Appendix for "One bad apple spoils the barrel? Public good provision under threshold uncertainty"

Appendix A. Experimental Instructions

Appendix B. Theoretical Guidance

Appendix C. Additional Tables

Appendix A. Experimental Instructions

Throughout this appendix, comments and clarifications are made in brackets. In Section B.1.1, note that basic game rules differed across treatment only with respect to the third bullet point on payoffs. In Sections B.1.2 and B.1.3, for brevity we present examples and control questions only for summation under certainty (T1) and weakest link under uncertainty (T5). The corresponding materials used in other treatments are highly similar.

A.1 Introduction and game rules

Welcome to our experiment!

General information
In our experiment you can earn money. How much you earn depends on the decisions you and your fellow participants make. For a successful run of this experiment, it is essential that you do not talk to other participants. Now, read the following rules of the game carefully. If you have any questions, please raise your hand. Once everyone has read the instructions, we will give a brief oral presentation before continuing.

The experiment will consist of two parts. One of the two parts will be randomly picked and your final payouts will be based on the decisions you and other participants make in this part. It is therefore important that you pay close attention to the instructions. After the two parts, we have some background and attitude questions to ask you as well.

You will receive an initial endowment of €15 for your participation. Any loss during the experiment will be deducted from that amount, and gains will be added.

Rules for part 1
You are in a group of ten participants, meaning you and nine other persons. Each group member faces the same decision problem. All decisions in the experiment are anonymous. For the purpose of anonymity, you will be identified by a letter (between A and J), which you will see in the lower left corner of the screen.

At the beginning of the game, you will receive 20 tokens, which are credited to two personal accounts, Account A and Account B. You will have 10 tokens in each account. In the experiment, you can use the tokens to contribute to a joint project or you can leave them in the two accounts.

Tokens from Account A are worth €0.10 each. Tokens from Account B are worth €0.50 each. You can contribute any integer amount of tokens between 0 and 20 to the joint project – at most 10 tokens from Account A and at most 10 tokens from Account B.

The payment at the end of the game will consist of the following parts:

- The amount of tokens you have left in Accounts A and B will be paid to you in cash: €0.10 for each token left in Account A and €0.50 for each token left in Account B.
- You and all other participants in the group will get €0.05 for every token contributed to the joint project, irrespective of who contributed the token and whether it was a token from Account A or B.
- [*Weakest link, certainty:*] If any group member contributes fewer than 15 tokens to the joint project, every player will lose €15. If each member of the group contributes 15 or more tokens to the joint project, no player will lose any money.
- [*Weakest link, uncertainty:*] If any group member contributes less than a certain minimum amount of tokens to the joint project, every player will lose €15. If each member of the group contributes the minimum amount or more to the joint project, no player will lose any money. The minimum amount of tokens is not known beforehand. What you know is that it is between 10 and 20 [T3: 14 and 16], that each integer value from 10 to 20 has the same probability of being selected, and that the minimum amount will be randomly drawn after the decisions have been made.
- [*Summation, certainty:*] If the group as a whole contributes fewer than 150 tokens to the joint project, every member of the group will lose €15. If the group contributes 150 or more tokens to the joint project, no participant will lose any money.
- [*Summation, uncertainty:*] If the group as a whole contributes less than a certain minimum amount of tokens to the joint project, every player will lose €15. If the group contributes the minimum amount or more to the joint project, no player will lose any money. The minimum amount of tokens is not known beforehand. What you know is that it is between 100 and 200 [T6: between 140 and 160], that each integer value from 100 to 200 has the same probability of being selected, and that the minimum amount will be randomly drawn after the decisions have been made.

Note that you can contribute any number of tokens between 0 and 20. These contributions will automatically first be deducted from your Account A (up to ten tokens), before tokens are taken out of Account B (up to another ten tokens).

This game will be played only once. You should think carefully about how to decide in the game. Before playing, we will go through two examples. The examples are presented on the next two pages, but will also be shown on the screen. Therefore, please click on the screen to move to the examples on the screen. Please note that these examples are for illustration only, so you will not be able to choose contribution levels.

[*Examples and control questions, followed by play in part 1. Immediately before part 2, the following instructions were given.*]

A change in the rules
We will now ask you to make decisions in a similar setting as before. However, there is a change in how the game proceeds and again it is important for you to pay close attention to the instructions.

In addition, we will reshuffle the groups so you will play with a different group of people than in Part 1 of the experiment.

[*Weakest link treatments:*] The difference is that before you and the other participants decide how many tokens to contribute, everyone will be given an opportunity to make two non-binding announcements. First, each participant will make a proposal (between zero and 20) about how many tokens each group member should contribute to the joint project. Second, each participant will make a pledge (between zero and 20) for how many tokens he or she intends to contribute to the joint project. All proposals and pledges made by the players will be displayed before you and the other participants decide how much to contribute.

[*Summation treatments:*] The difference is that before you and the other participants decide how many tokens to contribute, everyone will be given an opportunity to make two non-binding announcements. First, each participant will make a proposal (between zero and 200) about how many tokens the group as a whole should contribute to the joint project. Second, each participant will make a pledge (between zero and 20) for how many tokens he or she intends to contribute to the joint project. All proposals and pledges made by the players will be displayed before you and the other participants decide how much to contribute.

In all other respects, the game is the same as before, but we will still repeat these other rules here. [...]

A.2 Examples

Example 1 [*Weakest link, uncertainty*]
Here, you can see a hypothetical example of the decisions made by ten participants.

