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Climate clubs in the laboratory☆

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ABSTRACT

International efforts to mitigate climate change are lagging behind. We study in an experiment a stylized climate club along the line of Nordhaus's proposal to assess the behavioral effects on cooperation and surplus. We also evaluate in isolation the effects of different elements of the club design. Overall, a climate club increases cooperation but not surplus, with respect to voluntary cooperation in a baseline public good game.

1. Introduction

While the impacts of climate change are becoming more and more visible, greenhouse gas emissions keep increasing every year (Lee & Romero, 2023). Why is the international community not embarking in drastic mitigation policies? One reason may lie in the difficulty in designing an effective international climate treaty. Here, we study the proposal to structure the international treaty as a Climate Club (Nordhaus, 2015). Both the 1997 Kyoto protocol and the 2015 Paris agreement have so far not succeeded in reducing emissions.[1] Compared to Nordhaus's proposal (Nordhaus, 2015), those treaties lack two key elements that have the potential to stabilize meaningful cooperation on global mitigation efforts. The first consists in giving up universal participation but instead set up a smaller coalition of countries that are willing to pursue strong mitigation policies. The second is the commitment by the climate club members to sanction those outside the coalition. In practice, sanctions would take the form of higher tariffs levied on non-member international trade partners.

Our methodology is experimental, as it provides a clean way to assess the impact of a climate club on cooperation and on surplus. No other way is currently available for its empirical assessment, given that no existing climate treaty has the form of a club. We model climate mitigation as a public goods game among agents of different sizes. Our design departs from Nordhaus' proposal in two directions: sanctions are costly also for the country that imposes them, and countries that are the target of sanctions can counter-punish. We think that these modifications are realistic as deviating from free trade is typically costly for all parties, and trade sanctions (on non-compliant countries) have the potential to instigate trade wars. Both features will likely lower the performance of a Climate Club, hence this study should be interpreted as a stress-test for the efficacy of Climate Clubs.

We are interested in comparing a baseline vs. a Club treatment, in addition to three other treatments, which aim at disentangling the separate effects of allowing to form a climate club, punishing others as well as the joint effect of club membership together with punishment. As we will see, the performance of the climate club treatment in the lab is weak, both in terms of cooperation level and total surplus. The paper is structured as follows. Section 2 reviews the related literature, Section 3 puts forward the experimental design, and Section 4 presents the results. Section 5 concludes.

2. Related literature

Academics have modeled international agreements on climate mitigation using a variety of strategic settings: prisoner's dilemma, public

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[1] On the effectiveness of the Kyoto Protocol see e.g. Almer and Winkler (2017), Bachram (2004), Böhringer (2003), Haya et al. (2012), Prins and Rayner (2007), Schneider et al. (2007), Victor (2011), Wara and Victor (2008), Zhang and Wang (2011) and on the Paris Agreement see e.g. Raiser, Kornek, Flachsland, and Lamb (2020), Rogelj et al. (2018).

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goods game (Nordhaus, 2015), stag hunt game (Barrett, 2013; Barrett & Dannenberg, 2014), threshold public good game with and without refunding (Alberti & Cartwright, 2016; Bosetti, Heugues, & Tavoni, 2017; Cherry & McEvoy, 2013; Dannenberg, Löschel, Paolacci, Reif, & Tavoni, 2015; Feige, Ehrhart, & Krämer, 2018), as well as non-cooperative coalition theory (Barrett, 1994; Carraro & Siniscalco, 1993; Finus, 2008; Marchiori, Dietz, & Tavoni, 2017; Tavoni & Winkler, 2021).

