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Climate Policy Commitment Devices

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Summary

We develop a dynamic resource extraction game that mimics the global multi-generation planning problem for climate change and fossil fuel extraction. We implement the game under different conditions in the laboratory. Compared to a 'libertarian' baseline condition, we find that policy interventions that provide a costly commitment device or reduce climate threshold uncertainty reduce resource extraction. We also study two conditions to assess the underlying social preferences and the viability of ecological dictatorship. Our results suggest that climate-change policies that focus on investments that lock the economy into carbon-free energy sources provide an important commitment device in the intertemporal cooperation problem.

Keywords: Climate Policy Instruments, Intertemporal Cooperation, Climate Game, Experiments

JEL Classification: C91, D62, D99, Q38,Q54

We thank seminar participants at the Workshop on CO2 pricing and sectoral complementary policies (April 2016, Montreal), the annual EAERE conference (June 2016, Zurich), the 6th CREE Research Workshop (Oslo, October 2016), the University of Innsbruck, Tilburg University, and the ZEW Mannheim for helpful comments.

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Climate Policy Commitment Devices

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September 8, 2017

Abstract:
We develop a dynamic resource extraction game that mimics the global multi-generation planning problem for climate change and fossil fuel extraction. We implement the game under different conditions in the laboratory. Compared to a 'libertarian' baseline condition, we find that policy interventions that provide a costly commitment device or reduce climate threshold uncertainty reduce resource extraction. We also study two conditions to assess the underlying social preferences and the viability of ecological dictatorship. Our results suggest that climate-change policies that focus on investments that lock the economy into carbon-free energy sources provide an important commitment device in the intertemporal cooperation problem.

Highlights

- An experimental test of policies for a fossil-fuel climate economy
- A libertarian rule exhausts the resource; a costly solar rule preserves it.
- Participants (endogenously) choose the costly solar commitment device

JEL codes: C91, D62, D99, Q38,Q54
Keywords: climate policy instruments; intertemporal cooperation; climate game; experiments

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1. Introduction

Reducing fossil fuel use is a major component of climate policy. Yet the economic mechanisms for exhaustible resources amplify the coordination difficulties for the public good. Effective climate policy requires coordination both between countries, and over time between generations, because the exhaustible resource characteristics of fossil fuels tend to annul unilateral action (cf. Karp 2015 and references therein). A decrease of fuel demand induces increasing demand by others, both by other countries as emphasized in the carbon leakage literature (Michielsen 2014), and over time as reported in the green paradox literature (Sinn 2008, Gerlagh 2011, van der Ploeg 2016). Policy makers who are unaware of these challenges tend to develop too optimistic plans and early climate targets are subsequently relaxed. Such lack of commitment is especially problematic if climate change is uncertain, and the threshold for a 'catastrophe' is unknown (Barrett and Dannenberg 2012, Gerlagh and Michielsen 2015, Dannenberg et al. 2015). There is an abundant literature on the *international* coordination problem, mostly presenting a pessimistic free-rider perspective (Barrett 1994, 2013), though recent papers present a more constructive contracting approach (Harstad 2015b).[1] In contrast, we focus on the *intertemporal* coordination problem. Recently, some more optimistic analyses suggest democratic rules (Hauser et al. 2014) and investments in renewable energy as a commitment device as solutions of the dynamic problem (Holtsmark and Midttomme 2015, Harstad 2015a).[2] Our contribution is threefold. We develop a dynamic threshold public good game where players choose their actions sequentially, focusing on intergenerational trade-offs rather than international negotiations.[3] Second, in the context of the intertemporal resource extraction dilemma, we show that a commitment device that reduces future resource demand can help to implement resource conservation. This holds even though the commitment device is costly, meaning that its use is inefficient – a waste of

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[1] The free-rider incentive in Barrett (1994) derives from the concept of a group of countries who set up an agreement, while the outsiders to the agreement play a Nash strategy. The free entry-exit condition for the agreement then constrains the maximum effort inside the agreement. Harstad (2015b) invokes a contract mechanism that involves all players.

[2] In Harstad (2015a) players have a positive incentive to investment in clean technologies as these serve as commitment over time that reduce emissions. In Harstad (2015b) countries reduce investment in clean technologies as these enable other countries to exploit the commitment that comes with clean energy. This paper is more closely related to the first mechanism; the insights complement those of the second paper.

[3] Compare with Calzolari et al. (2016). In their dynamic climate change model, players represent countries that are active over all rounds. In our model players represent generations who, when time passes, enter and leave the game.

welfare – from a first-best planner's perspective. Yet, in the context of a strategic interaction between generations, it helps to improve the outcome compared to a context where this commitment device is not available. The third major contribution is that we connect subjects' behavior *across* conditions (within-rule choice) with their votes *for* a game condition (rule-choice). The findings suggest that successful cooperation not only needs to overcome a gap between individual incentives and public interests, but also a fundamental heterogeneity between subjects with respect to beliefs and preferences about the way in which this should be achieved.

We develop a simple 3-player 3-period sequential resource extraction game in the spirit of Erev and Rapoport (1990) and Budescu et al. (1992). The game mimics the essential characteristics of the climate change, fossil fuel resource-planning problem through four key features. First, players in the game can exploit or conserve a resource, but conservation by one player does not prevent exhaustion by others. Second, resource conservation is a public good. Each generation values its own consumption, but also derives utility from contributing to a stable climate. We model the public good feature through a payoff for all players that depends on both their own resource extraction and the end-of-game resource conservation as in Schmidt et al. (2011), Neubersch et al. (2014) and Gerlagh and Michielsen (2015). Third, the public good is uncertain, so that the benefits from resource conservation are not precisely known (akin to the threshold for climate catastrophe being uncertain). This is an important difference with Hauser et al. (2014), who have a perfectly known sustainability threshold. The certainty of the climate threshold has been found to have profound effects on cooperation (Barrett and Dannenberg 2012, Dannenberg et al. 2015), and will be a policy variable in the current study (Tavoni 2014). Fourth, the game is played sequentially, so that strategies are asymmetric. Players in earlier positions must base their decisions on expectations regarding future strategies by other players and the consequential conservation outcomes. Players in later positions can condition their actions on outcomes of choices by others.

We study the game's outcomes in an incentivized laboratory experiment under five different conditions. A benchmark condition called *Libertarian* reflects a democratic business-as-usual scenario in which submitted choices are simply implemented. Two conditions refer to potential policy interventions, two others investigate ethical aspects of the public good dilemma in resource conservation.

The first policy condition, *Certainty*, eliminates uncertainty about the catastrophe threshold, for example through an increased funding of research to improve climate change predictions. This condition resembles the setting studied in more detail by Barrett and Dannenberg (2012). Importantly, in our design we impose a conservative assessment, with climate catastrophe resulting for any non-zero degree of exploitation of the resource, i.e., the Certainty condition provides a physically strictly worse environment.[4] However, in equilibrium, the threat of climate catastrophe leads to full resource conservation. The second policy condition, *Solar*, introduces a costly commitment device resembling the development of renewable energy, based on a recently developing literature emphasizing the commitment problem as one of the key-elements of effective climate policy (Gerlagh and Michielsen 2015, Harstad 2015a, Holtsmark and Midttomme 2015). In the Solar condition, the first generation is presented with the choice of using a costly commitment device. The commitment is intertemporal; we do not study intra-temporal commitment mechanisms, e.g. public choices enforced through voting (Hauser et al. 2014).

The first ethical condition, *Dictator*, introduces commitment through dictatorship of the first generation. The first generation has the possibility to become a benevolent ecological dictator installing full resource conservation to the benefit of future generations. However, it is also possible that the first generation exploits the resource for own benefits, while restricting only future generations. This trade-off reflects the discussion on the desirability of ecological dictatorship (Stehr 2015). The second ethical condition, *Rawls*, introduces a 'veil of ignorance:' subjects propose an entire plan for all three generations in the game, not yet knowing which generational position they will hold. It aims to move the perspective of the decision maker away from individual to group benefits, i.e., considering the outcome of all generations jointly. These two conditions provide empirical insight into the trade-off between own benefits and group benefits, which is inherent to the intergenerational resource extraction dilemma. Note that meaningful labels are used for convenience here, but were not part of the experiment.