Participant	Contribution	Payoff in Part 1
A	0	-4.4
B	0	-4.4
C	10	-5.4
D	0	-4.4
E	12	-6.4
F	10	-5.4
G	8	-5.2
H	15	-7.9
I	17	-8.9
J	20	-10.4
Total	92	

The contribution column displays each participant's actual contribution to the joint project. The final column shows the total payoff for each group member. The payoff depends on the number of tokens left in Accounts A and B, payoff from total contributions to the joint project, and whether there is a loss or not.

The total contribution of 92 tokens to the joint project means that each member receives €0.05 times 92 = €4.60 from the joint project. The required minimum amount of tokens for no loss is between 10 and 20, and since at least one member contributed less than 10 tokens, every player will incur a loss of €15. [T1: … from the joint project. In addition, since at least one member contributed less than 15 tokens, every player will incur a loss of €15.]

Let us look at two participants to see how total payoff is determined.

Participant A did not contribute anything so he/she will receive 10 times €0.10 from Account A and 10 times €0.50 from Account B, totaling €6. If we add everything together, player A will get 6 + 4.6 – 15 = -€4.4. This loss will be deducted from the endowment of €15.

Participant H contributed 15 tokens (10 from Account A and 5 from Account B), so he/she will receive 5 times €0.50 from Account B, which equals €2.50. If we add everything together, player C will get 2.5 + 4.6 – 15 = -€7.9.

Example 2 [*Weakest link, uncertainty*]
Here is another hypothetical example of the decisions made by the ten group members.

Participant	Contribution	Payoff with no loss in Part 1	Payoff with loss in Part 1
A	15	10.3	-4.7
B	15	10.3	-4.7
C	15	10.3	-4.7
D	15	10.3	-4.7
E	15	10.3	-4.7
F	15	10.3	-4.7
G	16	9.8	-5.2
H	20	7.8	-7.2
I	15	10.3	-4.7
J	15	10.3	-4.7
Total	156		

The total contribution of 156 tokens to the joint project means that each participant receives €0.05 times 156 = €7.80 from the joint project. Since all players contributed between 10 and 20, we do not know for sure whether there will be a loss of €15. The lowest contribution is 15 (players A, C, E, F). If the random draw of the required minimum amount of tokens is 15 or lower, then there is no loss. If the random draw of the required minimum amount of tokens is larger than 15, then there is a loss. We therefore have two columns with payoffs in the table.

Let us look at two participants to see how total payoff is determined.

Participant A contributed 15 tokens (10 from Account A and 5 from Account B), so he/she will receive 5 times €0.50 from Account B, which equals €2.50. If we add everything together, participant A will get 2.5 + 7.8 = €10.3 if there is no loss. If there is a loss, the payoff will be 2.5 + 7.8 -15 = -€4.7.

Participant H contributed 20 tokens (10 from Account A and 10 from Account B). This means that if there is no loss the player will only get a payment from the joint project: €7.80. If there is a loss, the payoff will be 7.8 – 15 = -€7.2.

Example 1 [*Summation, certainty*]

Here, you can see a hypothetical example of the decisions made by ten participants.

Participant	Contribution	Payoff in Part 1
A	0	-4.4
B	0	-4.4
C	10	-5.4
D	0	-4.4
E	12	-6.4
F	10	-5.4
G	8	-5.2
H	15	-7.9
I	17	-8.9
J	20	-10.4
Total	92	

The contribution column displays each participant's actual contribution to the joint project. The final column shows the total payoff for each group member. The payoff depends on the number of tokens left in Accounts A and B, payoff from total contributions to the joint project, and whether there is a loss.

The total contribution of 92 tokens to the joint project means that each member receives €0.05 times 92 = €4.60 from the joint project. In addition, since total contributions are less than 150, every player will incur a loss of €15.

Let us look at two participants to see how total payoff is determined.

Participant A did not contribute anything so he/she will receive 10 times €0.10 from Account A and 10 times €0.50 from Account B, totaling €6. If we add everything together, we have that player A will get 6 + 4.6 – 15 = -€4.4. This loss will be deducted from the endowment of €15.

Participant H contributed 15 tokens (10 from Account A and 5 from Account B), so he/she will receive 5 times €0.50 from Account B, which is equal to €2.50. If we add everything together, we get that player C will get 2.5 + 4.6 – 15 = -€7.9.

Example 2 [*Summation, certainty*]

Here is another hypothetical example of the decisions made by the ten group members.

Participant	Contribution	Payoff in Part 1
A	15	10.3
B	15	10.3
C	15	10.3
D	15	10.3
E	15	10.3
F	15	10.3
G	16	9.8
H	20	7.8
I	15	10.3
J	15	10.3
Total	156	

The total contribution of 156 tokens to the joint project means that each participant receives €0.05 times 156 = €7.80 from the joint project. In addition, since total contributions are higher than 150, there will be no loss of €15.

Let us look at two participants to see how total payoff is determined.

Participant A contributed 15 tokens (10 from Account A and 5 from Account B), so he/she will receive 5 times €0.50 from Account B, which equals €2.50. If we add everything together, participant A will get 2.5 + 7.8 = €10.3. This gain will be added to the endowment of €15.

Participant H contributed 20 tokens (10 from Account A and 10 from Account B). This means that the player will only get a payment from the joint project: €7.80.

A.3 Control questions

(a) Take a look at the hypothetical example below (same as the first example we looked at before). Are the contributions [*Summation treatments: "collective contributions"*] within the group sufficient to avoid the loss?

○ Yes ○ No
[*Summation, uncertainty treatments:* ○ It depends on the random draw]

Participant	Contribution
A	0
B	0
C	10
D	0
E	12
F	10
G	8
H	15
I	17
J	20
Total	92

(b) Assume that the group as a whole (including you) has contributed 0 tokens to the joint account so that there is a loss of €15. What would be your total payoff from the game (excluding the initial endowment of €15)?

