion.

Proposition 1 (Social regret-neutrality): If $R(\cdot)$ is *linear*, then the regret utility reinforces the delegate's standard preference described by $u(\cdot)$:

$$u(0|\pi_i) \gtreqless u\left(\frac{T}{N}|\pi_i\right) \Leftrightarrow \eta(0|m^*,\pi_i) \gtreqless \eta\left(\frac{T}{N}|m^*,\pi_i\right) \Leftrightarrow$$
$$V(0|m^*,\pi_i) \gtreqless V\left(\frac{T}{N}|m^*,\pi_i\right).$$

Proof of Proposition 1

(i) The condition $V(0|m^*,\pi_i) \geq V(T/N|m^*,\pi_i)$, expressed in equation (10), can be written as follows:

$$\pi_i\left(\underbrace{-x_{RT} + R(-x_{RT}) - R(x_{RT})}_{\Psi(-x_{RT})}\right) + p(1-\pi_i)\left(\underbrace{x_{NTL} + R(x_{NTL}) - R(-x_{NTL})}_{\Psi(x_{NTL})}\right) +$$
$$(1-p)(1-\pi_i)\left(\underbrace{x_{NTNL} + R(x_{NTNL}) - R(-x_{NTNL})}_{\Psi(x_{NTNL})}\right) \geq 0 \Leftrightarrow \qquad (13)$$

For $R(\cdot)$ linear, it simplifies to the following:

$$-3\pi_i x_{RT} + 3p(1-\pi_i)x_{NTL} + 3(1-p)(1-\pi_i)x_{NTNL} \geq 0 \Leftrightarrow$$

$$-\pi_i x_{RT} + p(1-\pi_i)x_{NTL} + (1-p)(1-\pi_i)x_{NTNL} \geq 0 \Leftrightarrow$$

$$\pi_i(-x_{RT} - px_{NTL} - (1-p)x_{NTNL}) \geq -px_{NTL} - (1-p)x_{NTNL} \Leftrightarrow$$

$$\pi_i \geq \frac{px_{NTL} + (1-p)x_{NTNL}}{x_{RT} + px_{NTL} + (1-p)x_{NTNL}}$$

Substituting the values for $x_{RT} = pq(1-q) - \frac{T}{N}$, $x_{NTL} = q\frac{T}{N}$, and $x_{NTNL} = \frac{T}{N}$ give:

$$\pi_i \geq \frac{pq\dfrac{T}{N} + (1-p)\dfrac{T}{N}}{pE(1-q) - \dfrac{T}{N} + pq\dfrac{T}{N} + (1-p)\dfrac{T}{N}} \Leftrightarrow$$

$$\pi_i \geq \frac{pqT + (1-p)T}{pEN(1-q) + pqT - pT} \Leftrightarrow$$

$$\pi_i \geq \frac{T\big(1 - p(1-q)\big)}{(EN-T)p(1-q)}.$$

The critical subjective belief in (10) becomes $\bar{\pi}_i^R = \frac{T(1-p(1-q))}{(EN-T)p(1-q)}$, which is the same as in (5). Note also that condition $\eta(0|m^*,\pi_i) \geq \eta(T/N|m^*,\pi_i)$, expressed in (12) would lead to identical critical subjective belief. The result follows immediately.

For linear $R(\cdot)$, the critical subjective belief introduced in Lemma 1 coincides with the subjective belief in (5). Suppose a delegate's subjective belief π_i favors, say, no contribution over contributing T/N in the absence of teammates' messages $\left(u(0|\pi_i) > u(T/N|\pi_i)\right)$. Then, the delegate would favor the opinion of the teammate who suggests not contributing owing to her regret utility: $\eta(0|m^*,\pi_i) > \eta(T/N|m^*,\pi_i)$. Thus, the delegate's perceived regret utility for $m^* = (m_h = T/N, m_l = 0)$ yields the same preferences as those that would be obtained without the teammates' messages.