The experimental literature has also studied the role of inequality across countries. Inequality has been mostly introduced in terms of the role of countries' endowment in affecting collective action, in order to account for wealth disparities. Tavoni, Dannenberg, Kallis, and Löschel (2011) find that inequality reduces the chances of reaching an agreement on dividing up the burden of mitigation in the face of dangerous climate change. Overall, though, the evidence is mixed (Gavrilets, 2015). We have not found studies that model inequality in size, intended as nation-specific marginal return from public good contributions, as we do in our paper.[2]

Next, we review the literature related to the two key elements of the Climate Club. The first element is about how the parties become members of the club. We model this aspect by giving countries the possibility to choose to contribute to the public good conditionally on what others do, and matching them if their conditional cooperation strategies are compatible with a cooperative outcome (the club). The Club does not necessarily have to include everyone. In our design, participants can choose among defecting, unconditionally cooperating, or conditionally cooperating. In a typical public good experiment, this latter option is not available as participants can contribute only unconditionally. For the design we build upon one of the most prominent experiments about conditional cooperation (Fischbacher, Gächter, & Fehr, 2001), where the authors estimate that about 50% of the population is to some degree a conditional cooperator.[3] This finding has been replicated by Bardsley and Moffatt (2007), Burlando and Guala (2005), Fischbacher and Gächter (2008), Ones and Putterman (2007) and others. Instead of measuring the attitudes and preferences – as it has been done so far in the literature – we assume that many people are conditional cooperators and enable them to rely on their conditional attitude to form a club.

The second element is about the commitment of club members to punish non-members. In addition to theoretical work, e.g. on the evolution of cooperation on punishment and norm enforcement (Dreber et al., 2010; Sethi & Somanathan, 1996), there exists a vast experimental literature on peer punishment that is overwhelmingly focused on punishment and to a very small extent on counter-punishment (which is instead allowed in this study). Our experiment has three peculiarities with respect to the peer punishment literature. First, no punishment of cooperators is allowed (only defectors can be punished). Second, participants cannot discriminate individual targets: they either punish all defectors or none. Third, the differences in size among nations are reflected also in the vulnerability to sanctions.

3. Experimental design, equilibria and procedures

3.1. Experimental design

A group of three players (that can be thought of as nations) face a public good game where, as for mitigation efforts, contributions are voluntary and costly. The experiment was neutrally framed, in terms of "participants" and "actions", without references to climate change, or nations. The interaction is repeated 30 times with fixed groups of three decision-makers. Unlike in the climate mitigation experiment of Ghidoni, Calzolari, and Casari (2017), here the interaction is finitely repeated and the whole setup is deterministic. The three nations in each group are heterogeneous in size: S(mall), M(edium) and L(arge), and are in practice single individuals who are the decision-makers for the nations.

The experiment is articulated into five treatments, as illustrated in Table 1. Treatments differ along two dimensions: the set of mitigation strategies and punishment strategies available to each nation.

While our main interest is the Club treatment, we begin to describe the Public Good treatment, which is the simplest, and then build up from there.

In the **Public Good Game** treatment, each participant receives an endowment of 12 points at the beginning of every round (1 point = 0.03 euros), and makes a binary choice: either keeping all the endowment to herself, or contributing it to the public good. The marginal aggregate return is 1.5, with heterogeneous marginal private returns across players: 0.5 for Small, 0.7 for Medium, and 0.9 for Large. Nations generally have different weights on the international arena, and their costs and benefits might relate to their size. The earnings for a single agent i are the following:

$$\pi_i = 12 - x_i + \frac{1}{3}x_S + \frac{1}{2}x_M + \frac{2}{3}x_L$$

In other words, a participant can allocate her entire endowment to either a private or a public account. Keeping it in the private account increases just her own earnings, whereas placing it in the public account increases both her earnings and those of the other group members. The earnings from placing one's endowment in the public account depend on the size: 8 points for L, 6 for M, and 4 for S. After every round, participants could observe the individual actions of their group members.

We present now two treatments that introduce two basic variants in design, conditional cooperation and peer punishment. In the **I-Will-If-You-Will** treatment, the strategy set is richer: besides defection (x=0) and cooperation (x=12), participants can submit a conditional strategy, where the endowment is placed in the public account if at least one other group member does the same; otherwise, the endowment is automatically moved to the private account.[4] By conditionally cooperating, the participant commits to cooperating also when another group member cooperates (conditionally or unilaterally). Conditional cooperation reduces the level of strategic uncertainty and avoids situations where only one participant contributes. It is not possible to specify whether the other cooperating group member should be S, M, or L. If participants would be restricted to either defecting or conditionally cooperating, this design would resemble to a threshold public good with refunding, where the individual contribution takes place only if at least two out of the three players do so. I-Will-If-You-Will is richer as the strategy set comprises three options. After every round, participants could observe the individual actions of their group members that were implemented but not their ex-ante strategies.