The experiment has three stages. In Stage 1, subjects are matched in groups of 3 players and play each condition exactly *once* without receiving feedback on outcomes. This allows for

[4] To be sure, new research on climate dynamics may result in more optimistic or more pessimistic views. To keep the number of treatments limited, we select only the more pessimistic research outcome for study. The choice is theoretically appealing, because in equilibrium, counterintuitively, a more pessimistic belief increases the expected payoffs.

within-person comparison of behavior across the different institutions. In the Stage 2, subjects vote in their groups for their preferred condition under a simple majority rule with tie breaking, and play the selected game *once* without receiving feedback on outcomes. Here we aim to understand the perceived legitimacy of the different institutions and how it affects endogenous institutional choice (Sutter et al. 2010, Barrett and Dannenberg 2016). For example, even if dictatorship yields better social outcomes than the libertarian condition, it may not be acceptable as an institution. In the Stage 3, players are randomly regrouped and each group plays one of the conditions *repeatedly* for six rounds *with* feedback on outcomes, allowing players to accumulate experience. We thus observe whether a condition directly implements a certain level of resource conservation, or whether learning and experience of realized outcomes are crucial for players to understand the underlying mechanisms.

2. The resource-extraction game

The resource extraction game models the behavior of three players in a sequential resource extraction setting. We assume that the resource stock S_t develops according to the dynamic equation

$$S_{t+1} = S_t - R_t, \tag{1}$$

where $R_t \in \{0,1\}$ denotes exploitation in period t (by player t), and an initial resource stock of $S_1 = 2$. S_4 denotes the final stock, which determines whether a stable climate can be attained. Each player receives direct benefits from resource exploitation, but also from resource conservation through climate protection.[5] Payoffs are given by

$$V_t = 6R_t + 8C, \tag{2}$$

where V_t denotes the payoffs to the player living in period t, and $C \in \{0,1\}$ is an indicator for a stable climate.

The payoff structure presents a subtle difference in preferences between generations in the climate change context. Each generation gives a higher weight to its own consumption vis-à-vis the consumption of next generations; such myopic preferences are typical for descriptive

[5] At first glance, it may seem impossible that welfare of the present generations depends on the future state of the climate, as the present cannot observe the state of climate after its passing. The interpretation is that present utility depends on the expected state of conservation. For risk-neutral players, letting the payoff depend on the actual state of conservation at the end of the game is consistent with a payoff that is dependent on the expected state at the end of the game.

models of intertemporal allocation problems. The first term in (2) represents a simplified version of these: it associates zero weight to the benefits of resource extraction by next generations. Note that our empirical data will inform about the importance of any direct (and unspecified) altruism towards the other parties in the context of the current dilemma. Such attitudes would be relevant if the current generation forgoes benefits of extraction in favor of the next generation, at its own expense after accounting for long-term benefits. The payoff function specifies that generations are not fully myopic. They are concerned about far-future outcomes of their decisions. In climate-economy models, the positive weight for long-term outcomes can be modelled through quasi-hyperbolic time discounting (Gerlagh and Liski 2016), or through a positive weight for the long-term future through an additional payoff (Chichilnisky 1996, Gerlagh and Michielsen 2015). The second term in (2) captures such a dislike of each generation to add risk to the climate system, representing decision making under scientific uncertainty. The altruism towards far-future generations is explicitly modelled in the payoffs through the stable climate indicator. That is, we do not measure home-grown altruism regarding far off generations, but aim to study intertemporal cooperation *conditional* on the presumed empirical relevance of such altruism, using induced preferences (Smith 1976).

The payoff structure constructs a paternalistic view in which the first generation prefers a stable climate, but also likes to reap the gains from fossil fuel use and to shift costs of achieving a climate target on to the second and third generation. The second generation also appreciates a stable climate, but as well the own gains from fossil fuel use. This setup constructs an intertemporal dilemma. Each generation would like to commit the next generations to abandon fossil fuel use, but without commitment device, the accumulation of short-term exploitation gains results in long-term climate damages.

2.1. The benchmark (Libertarian) game

In the benchmark, or *Libertarian*, version of the game, there are no restrictions on the players' exploitation choices. If both resource units of the initial stock are conserved, a stable climate is ensured. If only one of the two resource units is conserved, the probability of a stable climate is 50%. If the resource is fully exploited a stable climate is impossible.

$$S_4 = 0 \Rightarrow C = 0 \tag{3}$$

$$S_4 = 1 \Rightarrow P(C = 1) = \frac{1}{2}, \tag{4}$$

$$S_4 = 2 \Rightarrow C = 1 \quad (5)$$

Thus, the expected climate variable is linear in the final resource stock: $\mathbb{E}(C) = \frac{1}{2}S_4$. It follows that for the third player, expected payoffs are maximized by extracting the resource:

$$\mathbb{E}(V_3) = 6R_3 + 4S_4 = 4S_3 + 2R_3 \quad (6)$$

Through backward induction, it is clear that for each player it is optimal to extract the resource if given the opportunity. In contrast, the expected group payoff is maximized by full resource conservation:

$$\mathbb{E}(V_1 + V_2 + V_3) = 6R_1 + 6R_2 + 6R_3 + 24\mathbb{E}(C) = 12 - 6S_4 + 12S_4 = 12 + 6S_4 \quad (7)$$

The expected group payoff increases in conservation S_4, but resource extraction is individually optimal for players who are only concerned about their own payoffs as given by (2). For the earlier players resource conservation is particularly risky as it leaves the opportunity for the subsequent players to extract the resource, not leaving any reserve at the end, so that good deeds might not be paid back by gains of enjoying a long-term stable climate.[6]

2.2. Two policy conditions

We study two policy conditions that aim to overcome coordination failure. First, the *Certainty* condition assumes that scientific research has sufficiently progressed to pinpoint the precise catastrophe threshold. As a conservative assessment, we assume that the threshold is found to be at the lower end. That is, a catastrophe is certain whenever any part of the resource is exhausted:

$$C = \begin{cases} 1 \; if \; S_4 = 2 \\ 0 \; if \; S_4 < 2 \end{cases} \quad (8)$$

In this case, exploiting the first unit is more harmful than in the above setting with uncertainty, while there is no additional harm from exploiting the second unit. For the third player, the individually rational conservation decision depends on the inherited resource stock. If two resource units are inherited, conservation leads to payoff of 8 units, while extraction pays 6 units. Thus, conservation is individually rational. If one resource unit is inherited, a stable climate is

[6] The game resembles a centipede game in the sense that everyone benefits if the resource is conserved period after period, while backwards induction leads to equilibrium strategies with the quickest possible resource extraction. Differently from the centipede game, in each period a new player enters; which makes coordination between the players more difficult.

unattainable and resource extraction is the superior strategy. By backward induction, one can see that full resource conservation is the unique Nash equilibrium, but it requires a supporting belief structure of the first and second player in the conservationist strategy by the subsequent player(s). Empirically, it may be easier to maintain cooperation in the absence of uncertainty (cf. Barrett and Dannenberg, 2012).

The second policy condition, *Solar*, concerns an investment $I_1 \in \{0,1\}$ of the first player into a technology (e.g., renewables) that makes future resource exploitation redundant. As in the libertarian game, however, there exists uncertainty about the threshold for climate catastrophe. We model the treatment such that an up-front cost can be incurred by player 1, which fixes future exploitation at zero for player 2 and 3 ($R_2 = R_3 = 0$); player 1 can still exploit the resource though. The investment is costly for player 1, reducing payoffs by 1 unit:

$$V_1 = 6R_1 - I_1 + 8C \tag{9}$$

In the *Solar* condition player 1's expected payoffs are maximized by exploiting the resource and simultaneously investing in the renewable, with a probability of a climate catastrophe of 50%.

We emphasize that the Certainty condition strictly restricts the opportunity set in the case of exactly one resource unit being extracted, while employing the Solar option also strictly restricts the opportunity set also reducing the payoff. The important empirical question we aim to answer in this paper is whether in the presence of a conflict between individual and social rationality, these policies can implement better outcomes despite the restricted opportunity sets.