Proposition 2 (Social regret-aversion): Let $u(\cdot)$ be continuous and $\bar{\pi}_i^R$ be the critical subjective belief under linear $R(\cdot)$. If $\Psi(.)$ is *convex* in $\mathbb{R}^+$ and $|x_{RT}| \leq max\{x_{NTL}, x_{NTNL}\}$, then there exists some $\pi_i \in (\bar{\pi}_i^R, \pi_i^R)$ such that $u(0|\pi_i) < u(T/N|\pi_i)$, $\eta(0|m^*,\pi_i) > \eta(T/N|m^*,\pi_i)$, and $V(0|m^*,\pi_i) > V(T/N|m^*,\pi_i)$.

Proof of Proposition 2

We show how convex $\Psi(\cdot)$ in $\mathbb{R}^+$ in comparison to linear $R(\cdot)$, implying linear $\Psi(\cdot)$, changes the condition in (13). While the first term in (13) favors contributing T/N, the second and third terms favor no contribution. The $|x_{RT}| \leq max\{x_{NTL}, x_{NTNL}\}$ and convexity of $\Psi(\cdot)$ guarantees that at least one of the terms favoring no contribution will increase faster than the first term. Thus, the latter terms become more positive under convex $\Psi(\cdot)$ in comparison to linear $\Psi(\cdot)$. Therefore, the critical subjective belief in (11) becomes $\pi_i^R > \bar{\pi}_i^R$.

At $\pi_i = \bar{\pi}_i^R$, $u(0|\bar{\pi}_i^R) = u(T/N|\bar{\pi}_i^R)$ by (5), and $\eta(0|m^*,\bar{\pi}_i^R) > \eta(T/N|m^*,\bar{\pi}_i^R)$, since $\pi_i = \bar{\pi}_i^R < \pi_i^R$. Therefore, $V(0\middle|m^*,\bar{\pi}_i^R) > V(T/N\middle|m^*,\bar{\pi}_i^R)$. By the continuity of $R(\cdot)$ and $u(\cdot)$, for some $\pi_i = \bar{\pi}_i^R + \mathcal{E}$, where $\mathcal{E} > 0$, we have $u(0|\pi_i) < u(T/N|\pi_i)$, $\eta(0|m^*,\pi_i) > \eta(T/N|m^*,\pi_i)$, and $V(0|m^*,\pi_i) > V(T/N|m^*,\pi_i)$, completing the proof.

For convex $\Psi(.)$ in $\mathbb{R}^+$, the delegate values higher payoff differences more than lower ones, then the condition $|x_{RT}| \leq max\{x_{NTL}, x_{NTNL}\}$ suffices for the terms favoring no contribution to increase faster than the first term in comparison to linear $\Psi(.)$. This implies that the critical subjective belief will be higher than in the linear case (i.e., $\pi_i^R > \bar{\pi}_i^R$). Then, for some $\pi_i \in (\bar{\pi}_i^R, \pi_i^R)$, the delegate would favor contributing T/N without the messages, $u(0|\pi_i) < u(T/N|\pi_i)$. However, realizing that she would feel more regret than rejoice if she contributed T/N after receiving messages m^*, $\eta(0|m^*, \pi_i) > \eta(T/N|m^*, \pi_i)$, she will prefer not to contribute: $V(0|m^*, \pi_i) > V(T/N|m^*, \pi_i)$.

We can now combine the results of Proposition 2 with the argument that teams (delegates) have a tendency towards inaction when the teammates play no role in the decision, as discussed at the end of section III B. Here, we conjecture that m_l will be focal when $|x_{RT}| \leq max\{x_{NTL}, x_{NTNL}\}$ is satisfied. In other words, delegates are more likely to conform to a message that suggests a low contribution.

Note that in this setup, a delegate receiving unanimous messages, $m^h \equiv (m_h, \dots, m_h)$ or $m^l \equiv (m_l, \dots, m_l)$, would have the same preferences. In Lemma 1 and Proposition 1, we compare $\eta(0|m^*, \pi_i)$ with $\eta(T/N|m^*, \pi_i)$. For unanimous high and low messages, we need to compare $\eta(0|m^h, \pi_i)$ and $\eta(T/N|m^l, \pi_i)$, respectively, with the zero regret utility. These conditions coincide with the condition in Lemma 1 and Proposition 1 and, thus, favor no contribution.