○ -15 ○ -9 ○ 0 ○ 6 ○ 15

(c) Assume that the group as a whole (including you) has contributed 150 tokens to the joint project. How much would each participant receive in payment from the joint project only?

○ 0 ○ 5 ○ 7.5 ○ 10 ○ 15

[*Weakest link, certainty*] (d) What is the lowest number of tokens each participant must contribute to the joint account in order to avoid the loss?

○ 0 ○ 5 ○10 ○ 15 ○ 20

[*Weakest link, uncertainty (T2, T3)*] (d) What is the lowest number of tokens each participant must contribute to the joint account to have some possibility to avoid the loss?

○ 10 ○ 14 ○15 ○ 16 ○ 20

[*Weakest link, uncertainty (T2, T3)*] (e) How many tokens must each participant contribute to the joint account to be sure to avoid the loss?

○ 10 ○ 14 ○15 ○ 16 ○ 20

[*Summation, certainty*] (d) What is the lowest number of tokens the group must reach to avoid the loss?

○ 0 ○ 50 ○100 ○ 150 ○ 200

[*Summation, uncertainty (T5, T6)*] (d) What is the lowest number of tokens the group must reach to have some possibility to avoid the loss?

○ 100 ○ 140 ○150 ○ 160 ○ 200

[*Summation, uncertainty (T5, T6)*] (e) How many tokens must the group reach to be sure to avoid the loss?

○ 100 ○ 140 ○150 ○ 160 ○ 200

A.4 Survey questions

1. Did you trust the other players to make the contributions they pledged?
   □ Very much
   □ Somewhat
   □ Not much
   □ Not at all

2. Can you can describe the main reasons you did or did not trust the pledges made by the other participants.
   ……………………………………………………

3. What was the most important reason for your pledge?
   □ To signal my intended contribution
   □ To get others to contribute
   □ Other reason: ………

4. Did other group members' pledges affect your own contribution?
   □ No
   □ Yes, it made me increase my contribution relative to what I initially intended to contribute.
   □ Yes, it made me decrease my contribution relative to what I initially intended to contribute.

5. Did other group members' proposals for the group contribution affect your own contribution?
   □ No
   □ Yes, it made me increase my contribution relative to what I initially intended to contribute.
   □ Yes, it made me decrease my contribution relative to what I initially intended to contribute.

6. Please tell me, in general, how willing or unwilling you are to take risks. Please use a scale from 0 to 10, where 0 means you are" completely unwilling to take risks" and a 10 means you are "very willing to take risks."

7. We now ask for your willingness to act in a certain way in four different areas. Please again indicate your answer on a scale from 0 to 10, where 0 means you are "completely unwilling to do so" and a 10 means you are "very willing to do so".

   a. How willing are you to give up something that is beneficial for you today, in order to benefit more from it in the future?
   b. How willing are you to punish someone who treats you unfairly, even if there may be costs for you?

c. How willing are you to punish someone who treats others unfairly, even if there may be costs for you?
d. How willing are you to give to good causes without expecting anything in return?

8. How well do the following statements describe you as a person? Please indicate your answer on a scale from 0 to 10. A 0 means “does not describe me at all” and a 10 means “describes me perfectly.”

a. When someone does me a favor, I’m willing to return it
b. If I am treated very unjustly, I will take revenge at the first occasion, even if there is a cost to do so.
c. I assume that people have only the best intentions.

9. Please imagine the following situation: You can choose between a sure payment of a particular amount of money, or a draw, where you would have an equal chance of getting 300 euro and getting nothing. We will present to you five different situations. [*Followed by five lottery choices, where later lotteries condition on earlier choices*]

10. Please think about what you would do in the following situation. You are in an area you are unfamiliar with and realize that you are lost. You ask a stranger for directions. The stranger offers to take you to your destination. Helping you costs the stranger about 20 euro in total. However, the stranger says he or she does not want any money from you. You have six presents with you. The cheapest present costs 5 euro, the most expensive one costs 30 euro. Do you give one of the presents to the stranger as a “thank you” gift? If so, which present do you give to the stranger?

□ no present
□ the present worth 5 euro
□ the present worth 10 euro
□ the present worth 15 euro
□ the present worth 20 euro
□ the present worth 25 euro
□ the present worth 30 euro

11. Imagine the following situation: Today you unexpectedly received 1,000 euro. How much of this amount would you donate to a good cause? (Values between 0 and 1,000 are allowed)

……………………….. euro

12. What is your gender?

□ Male

□ Female

13. What is your year of birth?
…….

14. In what academic domain does your major belong?
□ Natural sciences
□ Social sciences
□ Humanities
□ Business
□ Economics
□ Law

Appendix B. Theoretical guidance

Here we derive best responses and characterize associated Nash equilibria for each treatment in the experiment. We limit attention to symmetric equilibria. Since endowments have no impact on best responses, we disregard them throughout the analysis. We also do not consider proposals and pledges of the kind offered in the second round of the game. Players are assumed to be risk neutral throughout.

Recall that each player $i \in \{1,\ldots,10\}$ chooses how many tokens $q_i \in \{0,1,\ldots,20\}$ to contribute. For fixed player i, define $q_{-i} = \sum_{j \neq i} q_j$ as the sum of other group members' contributions and $q_i^{min} = \min_i(q_i)$ as the smallest contribution by any player. The threshold $\bar{Q}$ is uniformly distributed on integers $\{a, a+1, \ldots, b-1, b\}$, with $b \geq a > 0$.