2.3. Two ethical conditions

Compared to the benchmark *Libertarian* condition, the policy conditions *Certainty* and *Solar* change the technology of the game described in equations (1)-(7). We now define two ethical conditions that do not change technology compared to the benchmark, but do change the mapping from players and their decisions to payoffs. Again, as in the benchmark condition, there is uncertainty about the climate threshold.

The *Dictator* condition requires players to propose a plan for all three positions in the game, knowing that they will be in position 1, if their proposal is implemented. The proposal that is implemented and the positions of the player's whose proposal is not implemented are determined randomly. This treatment resembles a 'perfect commitment' equilibrium, with exploitation power for the first player and no exploitation power for the second and third player.

The condition relates to the discussion on ecological dictatorship (Stehr 2015); because there is no cooperation problem, the dictator has the possibility to implement a benevolent dictatorship with full resource conservation and maximum social welfare. However, selfish motives may lead the dictator to forgo social welfare maximization. The treatment thus informs on how much of the failure to achieve the socially optimal level of conservation is accounted for by cooperation failure compared to selfish preferences.

The *Rawls* treatment requires players to propose a plan for all three positions in the game, not yet knowing which position they will hold. The proposal that is implemented and the positions in the game are determined randomly. Thus, this treatment implements Rawls' 'veil of ignorance:' the players do not know in advance their role in the game, and their expected payoff is maximized by maximizing the group payoff (full conservation). This condition therefore should shift the players' focus towards social welfare maximization.

2.4. Predictions

On the basis of the different policy and ethical conditions for the cooperation dilemma we can summarize the theoretical predictions. Table 1 shows the expected equilibrium payoffs for each player ex-ante, before player roles are allocated, as well as the overall expected equilibrium payoff. The table also shows the equilibrium final resource conservation. Certainty and Rawls provide highest expected payoffs in equilibrium, followed by Dictator, Solar and Libertarian. Note that equilibrium payoffs differ in their distributional riskiness (variation of payoffs over generations), and also in terms of their strategic uncertainty, caused by the possibility of non-equilibrium play of later players. Importantly, we observe that conditions Solar and Dictator provide insurance against exploitation by later players.

Our benchmark prediction is risk-neutral equilibrium play in each condition. Thus, when institutional choice becomes relevant in the voting stage, we predict that Certainty and Rawls will be selected. Behavioral patterns may deviate from the current predictions for various reasons. Riskiness of the different conditions may affect behavior, and so may beliefs about other players. More subtle effects may be due to the degree of control over outcomes. In Libertarian and Certainty, all subjects' decisions are part of the outcome. In the other three conditions players may experience that decisions are explicitly imposed on them. In contrast to Dictator, Solar requires the first-generation player to invest some of her own funds to obtain such commitment power. A central question that the explicit voting addresses is how people perceive the value and the legitimacy of the different conditions. This is especially relevant from a practical viewpoint with respect to the policy interventions, and how these aspects may affect realized outcomes in each condition.

TABLE 1. Predictions of expected payoffs in equilibrium

Condition	Equilibrium Play	Final Stock S_4	Expected Payoffs (€)			
			P1	P2	P3	Avg.
Libertarian	Always exploit if possible	0	6	6	0	4
Certainty	Never exploit	2	8	8	8	8
Solar	Player 1 exploits and invests; Players 2 and 3 cannot exploit	1	9	4	4	5.67
Dictator	Player 1 exploits and forces Players 2 and 3 to conserve	1	10	4	4	6
Rawls	Never exploit	2	8	8	8	8

Notes: The table shows game-theoretic Nash equilibrium predictions of the five conditions, including the final resource conservation S_4 and the expected payoffs in € of the three players.

3. Empirical Methods

Our computerized experiment (zTree; Fischbacher 2007) involved 120 student participants from Tilburg University. The games and their payoffs were translated into Euro values by a 1-for-1 mapping of equation (2) (resp. equation (9)). Participants played multiple games, one of which was randomly selected for monetary payments according to participants' actual choices in this game at the end of the experiment (paying one game prevents income and portfolio effects across games).

The experiment consisted of three stages. In Stage 1, groups of three players played each of the five games exactly once (i.e., no repetition). Participants did not know the identity of their group members, and no feedback on choices or payoffs was given between the games. Importantly, each participant made decisions for all three positions in the game, for positions 2 and 3 these were conditional on the potential stocks at the respective position. Thus, when making decisions, subjects did not know the exact amount of resources that were taken from the common pool, as in Budescu et al. (1995). In condition Rawls this elicitation of full strategies was necessary to implement payoffs (because one person's decisions determine the full vector of choices). In the other conditions, the procedure allows us to observe strategies also for events that rarely obtain in sequential play (e.g., Brandts and Charness 2011), and maintains comparability of structure to the Rawls condition. For each game, after all strategies had been submitted, the position of the three players was randomly determined and choices were implemented according to the rules of the specific condition (but no feedback was given until the end of the experiment). To control for order effects when making choices in the 5 games in Stage 1, each group was assigned one of 40 pre-selected orders (out of the 120 possible orders) of the 5 games. We pre-selected these orders such that each game was played equally often in each position (i.e. 8 times as the first, second, … , last game) while also being played equally often earlier or later than any other game in pair-wise comparison (i.e. Libertarian appeared earlier than Rawls in 20 of the orders and later than Rawls in the other 20, etc.).

Stage 2 measures participants' preferences over the different institutions. Players were asked to vote for the game that they would prefer to repeat once more. The different conditions were listed to ensure that subjects knew what they vote for. We used a simple majority rule to determine for each group of 3 players which game was played again. In case of a tie, each of the three treatments that received a vote had a chance of 1/3 to be selected. While subjects were informed about which game was repeated once more, they were not informed about votes by other subjects. That is, subjects did not know whether the vote was consensual, a simple majority, or tied. The instructions of the selected game were repeated once more, subjects made their choices and were again not informed about choices by others or the outcome of the game.

Before Stage 3, participants were re-matched in new groups of three players. Then, each of the groups was randomly assigned to one of the five conditions, such that each condition was played by the same number of groups over the course of the experiment. These groups then played the selected condition 6 times repeatedly with feedback after each round. That is, at the end of each round, players were informed about their assigned position, the remaining resource units at their position and the implemented decision, as well as the final resource conservation and the resulting payoffs. Individual actions by others were not identifiable by the participants. This allowed the participants to learn about the behavior of their group members (which was impossible in Stages 1 and 2), and to adjust their behavior accordingly, without providing the opportunity to react to actions by specific other individuals.

After Stage 3 of the experiment, participants filled in a questionnaire eliciting individual characteristics such as attitudes towards risk (using an incentivized elicitation task), political orientation, views on climate change, numeracy, gender, age, study, and year of study. More details on the experimental implementation, as well as instructions and screen content, can be found in the online appendix.

4. Results

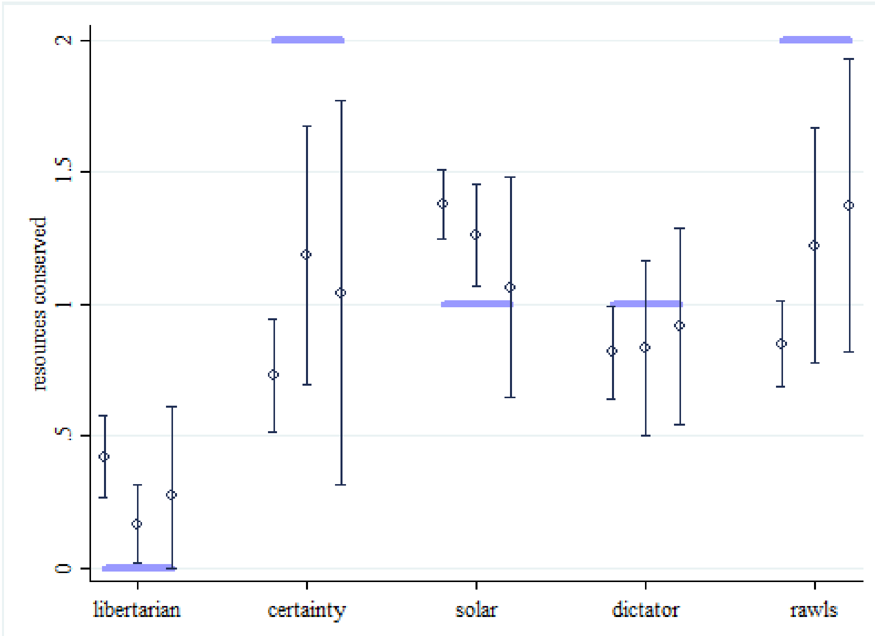
We first discuss results at the group level. In the following subsections we then analyze individual strategies in Stages 1 and 3 and discuss Stage 2 voting behavior. When discussing Stage 3 results, we always report results from the sixth iteration of the game in Stage 3 , that is, for behavior of experienced players.