In the above, we focused on the certain threshold case. Next, we briefly discuss the impact of threshold uncertainty. First, we have different states of the world. There are two other states that replace reaching the threshold (*RT*), namely reaching T_1 but not T_2 (RT_1NT_2) and reaching T_2 (RT_2). Threshold uncertainty deepens the coordination failure. In particular, contributing according to SPC1 might cause additional regret because the team's endowment will be wasted if the realized threshold happens to be T_2. Similarly, contributing according to SPC2 might cause additional regret because the team's endowment will be wasted if the realized threshold happens to be T_1. These possible cases enter as rejoices if the delegate does not contribute. Thus, the presence of threshold uncertainty pushes delegates further towards the low suggested contribution $m^l = 0$ relative to the SPC1 and SPC2 strategies. Therefore, we hypothesize that threshold uncertainty has a negative impact on contributions and disaster avoidance.

Appendix 2: ID cards, Instructions, and survey questions

ID cards

An ID card assigns a letter to determine each subject's team (or group, in the treatment with $k = 1$) and seven numbers to determine the subject's unique member ID in each round. For example, ID A3112442 means the subject belongs to team A (or group A) and his or her ID number is 3 in the practice round, 1 in Round 1, 1 in Round 2, 2 in Round 3, and so on. In treatments with $k = 3$, subjects remain in the same team until the end. In each round, each subject knows only his or her own ID number. Since an ID card assigns a different number in each round, this design should eliminate possible reputation effects. In treatments with $k = 3$, subjects in a team share the same number, so they can follow the teammates' actions, if announced. As the number varies randomly round by round, there is no reputation effect regarding the other two teams.

Instructions and survey questions

Subjects are given written instructions, which are read aloud by the experimenters before the experiment begins. In addition, prior to beginning the practice phase, participants answer several control questions, which aim to ensure they understand the features of the experiment. Once we are satisfied with the answers to the control questions, the subjects are divided randomly into four teams by allocating the ID cards.

After the experiment, the subjects are asked to fill out survey questions (see Table A.9 in the Appendix) about their motivation for their contribution decisions during the game, whether they would play the game in a different way, opinion about the game rules, their risk preferences, recycling experience, and their general opinion about climate change. The experiment and survey takes, on average, about one hour and 30 minutes.

More information on instructions, decision sheets, and survey questions can be found at https://goo.gl/tgSIHr.

Appendix 3: Related literature

A. Leadership in experiments

Both the appointment of a leader to facilitate decision-making and the delegation of decision power to an agent can have important implications for the behavior of individuals within a group. In particular, leadership and delegation can potentially enhance (or undermine) socially optimal behavior by affecting the level of cooperation of group members. Several studies have looked at leadership and delegation in an experimental setting. Predominantly, leadership has been found to have a positive effect in terms of motivating socially optimal behavior.

Contribution suggestions from a leader, whether elected or a volunteer, increase cooperation in public goods games (e.g., Levy et al., 2011). Hamman, Weber, and Woon (2011) find that electoral delegation results in full provision of the public good, given that group members elect pro-social leaders. Then, Brandts, Cooper, and Weber (2014) find that elected leaders improve group outcomes in cooperation games. Güth et al. (2007) find that when a leader volunteers to take that role, contributions to the public good increase, particularly if the leader has exclusion power. Rivas and Sutter (2009) also find that leadership increases contributions when the leader has the possibility to reward or punish group members. Similarly, Moxnes and Van der Heijden (2003) find that contributions to a "public bad" decrease with leadership. In a voluntary contribution fundraising exercise, Kumru and Vesterlund (2010) find that donations from individuals with higher social rank increase subsequent contributions. Then, Nash et al. (2012) find that delegating the coalition payoffs distribution to an elected agent increases the efficiency and the equality of payoffs in a coalition formation game.

An important channel through which leadership seems to decrease free riding is information provision. In public goods games, the centralization of information by the leader improves efficiency, as compared to a regime of information dispersal (Komai, Grossman, and Deters, 2011). Similarly, the opportunity to imitate first-movers who are well informed increases contributions (Potters, Sefton, and Vesterlund, 2005). A comparable result occurs in a weak-link game with manager-employee interactions (Brandts and Cooper, 2007) and in a stag-hunt type game where the concentration of information and the communication of a recommendation are positive for cooperation (Chaudhuri and Paichayontvijit, 2010).