The second variant is the **Public Good Game with Punishment** treatment, where everyone takes two decisions in each round, one about contributions and another about punishment. After the contribution stage, without having observed the other group member's contributions, participants face a decision either about punishment or counter-punishment. In particular, those who have cooperated must decide whether to punish or not those who have defected. Requesting punishment can lead to a fee of 0, 1 or 2 points. The actual payment depends on the combined effect of how many people are targeted, on one side, and how many of those targeted have defected, on the other

[2] Also Calzolari, Casari, and Ghidoni (2018) models inequality across countries with respect to climate change mitigation but does it in a hybrid way that does not fit into the mentioned categories.

[3] A person is considered a conditional cooperator if her contribution is a weakly increasing function of the average contribution of other group members.

[4] The name for this treatment was inspired by the title of the paper by MacKay et al. (2015).

Table 1
Treatments.

	Cooperation Strategies	Punishment Strategies
PGG	Unconditional (Cooperate/Defect)	Not Available
IwYw	Unconditional (Cooperate/Defect), Conditional (Cooperate if x others do)	Not Available
PGGwP	Unconditional (Cooperate/Defect)	Punish, Counter-punish
CCwP	Unconditional (Cooperate/Defect), Conditional (Cooperate if x others do)	Punish, Counter-punish
Club	Unconditional (Cooperate/Defect), Conditional (Cooperate if x others do)	Punish (mandatory for club members), Counter-punish

Notes: Treatments are: Public Goods Game (PGG), Public Goods Game with Punishment (PGGwP), I-Will-If-You-Will (IwYw), Conditional Cooperation with Punishment (CCwP) and Club.

side. For example, if a cooperator decides to punish and one of the group members cooperates, while the other defects, the paid fee is 1 point. If everyone cooperates, instead, no punishment takes place, and there is no fee. The effect of punishment is to lower the earnings of the target. This reduction is size-specific: the fine is 2 point if the target is L, 5 for M, and 8 for S. In other words, the fine-to-fee ratio varies: the smaller is the nation targeted, the more effective is the punishment, which nicely mirrors the functioning of trade sanctions. Notice also that punishment can accumulate in case of two members requesting punishment. Hence, in this case the fine for the target can be 4, 10, or 16 points.

Instead, those who have defected must decide whether they want to counter-punish or not in response to those who will punish them. This decision is elicited with the strategy method as the outcome is not known at the time of the decision. For instance, if a participant chooses to counter-punish and no one punishes her in the first place, there will be no counter-punishment and fee on her side. The fee and fines associated to counter-punishment are the same as for punishment. Notice that both punishment and counter-punishment are decisions taken in a cold state as opposed to a hot state. In this treatment, all decisions – contribution, punishment, and counter-punishment – are binary. In the design the punishment strategies aim to capture elements of international treaties, where sanctions are imposed only on non compliant parties. Moreover, in international contexts, those targeted for punishment often can and do strike back and without the possibility to choose a specific target.[5] This last feature was chosen to simplify the design.

The fourth treatment is **Conditional Cooperation with Punishment**, which is a combination of I-Will-If-You-Will and Public Good Game with Punishment. In the contribution stage, participants have three options: contribute, defect, conditionally contribute. In the punishment stage, participants have two options: to punish (or counter-punish) or not. If one cooperates (conditionally or unilaterally), then she will have the opportunity to punish defectors. Her requested punishment, however, would be disregarded if her endowment ends up in the private account (because nobody else cooperated). At the end of the period, participants observed the implemented actions but not he ex-ante contribution or punishment strategies.