4.1. Outcomes at group level

Figure 1 shows resource conservation in the five conditions. For each condition we show the average conservation level in Stage 1 (one-shot interaction), Stage 2 (self-selected conditions after voting), and Stage 3 (last iteration). In the calculation of conservation outcomes the figure accounts for within-group interaction by averaging game outcomes over all possible permutations of allocating subjects to generational positions (and hypothetically implementing their respective decisions). Results for the Libertarian condition demonstrate the essence of the intertemporal resource extraction dilemma, with low levels of resource conservation in all three stages. This allows for sensible assessments of the effects of the different policy interventions and the ethical conditions.

Compared to the Libertarian condition, the other conditions increase conservation. However, in contrast to the predictions in Table 1, Certainty and Rawls do not outperform Dictator and Solar in the initial round (Stage 1); only after sufficient experience does Rawls lead to higher conservation. Clearly, even in the last round of Stage 3 the average conservation over groups is substantially lower than the predicted full conservation. Interestingly, while Certainty and Rawls lead to predominantly full or zero conservation, Solar and Dictator show more prevalence of exactly one resource unit conserved (see Figure 2 in Online Appendix A). This finding is consistent with equilibrium predictions. The dynamics of behavior differ across conditions. The effect of Solar seems to be immediate and becomes more moderate with repetition; the effect of Rawls requires some experience to emerge fully.

FIGURE 1. Resource conservation dependence on conditions and stages



Notes: The chart shows the mean and 95% confidence intervals for the resources conserved over all games in each condition. Within each condition, the first line presents the results for Stage 1, the second line shows results for Stage 2 (after voting), and the third line shows results for Stage 3 (last iteration). Thick horizontal bars across all stages show the theoretical equilibrium prediction for the respective condition.

Table 2 provides statistical analyses of group outcome. It shows conservation rates in Stages 1 (columns (1)-(3)) and 3 (columns (4)-(6)), and the social welfare effects of the different conditions (columns 7 and 8), as a percentage of the maximum potential outcome. The table provides two perspectives on conservation outcomes. The first perspective measures the differences across conditions in terms of subjects' conservation strategies (columns (1) and (4)). More precisely, the variable $\bar{S}_4^O$ is defined as the resource stock left at the end of the game averaged over all players in the fictitious case when for each player the own strategy would be implemented for all 3 player roles (i.e. as if they had played against themselves). As this variable does not involve any group effects,[7] we consider it a measure for the individual resource conservation strategy. The second perspective measures the differences across conditions in terms of groups' expected conservation success (columns (2) and (5)). The variable $\mathbb{E}(S_4)$ is

[7] Apart from potential learning effects in stage 3 that indirectly affect individual behavior.

defined as the expected resource stock left at the end of the game on a group level as in Figure 1, averaging over all possible random selections of subjects in each role. Note that, for the Dictator and Rawls condition both perspectives, $\bar{S}_4^O$ and $\mathbb{E}(S_4)$, yield the same results because these conditions always implement the strategy of one player by design. For the Libertarian, Certainty and Solar condition, the gap between the two variables reveals the cost associated with incoherent strategies between the group members. That is, although a significant number of players may aim to conserve resources, groups in these conditions may still perform poorly due to a few subjects who exhaust the resource whenever given the opportunity.

TABLE 2. Resource conservation and expected social welfare

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable	$\bar{S}_4^O$	$\mathbb{E}(S_4)$	(1)–(2)	$\bar{S}_4^O$	$\mathbb{E}(S_4)$	(4)–(5)	$\mathbb{E}(V)$	$\mathbb{E}(V)$
Player-interaction	*No*	*Yes*		*No*	*Yes*		*Yes*	*Yes*
Stage	1	1	1	3	3	3	1	3
Libertarian	0.41	0.21	0.20***	0.17	0.14	0.03	0.21	0.14
Certainty	0.51**	0.36***	0.15***	0.63**	0.52##	0.10	0.24	0.48
Solar	0.75***	0.69***	0.06***	0.54**	0.53**	0.01	0.57***	0.41**
Dictator	0.41	0.41***		0.46**	0.46**		0.41***	0.46**
Rawls	0.43	0.43***		0.69**	0.69***		0.43***	0.69***

Notes: Resource conservation and expected social welfare expressed in percentage of potential maximum, on the scale from 0 to 1. Outcomes/payoffs are expected values over all subjects and positions. Columns (1) and (4) present (fictitious) outcomes if players played against themselves. Columns (2) and (5) present expected group outcomes and columns (3) and (6) present the effect of these within-group interactions between players. Columns (7) and (8) present expected group payoffs. *,**,*** indicate significance at the 10%, 5%, 1% level. For columns (1), (2), and (7), significance is determined by comparison with the Libertarian treatment, using Wilcoxon signed rank matched pairs test. For columns (3) and (6), significance is based on comparison with zero, using Wilcoxon signed rank matched pairs test. For columns (4), (5), and (8), significance is based on comparison with the libertarian treatment, using the Mann-Whitney two-sample tests. ## indicates that the certainty treatment has a higher probability of full resource conservation than Libertarian at the 5% significance level, though the Mann-Whitney test does not provide significance for the full resource conservation vector.

Based on Table 2, we can make a few observations regarding the average performance of the different conditions. Both policy interventions (Certainty and Solar) perform better in terms of resource conservation than Libertarian, irrespective of whether we consider the individual strategies or the average group outcomes. This is true for unexperienced behavior in Stage 1 (columns (1) and (2)), as well as for experienced behavior in Stage 3 (columns (4) and (5)). For experienced interactions there is little difference between the two policy conditions. However, in the absence of experience and at the group level (arguably the most relevant conditions from a practical perspective), the Solar condition outperforms Certainty (69% vs. 36%, $p<0.01$, Wilcoxon test). That is, although full resource conservation is the unique Nash Equilibrium in the Certainty condition, empirically subjects seem to hold pessimistic beliefs about others' actions and therefore often fail to coordinate.

We also find evidence for the "exhaustible resource curse," (the effect of conservation choices being substitutes over time) in Stage 1 (column (3)): we find that individual strategies are significantly less exploitative than group outcomes, i.e., the most exploitative players dominate the game outcomes. This is not the case in the last round of Stage 3 (column (6)). That is, subjects' behavior in a group thus converges over time. Interestingly, this adaptation effect points into different directions in the two policy conditions. In Certainty, individual and group outcomes increase insignificantly (from 51% to 63%, n.s., Wilcoxon matched pairs test; from 36% to 52%, n.s., Mann-Whitney U test). In contrast, behavior in Solar exhibits a downward trend in conservation with experience (from 75% to 54%, $p<0.01$ Wilcoxon matched pairs; from 69% to 53%, n.s., Mann-Whitney U test). In Libertarian, individual strategies become significantly more exploitative (from 41% to 17%, $p<0.01$, Wilcoxon matched pairs test), while group outcomes do not change significantly with experience (from 14% to 21%, n.s, Mann-Whitney U test), presumably because they were low to start with.

The two ethics conditions (Dictator and Rawls) show a somewhat different pattern. These conditions perform better than Libertarian in Stage 1 only on the group outcome, but not the individual strategy level. However, with sufficient experience in Stage 3 both conditions clearly outperform the Libertarian condition in terms of conservation. This is driven by two effects. On the one hand, conservation in the Dictator and Rawls conditions shows an upward trend with experience (from 41% to 46%, n.s.; from 43% to 69%, $p<0.05$, Wilcoxon matched pairs test). It seems that some experience is necessary to understand the mechanics of these social allocation mechanisms. On the other hand, conservation in Libertarian decreases with experience, thus widening the gap. Interestingly, the Dictator condition shows that even if coordination failure can be overcome, selfish preferences of some subjects still stand in the way of more substantial conservation outcomes.