Leading by example, rather than by words, appears to be more effective in motivating cooperation in public goods games (Czap and Czap, 2011). Leading by example also yields greater effort in coordination games. Here, leadership can be considered a "social good for the group," even though it is costly to the leader (Gillet, Cartwright, and Van Vugt, 2011). Potters, Sefton, and Vesterlund (2007) find that leading by example is beneficial when the leader has private information about the returns and her behavior acts as a signal to followers.[17] Leadership becomes less effective as the group size increases (Komai and Grossman, 2009), as well as when participants ignore the distribution of endowments within the group (Levati, Sutter, and Van der Heijden, 2007).

B. Delegation in experiments

Delegation in experimental games typically involves assigning a decision right to an interested party, a third party, or a non-human device. Delegation appears to be associated with more generosity in gift exchange games, where the delegation of wage choice leads to higher levels of employee effort, both when the decision is randomly delegated to an external body (Charness, 2000) and when it is delegated to the employee herself (Charness et al., 2012).[18]

In contrast, the delegation of a decision right in dictator and ultimatum games seems to be associated with less socially optimal behavior. In dictator games, the delegation of the decision right to the dictator decreases sharing (Hamman, Loewenstein, and Weber, 2010) and allows for responsibility attribution (and punishment) to be effectively shifted (Bartling and Fischbacher, 2012). The delegation of the decision right by proposers in ultimatum games is associated with an increased payoff for themselves (Fershtman and Gneezy, 2001) and with a higher rate of acceptance of unfair offers if intermediated by a random device (Blount, 1995).

Relatedly, the use of majority and unanimity voting rules seems to increases cooperation in experimental games. Walker et al. (2000) find greater levels of

[17] For more on signaling and leadership, see Meidinger and Villeval (2002).
[18] See Falk and Kosfeld (2006) and Huck, Müller, and Normann (2004) for additional results on delegation in contracts.

cooperation in a commons dilemma when voting rules are introduced. Then, Kroll, Cherry, and Shogren (2007) find that voting with or without endogenous punishment is associated with higher contributions in a public goods game.

Finally, experiments in social psychology (Insko et al., 1987) and economics (Charness and Jackson, 2007 and 2009; Charness et al., 2007; Song, 2008) show that team membership (in-group bias) and responsibility for others may affect behavior when all team members have common payoffs and the audience passively observes the game played and receives feedback of the outcomes in various games. The aforementioned works show that behavior in the prisoner’s dilemma, stag hunt, and trust games becomes more aggressive and less cooperative with delegation.[19]

C. Uncertainty in threshold public goods games and common resource pool dilemmas

The introduction of uncertainty in public goods games and common pool resource dilemmas is relevant to understanding cooperation in environmental dilemmas such as climate change. The experiments described below illustrate the use of threshold public goods and resource dilemmas to study the effect of several variables, particularly uncertainty, on cooperation. The dominant strategy in linear public goods games and common pool resource dilemmas is to act selfishly (the Nash equilibrium is to free ride). However, there are features, such as a threshold, that can lead to a Pareto-superior equilibrium, thus transforming the game into one of coordination between the non-provision equilibrium and the socially optimum provision equilibrium.

Threshold public goods games utilizing a specific climate frame have been employed to better understand climate change cooperation. Milinski et al. (2008) find that high risk of loss in the form of dangerous climate change is positive for cooperation, as long as the risk is higher than the average contribution needed. On the issue of equity, Tavoni et al. (2011) find that inequality in initial endowments hinders cooperation. Importantly, these studies simplify the task of selecting the Pareto-superior provision equilibrium by assuming perfect information over the location of the threshold and the costs incurred when it is crossed. A number of climate change experiments have

[19] However, Charness, Rigotti, and Rustichini (2007) find higher cooperation in a battle of the sexes game with delegation.