Finally, we illustrate the **Club** treatment (detailed instructions are available online: Instructions). In the contribution stage, participants have three options: contribute, defect, treaty strategy. There is a punishment stage only for those who contributed or defected but not for those who chose the treaty strategy. In the punishment stage, participants have two options: to punish (or counter-punish) or not as already described for other treatments. The treaty strategy involves both conditional cooperation and punishment of defector. In the treatment Conditional Cooperation with Punishment the two could be disjoint, while in Club treatment they are linked: a participant can choose to conditionally cooperate only if she simultaneously commits to punishing defectors. A club is formed when two or three group members choose the treaty strategy. If the others choose cooperation without punishment, the endowment of those who chose treaty will go to the private account. The treaty strategy is designed to make non-participation to the club less attractive. In the Club treatment, the choice of the treaty strategy was ex-post observable even if a club was not formed.

[5] We exclude antisocial punishment by design. That is, subjects are only allowed to punish free-riders. However, those that decide not to contribute are given the option to retaliate by choosing to counter-punish those that punished them.

3.2. Formalization of the Public Good Game with Punishment treatment

In this subsection we represent more formally the Public Good Game with Punishment treatment, to shed light on the mechanics of punishment and counter-punishment, and the ensuing enriched strategy space. The treatments featuring punishment kept the simultaneous move design implemented for contributions in PGG and IwYw, such that punishment and counter-punishment decisions were elicited with the strategy method, conditional on others' choices. This means that all treatments feature simultaneous moves, even if for clarity of exposition the instructions for PGGwP, CCwP and Club we separate contribution decisions and punishment decisions in consecutive parts (Part 1 and Part 2, respectively. See Instructions). Note that in Part 2 one can either punish (only if she cooperated in Part 1) or counter-punish (if defected in Part 1 and received punishment by one or more cooperators in Part 2). We can thus formalize PGGwP as follows. Consider the normal form game Γ=(N,S,π). where: $N = \{1, \dots, i, \dots, n\}$ is a finite set of players;

$S = \times S_i$ is the set of strategy profiles;

A strategy profile is given by $s = (s_1, \dots, s_n) \in S$ and $s_i \in S_i$;

S_i is the finite strategy set of player i for every player $i \in N$, s.t.

$S_i = \{(C \wedge P), (C \wedge nP), (D \wedge CP), (D \wedge nCP)\}$. Namely, one can choose between:

1. $(C \wedge P)$: Cooperate and Punish defectors (in case there is one or more)
2. $(C \wedge nP)$: Cooperate and do not Punish defectors
3. $(D \wedge CP)$: Defect and Counter-Punish cooperators from whom player was targeted
4. $(D \wedge nCP)$: Defect and do not Counter-Punish cooperators from whom player was targeted

$\pi_i : S \mapsto R$ is i's payoff function and π is a vector $(\pi_1, \dots, \pi_n)$.

The payoff function is given by

$$\pi_i(s_i, s_{-i}) = e - x_i + \sum \alpha_i x_i - \delta_i - \rho_i$$

where

$$x_i = \begin{cases} e, & \text{if } s_i = (C \wedge P) or (C \wedge nP) \\ 0, & \text{otherwise} \end{cases}$$

α_i is the marginal private return from the public good, such that $\sum \alpha_i = \lambda$ and $1 < \lambda < n$. λ is the marginal aggregate return, δ_i is the cost of punishing and counter-punishing and ρ_i is the cost of being punished (or being targeted by counter-punishment). Specifically:

$$\delta_i = \begin{cases} |d|\phi, & \text{if } s_i = (C \wedge P) \\ |c|\phi, & \text{if } s_i = (D \wedge CP) \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

where $\phi \in \mathbb{R}^+$ and $|d|$ is the number of players whose strategy is $(D \wedge CP)$ or $(D \wedge nCP)$, and $|c|$ is the number of players whose strategy is $(C \wedge P)$.

$$\rho_i = \begin{cases} |c|\theta_i, & \text{if } s_i = (D \wedge CP) \text{ or } (D \wedge nCP) \\ |\bar{d}|\theta_i, & \text{if } s_i = (C \wedge P) \\ 0, & \text{otherwise} \end{cases} \quad (2)$$

where $\theta_i \in \mathbb{R}^+$ and $|\bar{d}|$ is the number of players whose strategy is $(D \wedge CP)$

In the experiment, both α_i and ρ_i vary with strategy (s_i, s_{-i}) and size. Namely, parameters satisfy the following: $\phi = 1$, $\alpha_S < \alpha_M < \alpha_L$ and $\theta_L < \theta_M < \theta_S$. Thus, everything else equal, the larger i, the larger the return from contributing α_i and the smaller the cost of being the target of punishment/counter-punishment ρ_i.