Lastly, we take look at the social welfare implications of the different conditions (columns (7) and (8)), starting with Stage 1 behavior (without experience). Both ethics conditions Dictator and Rawls outperform Libertarian in terms of welfare. Remarkably, of the two policy conditions only Solar improves upon Libertarian with respect to welfare, despite the additional costs involved (but in line with theoretical equilibrium predictions). While Certainty improves conservation compared to Libertarian (column (2)), the less favorable mapping from conserved resources to payoffs renders them indistinguishable in terms of welfare. For the behavior of experienced subjects, the same pattern emerges.[8]

Finally, we can put the performance of the policy conditions (Certainty and Solar) and the potentially selfish ethics condition (Dictator) in perspective to the Rawls condition, where social welfare maximization should be easiest to attain. We observe that, with sufficient experience, subjects indeed attained the highest level of welfare behind a Rawlsian 'veil of ignorance'. Therefore, we conclude that selfish motives and coordination failure constrain resource conservation in the other conditions. However, noting the fact that only 69% of the theoretical maximum is achieved for Rawls shows that either policy condition (Solar or Certainty) can bridge about half of the gap between the low Libertarian outcome and the highest observed level of attained welfare.

4.2. Individual strategies

We analyze individual behavior with respect to two questions. First, do subjects condition their behavior on other subjects' decisions? Second, do they behave differently depending on the position in the game (conditional on identical resource endowment)?

Table 3 shows individual resource extraction strategies, for each position in the game and dependent on resources conserved by previous players. Note that for conditions Dictator and Rawls there were no such conditional strategies as the full strategy of one selected player was implemented for the group. We find a tendency for conditionality of individual choices in Libertarian, Certainty and Solar. Entries in columns (3) and (5) are always larger than the corresponding entries in columns (2) and (4), although not all comparisons are significant. That is, if the resource has been exploited by at least one person, people are more likely to respond by also exploiting the resource. Note that in the Certainty condition, this behavior should follow directly from the fact that conservation provides no benefit once the first unit has been exploited. Comparisons of columns (2) and (4) to column (1) show that people are typically less likely to exploit the resource the later in the game they are called to make a decision, conditional on full

[8] Although Certainty induces a level of welfare comparable to that of Solar, its effect is not statistically significant due to higher variability (Figure 1).

resource conservation S_t=2 at the moment of their decision.[9] This suggests that pessimistic beliefs about choices by “future” subjects negatively affect subjects’ conservation choices. Beliefs thus seem to play an important role in the breakdown of cooperation.

TABLE 3. Individual Exploitation Strategies R_i

Variable Conservation level	(1) $\mathbb{E}(R_1)$	(2) $\mathbb{E}(R_2)$ S_1=2	(3) $\mathbb{E}(R_2)$ S_1=1	(4) $\mathbb{E}(R_3)$ S_2=2	(5) $\mathbb{E}(R_3)$ S_2=1
Stage 1					
Libertarian	0.63	0.54	0.63	0.38***	0.64***
Certainty	0.49	0.35**	0.73***	0.15***	0.72***
Solar	0.41	0.51	0.59	0.35	0.58***
Stage 2 (voting)					
Libertarian	0.67	0.67	0.78	0.39*	0.78**
Certainty	0.33	0.17**	0.71**	0.00**	0.79***
Solar	0.57	0.52	0.70	0.37**	0.70**
Stage 3 (experienced, i.e., in last repetition)					
Libertarian	0.88	0.58**	0.83	0.38**	0.88**
Certainty	0.38	0.38	0.79**	0.17*	0.75**
Solar	0.67	0.63	0.88**	0.54	0.79

Notes: Entries are expected resource extraction averaged over participants in a condition. Stage 1 comparisons are based on one-sample tests of proportion on the individual level. Stage 2 and 3 comparisons are based on Wilcoxon matched-pair tests on the group level. In columns (2) and (4), *,**,*** indicates significant differences at the 10%, 5%, 1% level, compared to column (1); in columns (3) and (5), *,**,*** indicates significant differences at the 10%, 5%, 1% level, compared to columns (2) and (4), respectively.

4.3. Voting and voting effects

Stage 2 of the experiment offers insights into participants’ preferences for the different conditions. Table 4 shows that preferences vary widely (cf. Figure 3 in Online Appendix A for a graphical representation). Solar is the modal vote, receiving significantly more votes than the other conditions (37%, binomial proportion test, $p<0.01$). Vote shares for Libertarian, Rawls and Certainty are close to 20% each, whereas Dictator receives significantly fewer votes than the other conditions (10%, binomial proportion test, $p<0.01$). Note that all players had experienced each of the five conditions exactly once in Stage 1 in randomized order and without any feedback on the behavior of others. Thus, differences in preference over the different conditions can neither be driven by random experiences due to behavior of the other players in the group,

[9] The effect is less pronounced in the Solar condition. Recall, though, that choices of player 2 and 3 may not become relevant if player 1 forces non-extraction by others. Conditionality in choice may thus be diluted by the potential irrelevance of the choice (unknown at the moment the choice is submitted), as well as strategic considerations regarding why player 1 did not force non-extraction (in which case when the choice is relevant).

nor by order effects. Clearly, people have obtained only a modest degree of intuition about the potential payoffs of the different conditions from the one-shot decision made in each condition.

However, the middle panel of Table 3 above shows that there are pronounced differences in behavior between the conditions after voting, i.e., conditional on playing the game that has been elected in a group. Thus, although not all players in a group may play the game they have in fact voted for, this suggests that voting (and playing) was not random and that players took the special features of each condition into account once they reached Stage 2. We therefore analyze the potential predictors of voting behavior in terms of participants' Stage 1 behavior in more detail and show the results in Table 4.

TABLE 4. Stage 2 Voting and Stage 1 Individual Strategies Conditional on Voting

Voted for	(1) Libertarian	(2) Certainty	(3) Solar	(4) Dictator	(5) Rawls
Observations / %	22 / 18%	23 / 19%	44 / 37%***	12 / 10%***	19 / 16%
Stage 1 behavior	*Resource conservation $\bar{S}_4^O$ (percentage out of 2)*				
Libertarian	0.39	0.41	0.45	0.21	0.45
Certainty	0.45	0.70**	0.48	0.33	0.55
Solar	0.75	0.85*	0.77	0.67	0.66*
Dictator	0.48	0.39	0.35	0.29	0.55*
Rawls	0.36	0.59*	0.34	0.33	0.55
Average over treatm.	0.49	0.59**	0.48	0.37**	0.55
% Solar Invest.	0.68	0.52**	0.91***	0.75	0.63

Note: The table reads as follows: The 22 players who voted Libertarian are collected in the first column, etc. The first row collects all outcomes of the libertarian treatment. Significance in first row indicates difference from 20%, one-sample tests of proportion on the individual level. In other rows, significance indicates that those subjects voting for the specified treatment had significantly different scores for the variable, compared to all players who voted for another treatment, using Mann-Whitney two-sample tests. *,**,*** indicates significance at the 10%, 5%, 1% level.

Table 4 shows resource conservation shares out of the maximum conservation of 2 units, on the basis of individual behavior only ($\bar{S}_4^O$), i.e., as if subjects had played against their own strategy. Columns show data on subjects who voted for the respective condition, and rows present conservation results for these participants in each of the five conditions in Stage 1. The table also shows average resource conservation over all treatments, and the choice of the investment option in the Solar condition, in Stage 1 for each group of voters. We first observe that subjects do not vote for the condition that performed best conditional on their own behavior. In fact, all voter groups conserve most in the Solar treatment. But votes are significantly correlated with Stage 1 resource conservation choices. Those who vote for Solar almost all have made use of the commitment device in the Solar condition in Stage 1 (Table 4, last row). Certainty voters tend to conserve more resources than other participants for three specific conditions and overall, but invested the least in the commitment device available in the Solar condition. Potentially these players believe that the Certainty condition offers a cheaper commitment for coordination and therefore appreciate the costly Solar commitment device less. At the other extreme, we find that Dictator voters conserve the least compared to other players. Rawls voters have a higher conservation in the Dictator condition than other voters, suggesting other-regarding preferences play a larger role for these players. The poor performance and voting outcome of Rawls confirms the above-discussed result that significant experience is necessary to understand how the Rawls mechanism allows groups to align individual and group preferences. Investment in the Solar commitment device differs vastly across voters. Clearly, the modest voting success of Solar despite its good performance can be explained by low take up of the investment opportunity for non-Solar voters. We note that there were no significant correlations of voting behavior with individual differences in the subject's risk aversion, gender, or concerns for global warming.