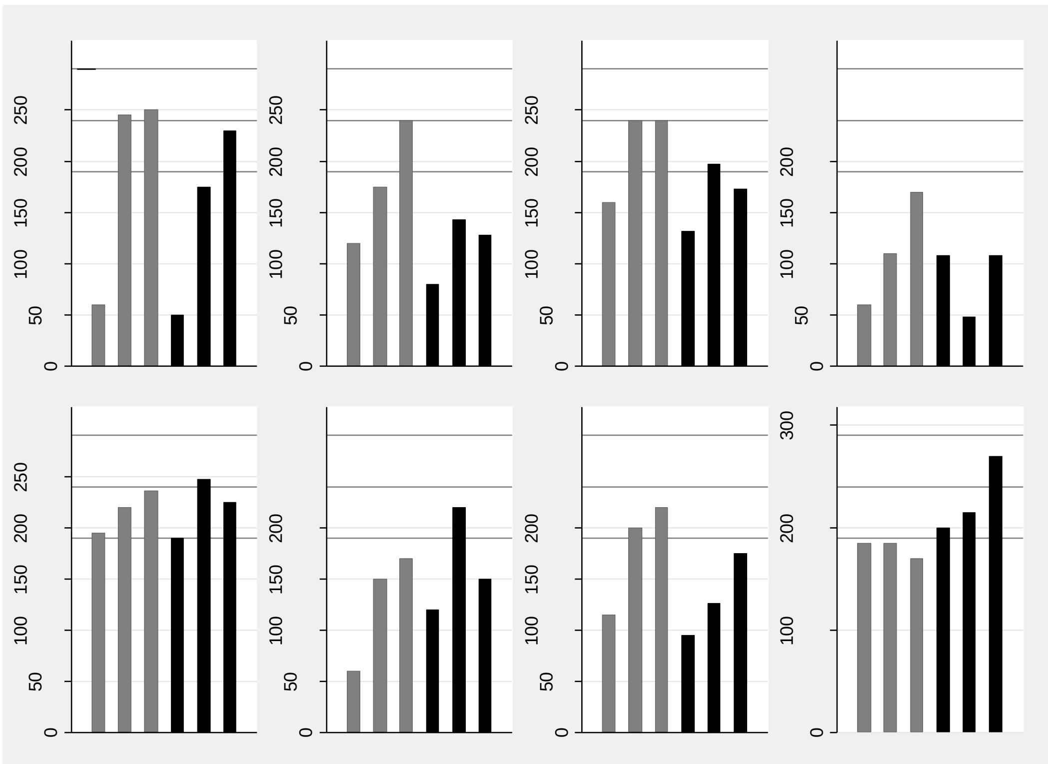
incorporated uncertainty as an important variable in an effort to coordinate a global response to this issue. For instance, Barrett and Dannenberg (2012) find that uncertainty over threshold location hinders collective action, while uncertainty over the impact of crossing the threshold has no negative effect on cooperation. Hasson, Löfgren, and Visser (2012) find that the decision to mitigate is not sensitive to the introduction of uncertainty over the occurrence of climate change. On the issue of intermediate targets, Freytag et al. (2014) find that the use of milestones representing mitigation goals, together with uncertainty over the impact of not reaching the target, is positive for efficiency "when there is no efficiency benchmark and free-riding 'disincentives' are low."

Uncertainty over the location of the provision point is detrimental to cooperation in threshold public goods games under the following conditions: when the level of uncertainty is high (Wit and Wilke, 1998); when players ignore the value or the probability distribution of the threshold (Dannenberg et al., 2014); or when signals regarding the threshold are private (Fischbacher, Güth, & Levati, 2011). On the other hand, uncertainty over the provision point can result in higher levels of cooperation when individuals have information about other players' estimates (Gustafsson, Biel, and Gärling, 2000). Van Dijk et al. (1999) find that the effect of uncertainty varies according to the type of dilemma, type of asymmetry, and type of uncertainty. Uncertainty over the impact of crossing the threshold and over the threshold location can result in lower levels of provision of the public good (McBride, 2010), for instance, owing to the fear of wasting one's contribution. That is, conditional cooperators may shy away from contributing in order to avoid being the "sucker" in a group (Au, 2004; Fischbacher and Gaechter, 2010; Suleiman, Budescu, and Rapoport, 2001).