3.3. Equilibria

Standard self-interested rationality yields the predictions summarized for pure strategies in Tables A.1–A.2 in Appendix A. In the binary **Public Good Game** baseline, contributing nothing to the public good is always the best response, independent of player type (S, M or L). Mutual defection is the unique Nash equilibrium of this game, and is always an equilibrium in the remaining four treatments. In addition, in **Public Good Game with Punishment**, symmetric cooperation and punishment of defectors can be sustained in equilibrium (as punishment is not carried out in the end since no-one defects in the end, circumventing second-order free-riding). In other words, in PGGwP the threat of punishment makes cooperation an equilibrium. The three treatments featuring the possibility of conditionally cooperating also open the door to cooperative outcomes. In the **I-Will-If-You-Will** treatment, there are two main outcomes that can be reached through four different equilibrium strategy profiles. As Table 2 shows, in addition to widespread defection, partial cooperation is an equilibrium (with two players cooperating and one defecting). In the latter case, either S and L or M and L can end up cooperating in equilibrium. The same level of cooperation (among the same players) is rationalizable in the **Conditional Cooperation with Punishment** treatment. In addition, the combination of conditional strategies and the threat of punishment yield several strategies that are conducive to the fully cooperative equilibrium. Lastly, similar to PGGwP, the Club treatment has either full cooperation or full defection as equilibria. However, in Club many strategy profiles are compatible with 100% cooperation.

3.4. Procedures

A total of 315 students took part in the experiment and were recruited through ORSEE (Greiner, 2015). The sessions were run at the BLESS laboratory of the University of Bologna between October and December 2021. We ran 20 sessions, 4 for each treatment, with 15 or 18 participants each.[6] Each person participated in only one session. The experimenter read instructions aloud while participants were asked to follow on their own printed copy (detailed instructions are available here: Instructions). Communication between participants was not allowed. Participants were asked to answer a series of comprehension questions to test their understanding before being matched into groups. The experiment was programmed through LIONESS, which is a web-based platform (Giamattei, Yahosseini, Gächter, & Molleman, 2020). On average, a session lasted about 50 min, and the subjects earned 12 euro on average. Everyone had a guaranteed a minimum earning of 5 euro.

[6] A relaxation of Covid rules increased the capacity of lab from 15 to 18 participants.

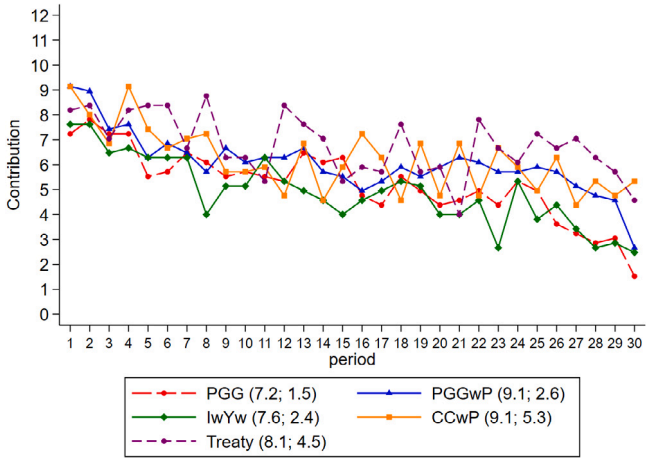

Fig. 1. Average contribution over time.
Notes: The numbers in parentheses indicate the average initial and final contribution level (range: 0–12).

Table 2
Aggregate results by treatment.