5. Discussion

We study the intertemporal resource extraction problem inherent to climate change mitigation in an experimental setting. We find that with uncertainty about the threshold for catastrophe, and in the absence of commitment devices, subjects do not succeed in cooperating to prevent climate catastrophe. There is clear evidence of an 'exhaustible resource curse': conservation choices are substitutes over time. Our game specification is simple and offers only discrete choices to subjects; yet we believe that this feature of our game is robust. It has been observed in other games with semi-continuous choices (Barrett and Dannenberg 2012), and studies repeatedly report that fossil fuels will continue their dominance in absence of drastic global policies (Covert et al. 2016).

We introduce two different mechanisms to mitigate the coordination problem. First, a reduction of uncertainty significantly improves resource conservation, despite being strictly worse in terms of the choice environment. This effect confirms earlier findings in the horizontal cooperation problem (Barrett and Dannenberg 2012). Second, a costly commitment device significantly improves resource conservation and social welfare, despite being a wasteful investment. An important insight is that subjects are willing to pay upfront costs to reduce resource exploitation in later rounds. Moreover, we find that this mechanism receives most support from the subjects, even if they do not know ex-ante whether they will be in charge of, or potentially be constrained by someone else being in charge of the commitment device (i.e., their position in the game). This suggests that assessments for investments in technology and infrastructure for renewable energy should also include the perspective of their benefits for intertemporal coordination. While present decision makers cannot commit to future carbon prices, they can invest in clean energy and commit to the availability of a competing non-carbon energy supply. The result does not suggest that standard economic reasoning is invalid: a global agreement that (explicitly or implicitly) sets sufficiently high carbon prices remains an efficient instrument available to reduce greenhouse gas emissions. While waiting for such an agreement, costly investments in clean energy could be an essential step. Importantly, the instrument seems to be perceived as the most legitimate by those who are exposed to it.

Even if cooperation failure can be overcome, low weight on other peoples' welfare is still a constraint on socially optimal resource conservation as the Dictator condition of our experiment shows. Moreover, as shown in the analysis of conditionality, pessimistic beliefs about other people making exploitative choices at a later stage prevent a higher degree of conservation. Combining the insights from the Dictator and the Solar condition, we note that strategic instruments aiming at distorting future decisions also carry a danger (Goeschl et al. 2013).

Lastly, the voting stage of our experiment provides a lens to reassess the difficulty in reaching global climate change cooperation, because it shows that strategies in the game are related to votes for conditions. This suggest a within-subject consistency between strategies, beliefs, and preferences for conditions, while at the same time, there is a large between-subject divergence of such beliefs and preferences. Climate change coordination is more difficult than the classic public good view suggests. Our findings suggest that successful cooperation not only needs to overcome a gap between individual incentives and public interests, but also a fundamental heterogeneity between subjects with respect to beliefs and preferences about the way in which this should be achieved.

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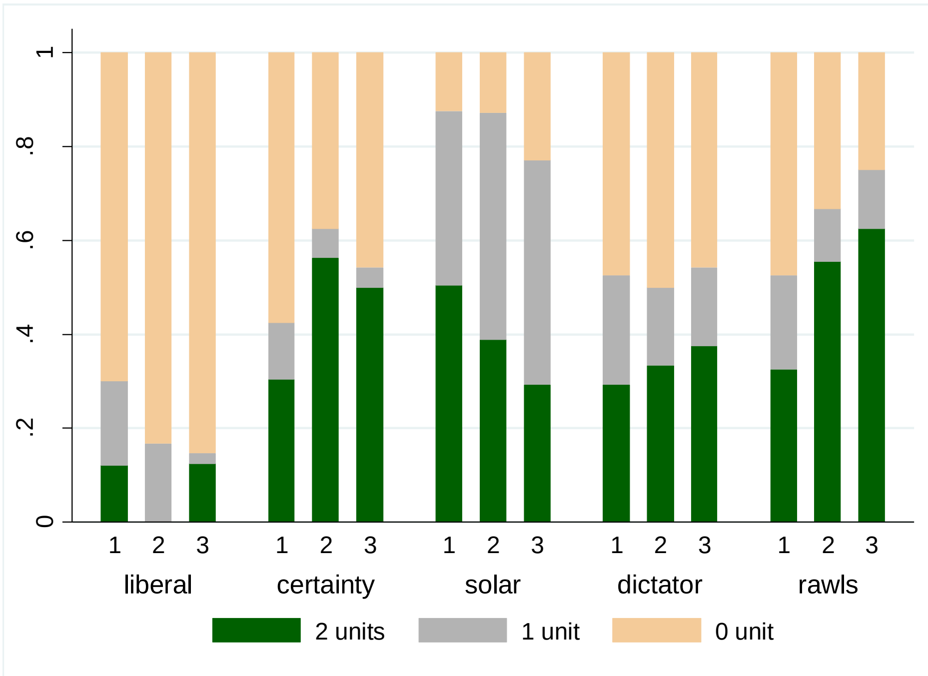
<u>Online</u> support material {included here to facilitate reviewing}

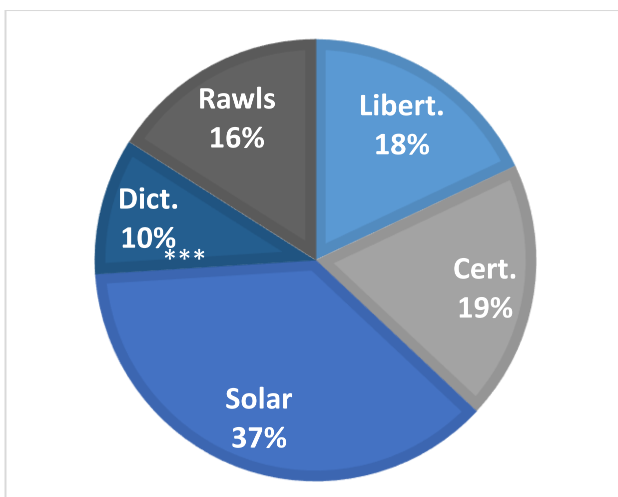
Appendix A: Further results

FIGURE 2. Resource conservation dependence on conditions and stages



Note: The chart shows the frequency for conservation outcomes (0 unit, 1 unit, or 2 units) over all games in a condition. Within each condition, the first column presents the results for stage 1, the second column shows results for stage 2 (after voting), and the third column shows results for stage 3 (last iteration).

FIGURE 3. Vote shares, Stage 2.



Notes: The chart shows frequency of votes for all conditions. Asterisks denote significant deviation from 20%, binomial proportion tests.

Appendix B: Additional Details on the Experimental Method

General Procedures

The experiment was conducted at Tilburg University with 120 student participants. Students were recruited via an online recruiting system. The experiment was programmed in zTree (Fischbacher 2007). The experiment consisted of 3 stages with a total of 12 tasks: Stage 1 consisting of tasks 1-5; Stage 2 consisting of task 6; and Stage 3 consisting of tasks 7-12. A final task 13 consisted of a risk attitude assessment and was followed by a questionnaire to collect background information on the participants' demographics (see "Controls"). At the start of the experiment, subjects were randomly allocated to private computers and to groups of 3 participants. At the beginning of each stage, general instructions were handed out on paper and read out aloud by the experimenter. Additionally, task-specific instructions were presented on the computer screen (see Appendix C). The instructions employed a neutral frame and language; meaningful labels were removed to avoid potential confounding effects due to use of language. Any questions were answered in private. Task 1-12 concerned 5 types of games that participants played in groups of 3 (see "The Games").