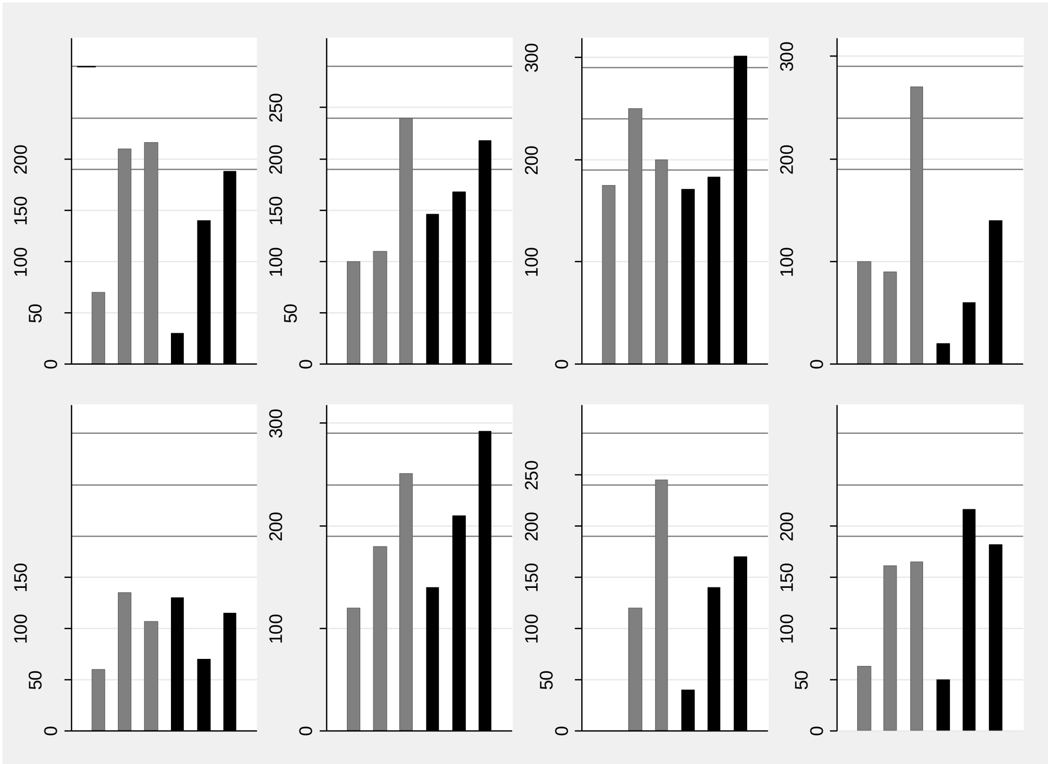
Appendix 4: Additional Figures and Tables