Each player's opportunity cost of contributing is piecewise linear and convex,

$$C(q_i) = \begin{cases} 0.1q_i, & \text{for } 0 \leq q_i \leq 10 \\ 1 + 0.5(q_i - 10), & \text{for } 11 \leq q_i \leq 20 \end{cases}$$

while total returns from contributing (after resolving the uncertainty in $\bar{Q}$) are

$$0.05(q_i + q_{-i}) - 15f(q_1, \ldots, q_n, \bar{Q})$$

where f is a discontinuous function of the contributions and the threshold level. Under a summation technology, $f = I(q_i + q_{-i} < \bar{Q})$, where I is the binary indicator function. Under a weakest-link technology, $f = I\left(q_i^{min} < \bar{Q}\right)$.

B.1 Weakest-link technology

B.1.1 Certain threshold (T1)

When the weakest-link threshold is certain and equal to $\bar{Q} = 15$, payoffs to player i are

$$U\left(q_i, q_{-i}, q_i^{min}\right) = 0.05(q_i + q_{-i}) - C(q_i) - 15I\left(q_i^{min} < 15\right).$$

We will now analyze i's best response $q_i(q_{-i}^{min})$, being a function of $q_{-i}^{min} = \min_{j \neq i}(q_j)$, the lowest contribution of any player other than i. There are two cases, each of which will support a symmetric Nash equilibrium whenever $q_i(q_{-i}^{min}) = q_{-i}^{min}$.

First, if $q_{-i}^{min} < 15$, then regardless of q_i, the threshold will not be met; therefore, since the marginal utility of contributing is negative, $q_i(q_{-i}^{min}) = 0$, supporting a noncooperative equilibrium where $q_i = 0$ for all i.

Second, if $q_{-i}^{min} \geq 15$, then payoffs for player i are given by

$$U(q_i, q_{-i}, q_i^{min}) = 0.05(q_i + q_{-i}) - C(q_i) - 15I(q_i < 15)$$

and i's best response is either zero or 15. In fact, since $0.05 \times 15 - 1 - 0.5 \times 5 = -2.75 > -15$, it is $q_i(q_{-i}^{min}) = 15$. This supports an equilibrium where $q_i = 15$ for all i.

In summary, there are two symmetric Nash equilibria: a non-cooperative one at $q_i = 0$ for all i, and a coordination/cooperation equilibrium at $q_i = 15$.

B.1.2 Uncertain threshold (T2, T3)

When the location of the threshold is uncertain, expected payoffs for risk neutral agents are

$$E\left[U(q_i, q_{-i}, q_{-i}^{min})\right] = 0.05(q_i + q_{-i}) - C(q_i) - 15P(q_i^{min} < \bar{Q})$$

Again, the best response of player i is a function of q_{-i}^{min}, and symmetric equilibria have $q_i(q_{-i}^{min}) = q_{-i}^{min}$. There are again two cases. Note that $b - a = 10$ under large uncertainty (T2) and $b - a = 2$ under small uncertainty (T3).

First, if $q_{-i}^{min} < a$, then $P = 1$, so $q_i(q_{-i}^{min}) = 0$ in this case, supporting a non-cooperative equilibrium where $q_i = 0$ for all i.

Second, if $q_{-i}^{min} \geq a$, player i is pivotal for threshold attainment up to the point where $q_i = q_{-i}^{min}$ or, if $q_{-i}^{min} \geq b$, the point where $q_i = b$ and thus $P = 0$. As a result, payoffs to player i are

$$E\left[U\left(q_i, q_{-i}, q_{-i}^{min}\right)\right] = 0.05(q_i + q_{-i}) - C(q_i) - 15 \times \min\left(1, \max\left(\frac{b - q_i}{b - a + 1}, \max\left(0, \frac{b - q_{-i}^{min}}{b - a + 1}\right)\right)\right).$$

Because of the weakest-link structure of the game, it will never be optimal for player i to contribute more than $\min(q_{-i}^{min}, b)$ tokens. Furthermore, the first nine units contributed by player i can never affect the probability of threshold attainment. Under large uncertainty, the tenth unit contributed will marginally impact P: this unit yields marginal payoff $-0.05 + 15/11 > 0$. Under small uncertainty, player i is able to affect P only by contributing more than 10 units. This implies facing higher marginal contribution costs; nevertheless, marginal payoffs of contributing more than 10 units while affecting P is $-0.45 + 15/(b - a + 1)$, which is positive under both large and small uncertainty. It follows that, under both large and small uncertainty, either $q_i\left(q_{-i}^{min}\right) = 0$ or $q_i\left(q_{-i}^{min}\right) = \min\left(q_{-i}^{min}, b\right)$.

In fact, for our parameter values, $q_i(q_{-i}) = \min\left(q_{-i}^{min}, b\right)$ in both treatments and any $q_{-i}^{min} \geq a$. For instance, under large uncertainty and $q_{-i}^{min} = 10$, contributing 10 tokens is preferable to contributing nothing since $-0.05 \times 10 + 15/11 > 0$. These best-response patterns thus support symmetric Nash equilibria at all $b - a + 1$ integers $q_i \in \{a, a + 1, \dots, b - 1, b\}$.

In summary, under large uncertainty, there exists a symmetric non-cooperative equilibrium at $q_i = 0$ and 11 symmetric coordination/cooperation equilibria at $q_i \in \{10, \dots, 20\}$. Under small uncertainty, there is again a symmetric equilibrium at $q_i = 0$ for all i, and also three coordination/cooperation equilibria at $q_i \in \{14,15,16\}$.