	Cooperation rate (ex-ante)	Cooperation rate (ex-post)	Gross earnings	Net earnings
PGG	43.54	43.54	14.76	14.76
IwYw	49.84	40.79	14.47	14.47
PGGwP	50.52	50.52	15.19	13.59
CCwP	58.30	51.56	15.13	13.86
Club	65.23	56.45	15.37	13.74

Notes: average values. The cooperation rate is the average contribution divided by 12. *Treatments:* Public Goods Game (PGG), Public Goods Game with Punishment (PGGwP), I-Will-If-You-Will (IwYw), Conditional Cooperation with Punishment (CCwP) and Club. N = 1890 per treatment.

4. Results

An overview of the average contribution levels is put forward in Fig. 1, where in all treatments the initial contribution is between 7 and 10 out of a maximum of 12 with a declining trend, a pattern usually seen in public good experiments.

The summary statistics about aggregate behavior by treatment are in Table 2. Next, we put forward the main patterns that emerge from the data, beginning with the impact of the conditional cooperation strategy on mitigation.

Result 1. When participants can conditionally cooperate there is no increase in aggregate cooperation or aggregate earnings.

Support for Result 1 is in Tables 2 and 3. Before presenting the evidence, one must clarify the distinction between ex-ante and ex-post cooperation rates. In the treatments with the option to cooperate conditionally there can be situations where the ex-ante intention to cooperate does not translate into an ex-post cooperative action and outcome. That happens for instance when two players choose to cooperate conditionally on the others doing the same, but one defects. In the IwYw treatment, for instance, 49.84% of participants chose to cooperate ex-ante, either conditionally or unconditionally. However a cooperative action ex-post happened only in 40.79% of the cases.

Evidence for Result 1 comes from a comparison between PGG vs. IwYw treatments: the ex-post cooperation rates are 43.54% vs. 40.79% and earnings are 14.76 vs. 14.47 points. The difference in terms of cooperation is not statistically significant (Wilcoxon Ranksum test, p