The Games

In the *Libertarian* game, each group started with a common pool of €12. Subjects were informed that group members would randomly be assigned a player role (Player 1, Player 2, or Player 3), and that each group member would have the option to take €6 from the common pool sequentially, in order of the player number. Every €6 taken from the common pool was rewarded privately. Subjects were informed that if there was €12 (€0) remaining in pool at the end of the game (i.e., after the action of Player 3 was implemented), each group member would receive €8 (€0) privately. If there was €6 remaining in the common pool, there was a 50% chance that each group member would receive €8 extra, and a 50% chance that each group member would receive nothing extra.

The *Certainty* game was similar to the *Libertarian* game, except for the fact that there was no uncertainty about the amount that subjects would receive at the end of the game if there was €6 remaining in the common pool; each group member would receive €0 in that case. The *Solar* game was similar to the *Libertarian* game, except for the fact that in the role of Player 1, subjects could decide to remove the possibility of the other group members to take €6 from the common pool, at the cost of €1. The *Dictator* game was similar to the *Libertarian* game, except for the fact that all actions of the group member assigned the role of Player 1 were implemented. Thus, in the Dictator game, the actions by Player 2 and Player 3 were in fact determined by the group member assigned the role of Player 1. The *Rawls* game was similar to the *Libertarian* game, except for the fact that all the actions of a randomly chosen group member were implemented. That is, players were randomly assigned the position in the game, and then one person's strategy vector was implemented. For example, in case the actions of Player 2 were chosen to be implemented, the action by Player 1 and Player 3 were determined by the actions of the group member assigned the role of Player 2 in the Rawls game.

Specific Procedures

In the first five tasks, subjects simply played each of the five games once without receiving feedback. To measure individual preferences towards each game, subjects were asked to vote for the game that they would prefer to repeat once more with majority voting at the beginning of task 6. The game that was thus selected was played once more in task 6. In case of a voting tie, each of the three games that received a vote had an equal 1/3 chance of being implemented in task 6. After task 6, the groups were reshuffled such that all subjects were in a different group, i.e., each subject was assigned to a new group with 2 participants that were not in their group before. These groups then played one of the five games repeatedly with feedback six times in task 7-12 within the same group. Thus, at the end of each game, subjects were informed about their player role, the action chosen by them, the actions chosen by the other group members, and their resulting payoff in that task.

Controls

To control for order effects when making choices in the five games, each group was assigned one of 40 pre-selected orders (out of the 120 possible orders) in task 1-5. We pre-selected these orders such that each game was played equally often in each task while also being played equally often earlier or later than any other game in pair-wise comparison. Individual risk attitudes were measured by a task that elicits the certain monetary amount that made subjects indifferent between receiving the certain amount and between receiving a lottery yielding either €10 or nothing with equal (50/50) probability, depending on the outcome of a die roll performed at the end of the experiment. In particular, respondents were asked to make a series of 21 choices between the lottery and an ascending range of certain amounts grouped together in a list. The certain amounts in the list ranged from €0 in the first choice to €10 in the final choice, and increased in equal steps of €0.50. The midpoint of the last choice in which the subject chose the lottery and the first choice in which the subject chose the certain amount was taken as the certain amount that made the subject indifferent. A certain amount lower/higher than the expected value of the lottery (€5) is indicative of risk averse (seeking) preferences.

In task 13, subjects were asked to report gender, age, study year, and type of study. In addition, we measured political orientation (left, middle, right), and attitudes towards global warming. Finally, we obtained an individual measurement of numeracy using 5 items from the numeracy scale employed by Peters et al. (2006; items 1, 2, 3, 7, and 10).

Payment

To avoid potential income effects (such as Thaler and Johnson's (1990) house money effect), 1 of the 13 tasks was randomly selected to be paid for real. For this purpose, at the start of the experiment, one participant was asked to assist the experimenter in drawing one envelope from a pile of sealed envelopes, each containing a card numbered 1-13. Participants were informed that the envelope would be opened at the end of the experiment and that the task corresponding with the number on the card inside the envelope would determine the earnings of the experiment. All non-selected envelopes were opened at the end to show that indeed all 13 tasks could have been selected for payment. Additionally to the task-contingent earnings, all subjects received a fixed show-up fee of €4. On average, subjects earned €9.32, while the experiment took about 1 hour and 15 minutes to complete.

Appendix C: Experimental Instructions

General Instructions

Welcome to this experiment. During the experiment:

- please no talking
- turn off your cell phone
- and raise your hand if anything is unclear, to be helped in private

This experiment consists of 13 tasks in total. Some tasks will involve a game that you will play with other participants; other tasks will involve choices between lotteries. For now, it is important to know that 1 of the 13 tasks will be randomly selected to be paid for real at the end of the experiment. For this purpose, the experimenter will now ask one of you to select an envelope from a pile of sealed envelopes containing cards with numbers 1-13 on them. In particular, the experimenter will ask one of you to draw an envelope from the pile of envelopes at random and sign it, so that you know that the envelope that will be opened at the end of the experiment indeed was the envelope selected by one of you.

<Experimenter will now ask one participant to draw an envelope>

Thus, at the end of the experiment, the randomly selected envelope will be opened, the numbered card will be shown to you, and your earnings in the task that corresponds with the number on the card will be paid for real. Suppose for example that the number on the card is 9. Then, you will be paid your earnings in the 9th task. On top of these earnings, you will receive a show-up fee of €4. Thus, your total earnings in the experiment are determined as follows:

Total earnings = Earnings of 1 of the 13 tasks (randomly selected) + show-up fee of €4.

All earnings will be paid to you in private. Your earnings in this experiment will be transferred to your bank account. The experimenter will now hand out the instructions for the first 5 tasks and read these instructions aloud. When everybody has completed the first 5 tasks, additional instructions will be handed out. Good luck!

Instructions Task 1-5

The first 5 tasks concern a game that you will play with two other participants. For this purpose, the computer will randomly match you with 2 other participants of this experiment for the duration of the first 5 tasks. You will not learn the identity of your group members; neither will your group members learn your identity. Each group has 3 members.

The 5 games that you and your group members will play all involve 3 player roles: Player 1, Player 2, and Player 3. The computer will randomly assign a role to you and to your fellow group members after you made your decisions. Thus, you do not know yet what your role will be when you are asked to make a decision. Hence, each group member is asked to make a decision for the three possible cases; that (s)he is selected as Player 1, Player 2, or Player 3. Notice that it is equally likely that you will be assigned the role of Player 1, Player 2 or Player 3 (i.e. the chance for each role is equal to 1/3).

Each game is played as follows: The group starts with a common pool of €12. In each role you can take out exactly €6 from the common pool, as long as there is money in the pool. Hence, each member decides whether or not to take €6 from the common pool for the three cases of being selected as Player 1, Player 2, or Player 3. The choices will be implemented sequentially, that is, Player 1 decides first whether to take €6 from the common pool, followed by Player 2, and finally by Player 3. Therefore, the decisions made by Player 2 and Player 3 are conditional on the amount of euros remaining in the pool after the previous players have made their decisions. For example, in the role of Player 2, you will be asked separately whether you want to take €6 from the pool if there are €6 remaining, and whether you want to take €6 if there are €12 remaining in the common pool. Which of the two cases holds depends on the choice of Player 1.

In each game, each player who takes €6 from the common pool receives these €6 privately. After all 3 players made their decision, the computer checks how much euros are left in the common pool at the end: 0, 6 or 12. Then, each player receives an amount of euros on top of the private earnings depending on how many euros are left in the common pool as follows:

- If there are €0 left in the common pool, each player receives nothing.
- If there are €12 left in the common pool, each player receives €8.
- If there are €6 left in the common pool, then what happens depends on the game; game specific details will be given on your decision screen.

Please raise your hand if you need further explanation from the experimenter. If you have no questions, the experimenter will soon start the program for the first 5 tasks.