B.2 Summation technology

B.2.1 Certain threshold (T4)

When the threshold level is certain, $\bar{Q} = 150$, payoffs to agent i are

$U(q_i, q_{-i}) = 0.05(q_i + q_{-i}) - C(q_i) - 15I(q_i + q_{-i} < 150)$.

We will now analyze i's best response $q_i(q_{-i})$, being a function of q_{-i}, the summed contributions of other players. There are three cases, and we will check whether best responses in each case support some symmetric equilibrium where $q_i(q_{-i}) = q_{-i}/9$.

First, if $q_{-i} < 130$, the last term in the utility function equals 15 regardless of q_i, so utility is everywhere decreasing in own contributions since marginal costs of contributing are always at least 0.1. Thus, $q_i(q_{-i}) = 0$ is optimal in this range, supporting a non-cooperative Nash equilibrium where $q_i = 0$ for all i.

Second, if $130 \leq q_{-i} < 150$, player i is pivotal in reaching the threshold. Clearly, contributing either zero or $150 - q_{-i}$ will be optimal; the latter is the case when

$$0.05 \times 150 - C(150 - q_{-i}) > 0.05q_{-i} - 15$$

which is always true given our parameter values. Thus, $q_i(q_{-i}) = 150 - q_{-i}$ in this range. This supports a symmetric coordination/cooperation equilibrium at $q_i = 15$ for all i, where all players have $q_{-i} = 135$.

Finally, if $q_{-i} \geq 150$, the threshold is certain to be reached regardless of q_i, and it follows that $q_i(q_{-i}) = 0$, similarly to the first case. Thus, no symmetric equilibrium is supported.

In summary, there are two symmetric Nash equilibria: a noncooperative one at $q_i = 0$ for all i and a coordination/cooperation equilibrium at $q_i = 15$.

B.2.2 Uncertain threshold (T5, T6)

When the location of threshold $\bar{Q}$ is uncertain, expected payoffs for risk-neutral players are given by

$$E[U(q_i, q_{-i})] = 0.05(q_i + q_{-i}) - C(q_i) - 15P(q_i + q_{-i} < \bar{Q})$$

where $P(\cdot)$ is the probability of failing to reach the uniformly distributed threshold. Again, the best response of player i is a function of q_{-i}, and symmetric equilibria have $q_i(q_{-i}) = q_{-i}/9$. The main difference is that there are now five cases, which we will discuss in turn. Note that $b - a = 100$ under large uncertainty (T5) and $b - a = 20$ under small uncertainty (T6).

First, if $q_{-i} < a - 20$, then $P = 1$ regardless of q_i, so then $q_i(q_{-i}) = 0$, again because marginal payoffs from contributing are everywhere negative. These best responses clearly support a Nash equilibrium where $q_i = 0$ for all i.

Second, if $a - 20 \leq q_{-i} < a - 1$, then player i is able to marginally impact the probability of threshold attainment, but only after having contributed the first $(a - 1) - q_{-i}$ units. This implies that expected payoffs become

$$E[U(q_i, q_{-i})] = 0.05(q_i + q_{-i}) - C(q_i) - 15 \times \min\left(1, \frac{b - (q_i + q_{-i})}{b - a + 1}\right)$$

where the final term reflects the discrete uniform distribution of $\bar{Q}$; recall that $\bar{Q}$ may take $b - a + 1$ values. Thus, the marginal utility of the initial unit(s) contributed by i is negative, but if q_i enters the range where $P < 1$ while $q_i \leq 10$, then the marginal utility becomes $-0.05 + 15/(b - a + 1)$, which is positive under both large and small uncertainty. Furthermore, i's marginal utility of contributing more than 10 units while impacting P is $-0.45 +$

$15/(1+b-a)$, which is negative under large uncertainty but positive under small uncertainty. It follows that, under large uncertainty, either $q_i(q_{-i}) = 0$ or $q_i(q_{-i}) = 10$. Under small uncertainty, either $q_i(q_{-i}) = 0$ or $q_i(q_{-i}) = 20$.

For our particular parameter values, we find the following. Under large uncertainty, where $a = 100$, $q_i(q_{-i}) = 10$ for $93 \leq q_{-i} \leq 98$, and is zero otherwise. Under small uncertainty, where $a = 140$, $q_i(q_{-i}) = 20$ for $126 \leq q_{-i} \leq 138$, and is zero otherwise. No Nash equilibria are supported by these best responses.

Third, when $a - 1 \leq q_{-i} \leq b - 20$, the choice of player i always affects P, so expected payoffs are

$$E[U(q_i, q_{-i})] = 0.05(q_i + q_{-i}) - C(q_i) - 15 \times \frac{b - (q_i + q_{-i})}{b - a + 1}$$

which, by similar reasoning as above, implies $q_i(q_{-i}) = 10$ under large uncertainty, and $q_i(q_{-i}) = 20$ under small uncertainty. Again, no Nash equilibria are supported in this range.

Fourth, when $b - 20 < q_{-i} < b$, player i starts out being pivotal; but the threshold is met with certainty for high enough q_i, and $P = 0$ for any contribution beyond that point. It follows that payoffs are

$$E[U(q_i, q_{-i})] = 0.05(q_i + q_{-i}) - C(q_i) - 15 \times \max\left(0, \frac{b - (q_i + q_{-i})}{b - a + 1}\right)$$

implying that under large uncertainty, $q_i(q_{-i}) = \min(10, b - q_{-i})$, while under small uncertainty, $q_i(q_{-i}) = b - q_{-i}$. For large uncertainty, no Nash equilibrium is supported by these patterns; but for small uncertainty, a coordination/cooperation equilibrium is supported at $q_i = 16$ for all i, where all players have $q_{-i} = b - 16 = 144$.