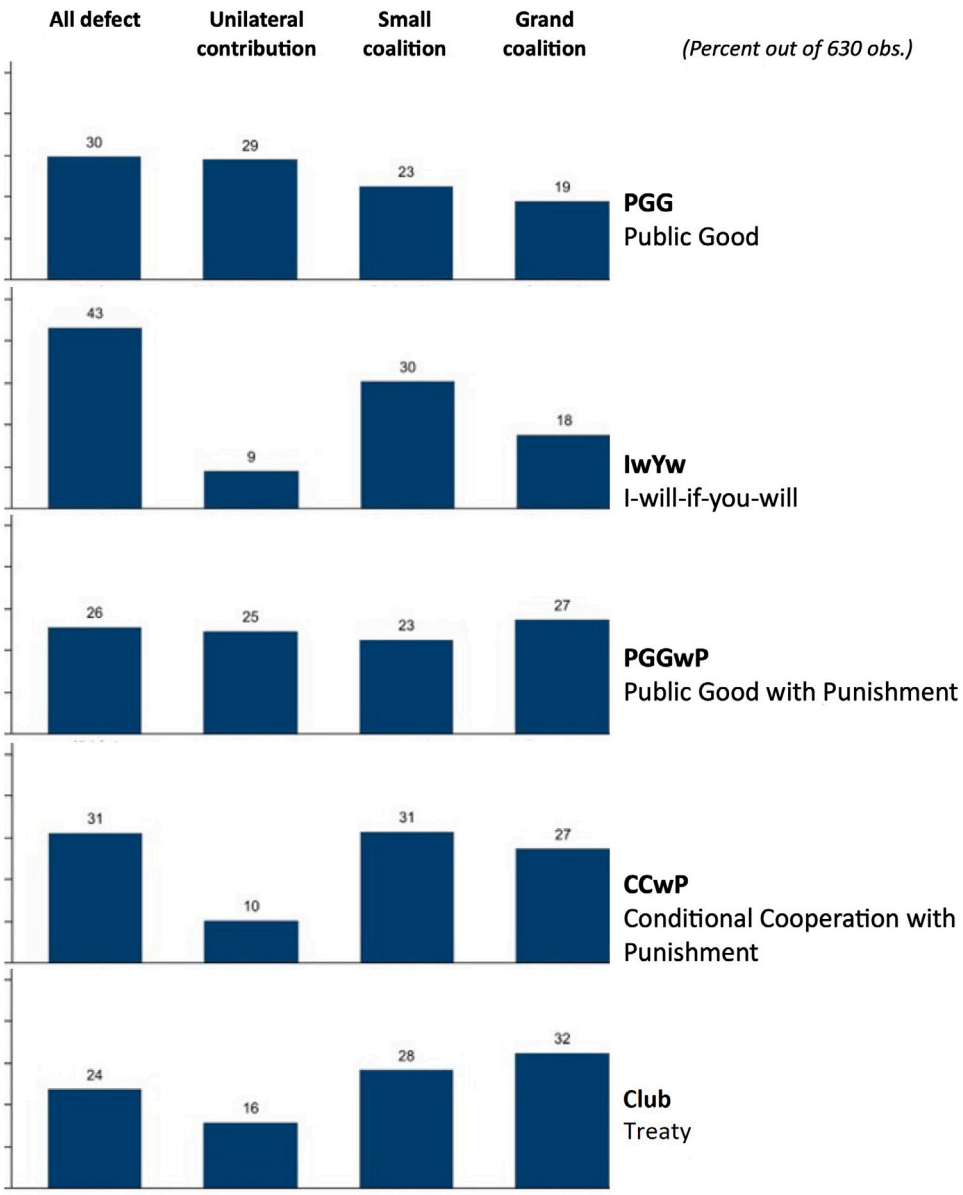

Fig. 2. Coalition types within a group.
Notes: All rounds. The unit of observation is a group of three participants (S, M, L) in a period.

= 0.59, N = 42: 21,21)[7] Similarly, differences in terms of net earnings are not statistically significant (Wilcoxon Ranksum test, p = 0.31, N = 42:21,21). This is confirmed also by an OLS regression (Table 3 for the last 10 rounds). Additional support for Result 1 comes from comparing two other treatments, PGGwP vs. CCwP, in terms of cooperation rates (50.52% vs. 51.56%) and net earnings (13.59 vs. 13.86 points). The differences are not statistically significant (Wilcoxon Ranksum test, p = 0.76 for cooperation, and p = 0.51 for earnings, N = 42:21, 21).

Despite the similar aggregate results, patterns of individual changed. A simple way to grasp these patterns is to classify group outcomes depending on the number of cooperators. Fig. 2 illustrate the percentage of coalitions of two or three group members who ex-post cooperated in a given round. The share of unilateral contributions is lower in IwYw than in PGG, in line with a preference of participants to avoid being

Table 3
PGG vs. IwYw in terms of *ex-post* cooperation and earnings.

	Cooperation (1)	Cooperation (2)	Net Earnings (3)	Net earnings (4)
IwYw	−0.019	−0.343	−0.305	−2.042
	(0.035)	(0.300)	(0.233)	(2.083)
Period	−0.022***	−0.028***	−0.113***	−0.147***
	(0.006)	(0.008)	(0.040)	(0.056)
IwYw ×Period		0.013		0.068
		(0.011)		(0.080)
Constant	0.880***	1.042***	16.946***	17.815***
	(0.150)	(0.198)	(1.047)	(1.453)
R-squared	0.027	0.027	0.017	0.017
Observations	420	420	420	420

Notes: OLS regressions. Last 10 periods only. The unit of observation is a group of three participants (S, M, L) in a period. Robust standard errors. Columns 1 and 2 the dependent variable takes values 0 if subject decided to defect or ended up defecting and 1 if the subject ended up cooperating ex-post. For columns 3 and 4 the dependent variable is net earnings. * p < 0.10, ** p < 0.05, *** p < 0.01.

[7] Even the difference in ex-ante cooperation rates is not statistically significant, 43.52% vs 49.84%; Wilcoxon Ranksum test, p = 0.274, N = 42:21,21.

Table 4
Individual strategies (ex-ante).