Appendix Figure 1. Group Contributions by Group and Treatment

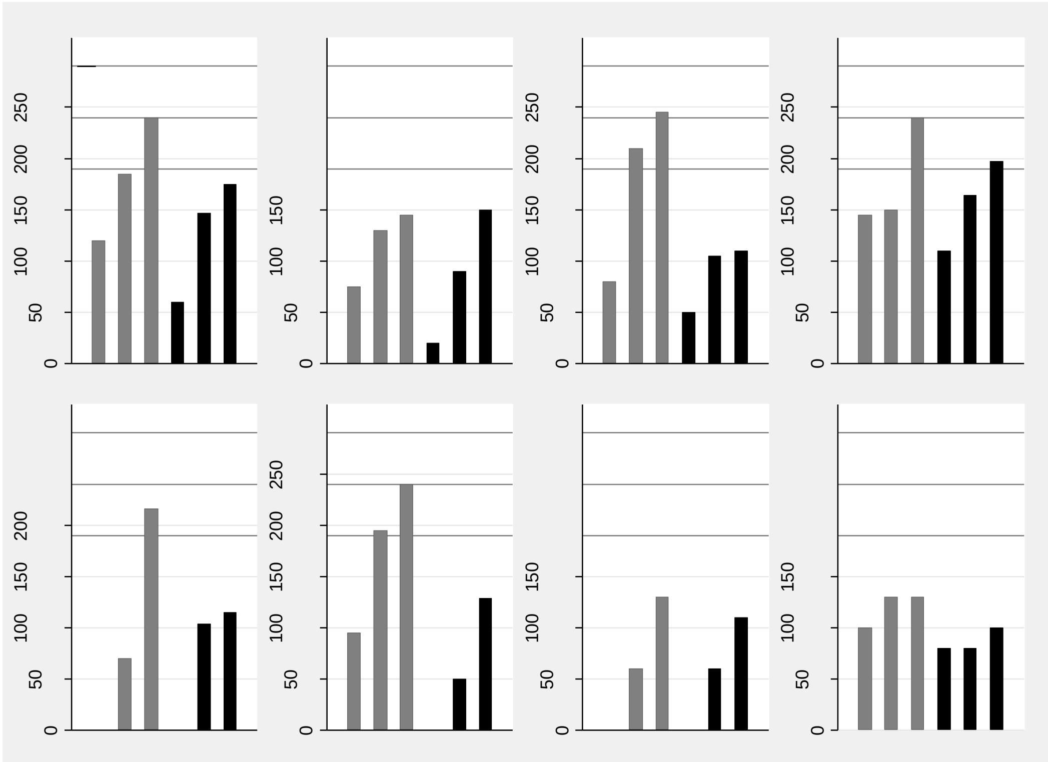
A. noD: 8 Groups and 6 Rounds



B. DnoM: 8 Groups and 6 Rounds

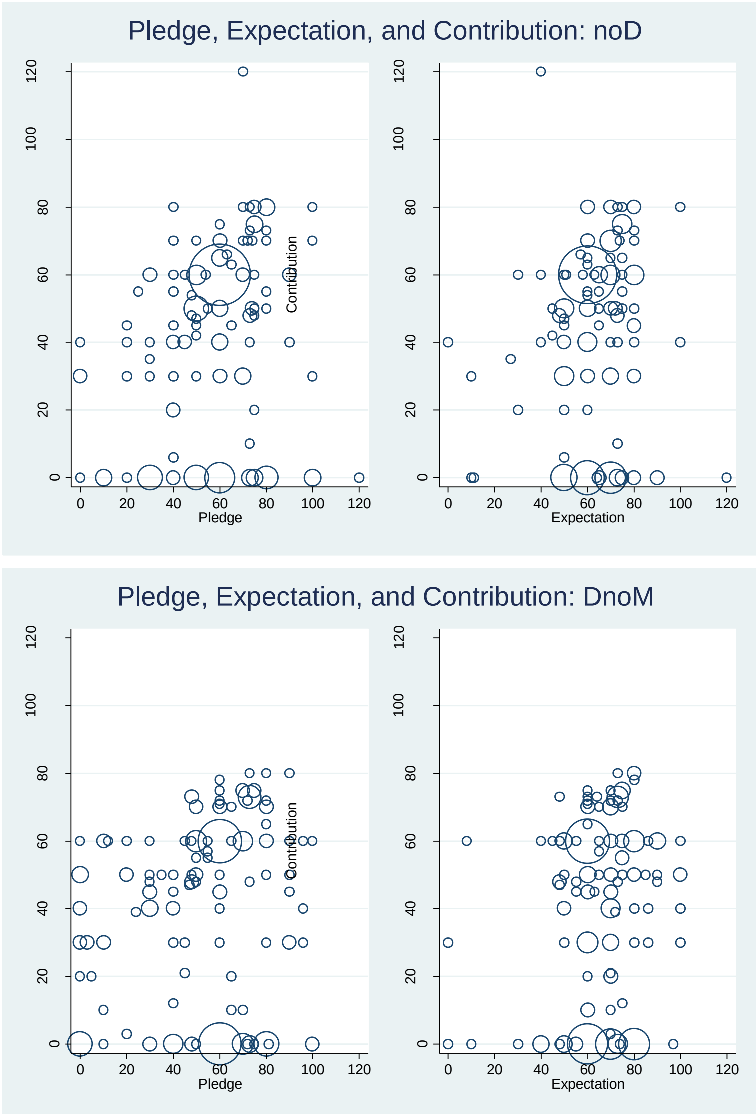


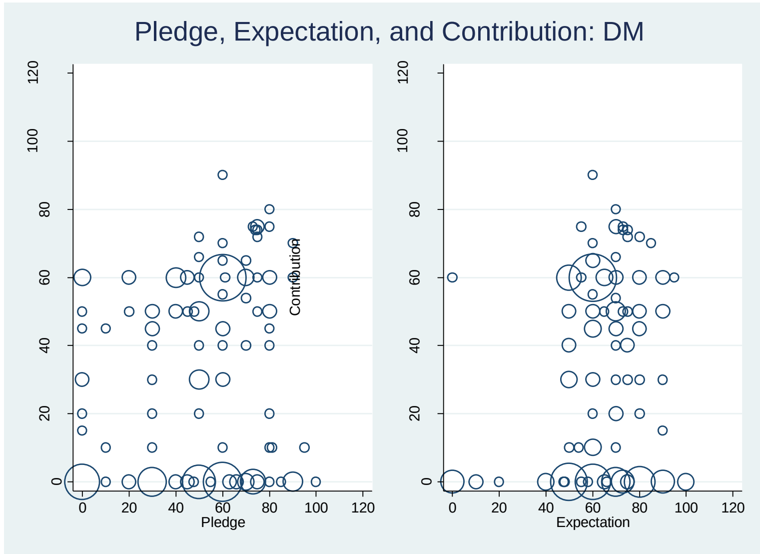
C. DM: 8 Groups and 6 Rounds



Notes: In each treatment, there are 8 groups. Each bar graph shows a group's total contribution in each treatment, ordered as follows; CT55%, CT75%, CT95%, UT55%, UT75%, and UT95%. That is, the gray bars represent total contributions when there is a single and certain threshold. The black bars represent total contributions when there are two uncertain thresholds. In case of no contribution (zero), there is no bar. Three horizontal lines represent thresholds, from the highest, higher (290), middle (240) and lower threshold (190).

Appendix Figure 2. Pledges, Expectation and Contribution





Pledge, Expectation, and Contribution: DM
Contribution
Pledge
Expectation
0
20
40
60
80
100
120

Appendix Table 1. Post-experiment Survey Responses

Survey questions	Responses	noD	Delegates DnoM	Delegates DM	Non-delegates DnoM	Non-delegates DM
Hard to understand game rules	Very difficult	0%	0%	0%	0%	0%
	A bit difficult	0%	3%	3%	8%	8%
	Medium	3%	13%	6%	19%	19%
	A bit easy	34%	34%	31%	39%	42%
	Very easy	63%	50%	59%	34%	31%