Instructions Task 6

In this task, you and your fellow group members will decide which of the first 5 tasks will be repeated once more. Thus, task 6 will be a repetition of either task 1, task 2, task 3, task 4 or task 5. To select the task that is going to be repeated once more, each group member will be asked to cast a vote on the task that (s)he prefers. The task that has the majority of the votes will be the one that will be repeated once more. If all group members vote for a different task – i.e., if each task receives 1 vote – the task will be selected at random from those that have received a vote. For example, if group member 1 votes to repeat task 2, group member 2 votes to repeat task 5 and group member 3 votes to repeat task 1, the computer will select either task 2, task 5 or task 1 with equal (1/3) chance.

In each task, you were asked to indicate whether you wanted to take €6 from the pool in case you are selected as Player 1, Player 2, and Player 3, conditional on how many euros were remaining in the common pool. Each player who took €6 from the common pool received these €6 privately. If after all three players made their decisions there were €0 remaining in the common pool, then there would be no payment to the players additional to their payments based on the private decisions. If there were €12 remaining in the common pool, then each player received an additional €8.

On your screen, you will find a summary of the task-specific instructions, so you can make a well-informed vote. Please raise your hand if you need further explanation from the experimenter. If you have no questions, the experimenter will soon start the program.

Instructions Task 7-12

The next 6 tasks again concern a game that you will play with two other participants. For this purpose, the computer will again randomly match you with 2 other participants of this experiment for the duration of the 6 tasks. Importantly, you will be matched with 2 **other** participants; your group members will not be same ones you were matched with in the first 6 tasks of today's experiment. Again, you will not learn the identity of your group members; neither will your group members learn your identity, and each group has 3 members.

Again, the 6 games that you and your group members will play all involve 3 player roles: Player 1, Player 2, and Player 3. The computer will randomly assign a role to you and to your fellow group members after you made your decisions. Thus, you do not know yet what your role will be when you are asked to make a decision. Hence, each group member is asked to make a decision for the three possible cases; that (s)he is selected as Player 1, Player 2, or Player 3. Notice that it is equally likely that you will be assigned the role of Player 1, Player 2 or Player 3 (i.e. the chance for each role is equal to 1/3).

Each game is again played as follows: The group starts with a common pool of €12. In each role you can take out exactly €6 from the common pool, as long as there is money in the pool. Hence, each member decides whether or not to take €6 from the common pool for the three cases of being selected as Player 1, Player 2, or Player 3. The choices will be implemented sequentially, that is, Player 1 decides first whether to take €6 from the common pool, followed by Player 2, and finally by Player 3. Therefore, the decisions made by Player 2 and Player 3 are conditional on the amount of euros remaining in the pool after the previous players have made their decisions. For example, in the role of Player 2, you will be asked separately whether you want to take €6 from the pool if there are €6 remaining, and whether you want to take €6 if there are €12 remaining in the common pool. Which of the two cases holds depends on the choice of Player 1.

In each game, each player who takes €6 from the common pool receives these €6 privately. After all 3 players made their decision, the computer checks how much euros are left in the common pool: 0, 6 or 12. Then, each player receives an amount of euros on top of the private earnings depending on how many euros are left in the common pool as follows:

- If there are €0 left in the common pool, each player receives nothing.
- If there are €12 left in the common pool, then each player receives €8.
- If there are €6 left in the common pool, then what happens will be described on the left side of the screen.

In the next 6 tasks, you will play the same game with the same group members and you will directly receive feedback about the outcome of the game after each group member has made their decision. Thus, you know your payoffs in each task.

Please raise your hand if you need further explanation from the experimenter. If you have no questions, the experimenter will soon start the program for the next 6 tasks.

Instructions Task 13

The final task concerns several choices between two options, labelled LEFT and RIGHT, grouped together in a list. Both options will yield an amount of money, potentially depending on the throw of a standard six-sided die performed at the end of the experiment. If this task is selected to be paid for real, you payoff will depend on the option you have chosen and, potentially, on the throw of the six-sided die.

Please raise your hand if you need further explanation from the experimenter. If you have no questions, the experimenter will soon start the program for the final task.

Detailed on-screen instructions for each condition

LEFT HALF OF THE SCREEN (Instructions for each condition)

General instructions
On the right, you are asked to indicate whether you want to take € 6 from the pool in case you are selected as Player 1, Player 2, and Player 3, conditional on how many euros are remaining in the common pool.
Each player who takes € 6 from the common pool receives these € 6 privately.
If after all three players made their decisions there are € 0 remaining in the common pool, then there will be no payment to the players additional to their payments based on the private decisions.
If there are € 12 remaining in the common pool, then each player receives an additional € 8.

Task-specific instructions

Libertarian
In this task, if there are € 6 remaining in the common pool, then there is a 50% chance that each player receives nothing extra, and a 50% chance that each player receives € 8 extra.

If this task is selected to be paid, then the game will be played based on the decisions made by you and the other group members, in the respective role that has been assigned to each of you.

Please raise your hand if you need further explanation from the experimenter. If you have no questions, please make your choices for this task on the right side of the screen.

Dictator
In this task, if there are € 6 remaining in the common pool, then there is a 50% chance that each player receives nothing extra, and a 50% chance that each player receives € 8 extra.

If this task is selected to be paid, then the game will be played based on the decisions made by the group member that has been assigned the role of Player 1.

The payments to you depend on the role that has been assigned to you. Player 2 receives the payments for Player 2 based on the decisions made by Player 1.

Player 3 receives the payment for Player 3, based on the decisions made by Player 1.

Please raise your hand if you need further explanation from the experimenter. If you have no questions, please make your choices for this task on the right side of the screen.

Rawls
In this task, if there are € 6 remaining in the common pool, then there is a 50% chance that each player receives nothing extra, and a 50% chance that each player receives € 8 extra.

If this task is selected to be paid, then the game will be played based on the decisions made by a randomly chosen group member ('the representative').

The payments to you depend on the role that has been assigned to you.
Player 1, 2 and 3 receive the payments for Player 1, Player 2, and Player 3, based on the decisions made by 'the representative'.

It is equally likely that you are selected as 'the representative', independent of your chances to be Player 1, 2, or 3, respectively.

Please raise your hand if you need further explanation from the experimenter. If you have no questions, please make your choices for this task on the right side of the screen.

Solar
In this task, if there are € 6 remaining in the common pool, then there is a 50% chance that each player receives nothing extra, and a 50% chance that each player receives € 8 extra.

In this task, Player 1 has one extra option. You can choose to force Player 2 and Player 3 to leave the euros in the common pool.

Choosing this option costs € 1, which is subtracted from your pay if you are assigned and the role of Player 1.

Please raise your hand if you need further explanation from the experimenter. If you have no questions, please make your choices for this task on the right side of the screen.

Certain
In this task, if there are € 6 remaining in the common pool, then each player receives nothing extra.

Only if there are € 12 left in the common pool will all players receive € 8 extra on top of their private payoff.

If this task is selected to be paid, then the game will be played based on the decisions made by you and the other group members, in the role that has been assigned to you.

Please raise your hand if you need further explanation from the experimenter. If you have no questions, please make your choices for this task on the right side of the screen.

RIGHT HALF OF THE SCREEN (Decision)

Solar choice screen (preceding the general choice screen in the Solar treatment)
As explained, before making a choice in each situation, you can force Player 2 and Player 3 to leave the euros in the pool, if you are selected as Player 1.

Doing so, will cost you € 1, if you are selected as Player 1.

Do you want to force Player 2 and Player 3 to leave the euros in the pool?
BUTTON: YES BUTTON: NO

General choice screen (in all treatments, in Solar this is the second decision screen)
For each situation described below, please indicate whether you take € 6 from the pool or not.

SITUATION 1: YOU ARE PLAYER 1
There are € 12 remaining in the pool, your decision: take do not take (radio buttons)

SITUATION 2: YOU ARE PLAYER 2

If there are € 12 remaining in the pool, your decision:	take	do not take	(radio buttons)
If there are € 6 remaining in the pool, your decision:	take	do not take	(radio buttons)

SITUATION 3: YOU ARE PLAYER 3

If there are € 12 remaining in the pool, your decision:	take	do not take	(radio buttons)
If there are € 6 remaining in the pool, your decision:	take	do not take	(radio buttons)

Additional References

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