Finally, if $q_{-i} \geq b$, $P = 1$ regardless of q_i, so then $q_i(q_{-i}) = 0$. Thus, no Nash equilibrium is supported in this range.

In summary, for large uncertainty, the only symmetric equilibrium is the non-cooperative one where $q_i = 0$ for all i. For small uncertainty, there is additionally an equilibrium at $q_i = 16$ for all i.

B.3 Strategic uncertainty

In this section, we analyze how the strategic uncertainty facing players influences optimal choice. The arguments developed here are summarized in Section 3.1 of the main paper.

Deriving clear-cut predictions on risk-based equilibrium selection requires a full treatment of multi-player, multi-action risk dominance in the context of our game, which is beyond the scope of this paper. Instead, as a starting point, we perform a set of pairwise risk-dominance comparisons across all symmetric equilibria in a given treatment (as in Riedl et al., 2016). To this effect, we consider a set of two-player games, where each player chooses between two strategies that each form symmetric equilibria in Table 2. For simplicity, these games abstract from players' endowment as well as the continuous public-good contribution made by the other player, neither of which affect players' risk calculus. In the summation treatments, we also need to make some assumption on what 2-player game can be viewed as analogous to the 10-player game. We consistently assume that the support of $\bar{Q}$ scales with the number of players; thus, for example, $\bar{Q} \in \{28, \dots, 32\}$ in the two-player game corresponding to Summation, small uncertainty. In all the games where we undertake pairwise risk-dominance comparisons (recall that there is only one symmetric equilibrium in the Summation, uncertainty treatment), the set of symmetric equilibria is then the same as with 10 players.

Consider, as one example, two players choosing between $q_i = 0$ and $q_i = 15$ in the Summation, certainty treatment (T4). Since the game is symmetric, we show only payoffs to player i:[1]

		q_j	
		0	15
q_i	0	-15	-15
	15	-17.75	-2.75

In this game, player i is willing to play $q_i = 15$ so long as the probability π that player j will do so as well is such that $-17.75(1-\pi) - 2.75\pi \geq -15$, or $\pi \geq 11/60$. Since this probability cutoff is less than $1/2$ (and the probability of j playing $q_j = 0$ required for i to be willing to also not contribute is $1-\pi$), the risk dominant equilibrium in this game is $(15{,}15)$.[2]

For the general case, let the comparison be between some pair of strategies q^l and q^h, with $q^l < q^h$. To provide a simple unified notation for summation and weakest link, define $p(q_i, q_j) = P(f(q_i, q_j, \bar{Q}) = 1)$, with f as in Appendix B, i.e., as an indicator function for either a summation or a weakest-link threshold. Then, for any treatment, the matrix of payoffs to player i is

		q_j	
		q^l	q^h
q_i	q^l	$0.05q^l - C(q^l) - 15p(q^l, q^l)$	$0.05q^l - C(q^l) - 15p(q^l, q^h)$
	q^h	$0.05q^h - C(q^h) - 15p(q^h, q^l)$	$0.05q^h - C(q^h) - 15p(q^h, q^h)$

[1] The general payoff formula in the matrix can be written as $U_i(q_i, q_j) = 0.05q_i - C(q_i) - 15(1 - I(q_i + q_j = 30)$, with I the binary indicator function.

[2] As is simple to verify, the cutoff is less than $1/2$ if and only if deviation losses are larger for the $(15{,}15)$ equilibrium than the $(0{,}0)$ one.

and, noting that $p(q^h, q^l) = p(q^l, q^h)$, player i will want to play q^h rather than q^l if and only if[3]

$$\pi \geq \frac{C(q^h) - C(q^l) - 0.05(q^h - q^l) - 15[p(q^l, q^l) - p(q^l, q^h)]}{15[2p(q^l, q^h) - p(q^l, q^l) - p(q^h, q^h)]} \equiv \bar{\pi}$$

We will now confirm that $\bar{\pi} < 1/2$ for *all* pairwise comparisons of this kind: thus, risk and payoff dominance fully coincide.

In the Summation, certainty treatment (T4) already covered above, $p(0,15) = p(0,0) = 1$ while $p(15,15) = 0$, so $\bar{\pi} = 11/60$. Also, in the Summation, small uncertainty treatment (T6), due to the fact that slightly larger average contributions are required to fully eliminate threshold risk, $\bar{\pi} = 16/75 > 11/60$. Thus, the cooperative equilibrium entails slightly greater risk under (small) threshold uncertainty.

Next, under a weakest-link technology, we have $p(q^l, q^h) = p(q^l, q^l)$, so

$$\bar{\pi} = \frac{C(q^h) - C(q^l) - 0.05(q^h - q^l)}{15[p(q^l, q^l) - p(q^h, q^h)]}$$

and we again have $\bar{\pi} = 11/60$ for the comparison between the two symmetric equilibria under certainty (T1). For the uncertainty treatments (T2 & T3), consider first the set of comparisons between $q^l = 0$ and some cooperative-equilibrium strategy $q^h \geq a$. If $s = \{3,11\}$ is the number of discrete mass points of the threshold distribution, we may rewrite $\bar{\pi}$ yet again as

$$\bar{\pi} = \frac{C(q^h) - 0.05q^h}{(15/s) \times (1 + q^h - a)} = \frac{s(0.5 + 0.45(q^h - 10))}{15(1 + q^h - a)}$$

which is decreasing in q^h for all a used in our design. For example, in T2, $\bar{\pi} = 1/3$ when $q^h = 20$ but $\bar{\pi} = 11/30$ when $q^h = 10$. Similarly, in T3, $\bar{\pi} = 16/75$ when $q^h = 16$ (same cutoff probability as for the corresponding summation

[3] The inequality holds iff $2p(q^l, q^h) - p(q^l, q^l) - p(q^h, q^h) > 0$, which is true in all treatments.

game) but $\bar{\pi} = 0.46$ when $q^h = 14$. As with the summation games, we note that all of these cutoffs lie above $11/60$, with the implication that cooperation is riskier under threshold uncertainty. More precisely, any cooperative equilibrium strategy in an uncertainty treatment is more risky relative to $q_i = 0$ than is $q_i = 15$ in the corresponding certainty treatment. (However, $q_i = 0$ is still the riskier strategy in all cases, since $\bar{\pi} < 1/2$.)