Main consideration	Threshold	25%	16%	9%	14%	13%
	Cash after contribution.	13%	22%	22%	22%	6%
	Other participants	34%	31%	28%	27%	38%
	Missing threshold	28%	31%	41%	38%	44%
Affected by the other participants' pledges	Yes	87%	72%	56%	69%	61%
Affected by the other participants' expectation	Yes	42%	38%	22%	25%	30%
Contribution as delegate (hypothetical)	Same	38%				
	More	63%				
	Less	0%				
Contribution as individual (hypothetical)	Same		69%	63%		
	More		16%	9%		
	Less		16%	28%		
Concerned about team members' knowing about pledges and expectation (0 not at all-10 very seriously)	Average		3.19	3.38		
Opinion about delegate's pledge	Too low				17%	19%
	Too high				36%	11%
	Appropriate				47%	70%
Opinion about delegation	Satisfied				81%	80%
	Unfair				19%	20%
Willing to be delegate	Yes				91%	83%
Number of subjects =		32	32	32	64	64

Appendix Table 2. Teams' Pledges and Contributions

	Pledge	Expectation	Contribution	Contribution > Pledge	Contribution = Pledge	Contribution < Pledge
noD	57.81	62.69	41.57	0.19	0.32	0.47
	(19.79)	(14.37)	(27.40)	(0.39)	(0.47)	(0.50)
DnoM	52.78	65.70	37.28	0.30	0.24	0.46
	(25.49)	(15.29)	(28.04)	(0.46)	(0.43)	(0.50)
DM	50.17	62.58	28.84	0.18	0.25	0.57
	(25.09)	(18.64)	(28.56)	(0.39)	(0.43)	(0.50)

Notes: Standard deviations are presented in parentheses.

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