Finally, in any comparison between two equilibrium strategies that satisfy $q^h > q^l \geq a$, we have

$$\bar{\pi} = \frac{0.5(q^h - q^l) - 0.05(q^h - q^l)}{(15/s) \times (q^h - q^l)} = \frac{3s}{100}$$

which confirms that $\bar{\pi} < 1/2$ in all cases, and thus that risk and payoff dominance coincide in these games.

However, our actual design involves ten players, not two. While we expect that threshold uncertainty entails greater cooperation risk than certainty in ten-player games as well, other aspects of a player's risk calculus are likely to change as the number of players grows. Again, fully exploring this issue would require a complete analysis of risk dominance in our game; yet, as a simple tool for thinking about this issue under summation as well as weakest link, consider the following game matrix, corresponding to the two certainty treatments:

		q_{-i}^{min} or $\bar{q}_{-i}$: 0	15
q_i	0	-15	-15
	15	-17.75	-2.75

Note that this matrix replaces q_j by either q_{-i}^{min}, the minimum contribution among all other players (in the weakest-link game), or $\bar{q}_{-i}$, the average contribution by all other players (in the summation game). Then, with $\bar{Q}$ certain, payoffs are as given in the matrix under both weakest link and summation, for any number of players.[4]

With these payoffs, player i will again be willing to play $q_i = 15$ if and only if $\pi \geq 11/60$. However, π now represents the probability that $\bar{q}_{-i}$ or q_{-i}^{min} equals 15 rather than the probability that some single $q_j = 15$. Moving back to the full game, it seems clear that i is less likely to prefer $q_i = 15$ over $q_i = 0$ as the number of players rises, since this raises the bar for successful coordination at the threshold. It also seems clear that the π-analogue is generally larger under weakest link than summation because, as the number of players increases, there are more strategy profiles where player i will want to choose $q_i = 15$ over $q_i = 0$ under the latter technology. The reason is that, under summation, players are able to compensate for low-contribution behavior by others. As a simple illustration, note that under summation there are many asymmetric strategy profiles that yield (approximately) $\bar{q}_{-i} = 15$ when only some proportion $\theta < 1$ of players other than i bid 15 or more. By contrast, under weakest link, $q_{-i}^{min} = 15$ applies only to strategy profiles where $\theta = 1$, i.e., where *all* such players bid at least 15; thus π becomes analogous to the product of the probability that each other player does so.

In summary, the risk calculus of player i may be expected to eventually favor low contributions, especially with many players (as in our experiment) and under weakest link and/or threshold uncertainty.

[4] When comparing across pairs of different high-contribution equilibria in the weakest-link uncertainty treatments, all cells of the corresponding payoff matrix involve paying strictly less than the entire cost $X = 15$ in expectation; nevertheless, qualitative conclusions are similar to those presented here.

Appendix C. Additional tables

Table C1. Probability of reaching threshold

	Weakest link			Summation		
	Certainty	Uncertainty	Small uncert.	Certainty	Uncertainty	Small uncert.
$P = 1$ (certain avoidance)	90%	0%	37.5%	60%	0%	50%
$0.5 \leq P < 1$	0%	10%	0%	0%	70%	30%
$0 < P < 0.5$	0%	50%	25%	0%	30%	10%
$P = 0$ (certain loss)	10%	40%	37.5%	40%	0%	10%
Mean	0.9	0.15	0.46	0.6	0.5	0.74

Table C2. Descriptive statistics: contributions in both rounds, pledges, and proposals for group contribution (per person)

		Contribution Round 1	Contribution Round 2	Pledge Round 2	Proposal for group behavior (per person)
		Mean (s.d.) Mode	Mean (s.d.) Mode	Mean (s.d.) Mode	Mean (s.d.) Mode
Weakest link:	Certainty	14.51 (3.82) 15	15.73 (1.71) 15	15.80 (1.80) 15	15.76 (2.06) 15
	Uncertainty	15.02 (4.81) 15	15.48 (4.54) 15	16.06 (4.16) 20	15.99 (4.25) 20
	Small uncertainty	14.63 (4.62) 16	15.55 (3.34) 16	16.11 (2.23) 16	16.14 (1.97) 16
Summation:	Certainty	13.74 (4.74) 15	14.84 (3.97) 15	14.50 (4.12) 15	14.05 (4.69) 15
	Uncertainty	13.68 (5.56) 20	14.95 (4.97) 20	15.70 (4.76) 20	14.85 (6.08) 20
	Small uncertainty	14.32 (4.55) 16	15.52 (3.86) 16	14.93 (4.37) 16	14.68 (4.79) 16

Table C3. Tobit regression model, individual contributions to the public good. Marginal effects evaluated at sample mean, standard errors clustered at group level

	Weakest link	Summation
Uncertainty	0.013	0.538
	(0.819)	(0.983)
Small uncertainty	-0.298	0.892
	(0584)	(0.669)
Constant	15.91***	15.07***
	(0.271)	(0.314)
N	280	300

Table C4. Probability of reaching threshold, observed and simulated, experiment without pledges

	Weakest link			**Summation**		
	Certainty	Uncertainty	Small uncertainty	Certainty	Uncertainty	Small uncertainty
	Observed					
$P = 1$ (certain avoidance)	30%	0%	12.5%	30%	0%	0%
$0.5 \leq P < 1$	0%	0%	12.5%	0%	10%	40%
$0 < P < 0.5$	0%	20%	0%	0%	90%	30%
$P = 0$ (certain loss)	70%	80%	75%	70%	0%	20%
Mean	0.30	0.02	0.21	0.30	0.37	0.40
	Simulated					
$P = 1$ (certain avoidance)	32%	0%	6%	20%	0%	10%
$0.5 \leq P < 1$	0%	6%	20%	0%	25%	23%
$0 < P < 0.5$	0%	29%	9%	0%	73%	28%
$P = 0$ (certain loss)	68%	65%	66%	80%	2%	39%
Mean	0.32	0.10	0.22	0.20	0.37	0.34

Table C5. Relation between contributions in round 1 and pledges in round 2, comparison at the individual level (p-values based on Wilcoxon sign rank)

		Contribution round 1	Pledge round 2	p-value
Weakest link	Certainty	14.51	15.8	0.002
		(3.82)	(1.8)	
	Uncertainty	15.02	16.06	0.015
		(4.81)	(4.2)	
	Small uncertainty	14.63	16.1	0.001
		(2.9)	(2.2)	
Summation	Certainty	13.74	14.5	0.064
		(4.7)	(4.1)	
	Uncertainty	13.68	15.7	0.000
		(5.56)	(4.8)	
	Small uncertainty	14.32	14.93	0.029
		(4.55)	(4.4)	

Table C6. Relation between pledges and contributions in round 2. Mean, minimum, and standard deviation at group level (p-values based on Wilcoxon sign rank)

			Pledge	Contribution	p-value
Weakest link	Certainty	Mean	15.80	15.73	0.385
		Min	14.5	14.5	1.000
		Std	1.66	1.55	0.414
	Uncertainty	Mean	16.06	15.48	0.575
		Min	7.8	7	0.678
		Std	4.05	3.89	0.721
	Small Uncertainty	Mean	16.11	15.55	0.360
		Min	13.25	10.75	0.722
		Std	1.80	2.38	0.674
Summation	Certainty	Mean	14.50	14.84	0.838
		Min	8.70	6.8	0.304
		Std	3.52	3.60	0.879
	Uncertainty	Mean	15.70	14.95	0.201
		Min	6	4.5	0.474
		Std	4.80	4.62	0.575
	Small Uncertainty	Mean	14.93	15.52	0.333
		Min	6.1	7.9	0.719
		Std	4.14	3.43	0.241

Table C7. Individual characteristics across treatments, standard deviations in parentheses

	Weakest link, certainty	Weakest link, uncertainty	Weakest link, small uncertainty	Summation, certainty	Summation, uncertainty	Summation, small uncertainty
Risk measure	5.52	5.51	5.90	5.55	5.80	5.36
	(2.05)	(2.28)	(1.81)	(2.12)	(2.13)	(2.08)
Time preference	7.35	7.30	7.20	7.36	7.54	7.45
	(1.90)	(2.34)	(2.14)	(2.00)	(2.12)	(2.01)
Generosity	7.45	6.82	7.13	7.44	7.46	7.27
	(2.14)	(2.40)	(2.18)	(2.04)	(2.11)	(1.98)
Punish you	4.95	5.32	5.46	5.37	5.35	4.96
	(2.56)	(2.77)	(2.70)	(2.70)	(2.55)	(2.56)
Punish others	5.85	5.65	5.55	5.57	5.71	5.57
	(2.37)	(2.42)	(2.27)	(2.38)	(2.52)	(2.39)
Trust	2.19	1.78	1.98	1.74	1.57	1.76
	(0.68)	(0.84)	(0.80)	(0.77)	(0.81)	(0.64)
Female	0.58	0.55	0.56	0.55	0.64	0.60
	(0.50)	(0.50)	(0.50)	(0.50)	(0.48)	(0.49)
Age	27.79	27.11	26.80	28.51	27.85	27.50
	(6.65)	(5.23)	(4.73)	(9.07)	(5.57)	(4.91)
Econ	0.20	0.26	0.33	0.28	0.22	0.27
	(0.40)	(0.44)	(0.47)	(0.45)	(0.42)	(0.45)
Observations	100	100	80	100	100	100

Note: Risk measures: Response to the question "Please tell me, in general, how willing or unwilling you are to take risks. Please use a scale from 0 to 10, where 0 means you are *completely unwilling to take risks* and 10 means *you are very willing to take risks.* Time preference: Response to question "How willing are you to give up something that is beneficial for you today, in order to benefit more from it in the future?" Generosity: Response to question "How willing are you to give to good causes without expecting anything in return?" Punish you: Response to question "How willing are you to punish someone who treats you unfairly, even if there may be costs for you? Punish others: Response to question "How willing are you to punish someone who treats others unfairly, even if there may be costs for you?" For these four questions, 0 means *completely unwilling to do so* and 10 means *very willing to do so*. Trust: Response to the question "Did you trust the other players to make the contributions they pledged?", where 0 means *very much* and 3 means *not at all*. Female: Dummy variable equal to one if female subject. Age in years. Econ: Dummy variable equal to one if majoring in economics or business.