Strategy → Treatment ↓	D-nP	D-P	UC-nP	UC-P	CC-nP	CC-P	Treaty	Totals
PGG	1067	–	823	–	–	–	–	1890
	56.46%		43.54%					100%
IwYw	948	–	294	–	648	–	–	1890
	50.16%	–	15.56%		34.29%			100%
PGGwP	423	512	502	453	–	–	–	1890
	22.38%	27.09%	26.56%	23.97%				100%
CCwP	405	383	246	243	311	302	–	1890
	21.43%	20.26%	13.02%	12.86%	16.46%	15.98%		100%
Club	261	396	360	280	–	–	593	1890
	13.81%	20.95%	19.05%	14.81%			31.38%	100%

Notes: treatments: Public Goods Game (PGG), Public Goods Game with Punishment (PGGwP), I-Will-If-You-Will (IwYw), Conditional Cooperation with Punishment (CCwP) and Club. *Individual strategies:* Defect (D), Defect & Punish (D-P), Unconditionally Cooperate (UC), Unconditionally Cooperate & Punish (UC-P), Conditionally Cooperate without Punishment (CC-nP), Conditionally Cooperate & Punish (CC-P), and Treaty. Total no. obs. 9450.

Table 5
PGG vs. Club in terms of cooperation and earnings.

	Cooperation (1)	Cooperation (2)	Net Earnings (3)	Net Earnings (4)
Club	0.197***	−0.407	−0.719**	−0.609
	(0.036)	(0.329)	(0.297)	(2.447)
Period	−0.016**	−0.028***	−0.149***	−0.147***
	(0.006)	(0.008)	(0.047)	(0.056)
Club ×Period		0.024*		−0.004
		(0.013)		(0.095)
Constant	0.740***	1.042***	17.870***	17.815***
	(0.166)	(0.198)	(1.230)	(1.453)
R-squared	0.076	0.081	0.028	0.026
Observations	420	420	420	420

Notes: OLS regressions. Last 10 periods only. The unit of observation is a group of three participants (S, M, L) in a period. Robust standard errors. Columns 1 and 2 the dependent variable takes values 0 if subject decided to defect or ended up defecting and 1 if the subject ended up cooperating ex-post. For columns 3 and 4 the dependent variable is net earnings. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 6
Net earnings by nation size.

	PGG	IwYw	PGGwP	CCwP	Club
M(edium)	−0.514	−0.629	0.524	1.333***	0.962*
	(0.475)	(0.413)	(0.481)	(0.439)	(0.513)
L(arge)	−0.914**	0.229	0.819*	1.181***	1.981***
	(0.443)	(0.394)	(0.458)	(0.430)	(0.471)
Period	−0.147**	−0.078	−0.142**	−0.053	−0.151***
	(0.061)	(0.056)	(0.064)	(0.058)	(0.057)
Constant	18.291***	15.906***	16.509***	14.149***	16.225***
	(1.667)	(1.447)	(1.680)	(1.544)	(1.487)
R-squared	0.011	0.006	0.009	0.015	0.032
Observations	630	630	630	630	630

Notes: OLS regressions. Last 10 periods only. The unit of observation is a participant in a period. Default is the S(mall) nation. Robust standard errors. * p < 0.10, ** p < 0.05, *** p < 0.01.

the sole contributor in a group. The effect of having a conditionally cooperative strategy is to address the fear of exploitation of some participants, which has been found to discourage contribution (Rapoport & Eshed-Levy, 1989). However – as Result 1 states – this was insufficient to increase ex-post aggregate cooperation levels. The sole contributor mostly stopped contributing, increasing the percentage of "All defect" (from 30% to 43%, Fig. 2). A similar pattern emerges when comparing PGGwP vs. CCwP.

Further individual patterns emerge from an analyses of the individual strategy profiles provided in Table 4. About one third of participants selected a conditionally cooperative strategy in IwYw (34.29%). A back-of-the envelope calculation – based on a comparison with the PGG treatment – suggests most conditional cooperators, about 27.98%, would have chosen unconditional cooperation (UC-np) had they played under the usual PGG rules. Only some, about 6.3%, would have chosen defection under the usual PGG rules. This means that less than 1 out of 5 conditional cooperators were former defectors that were reassured in the new situation by the removal of strategic uncertainty. More than 4 out of 5 conditional cooperators would have chosen unconditional cooperation anyway. This effect may account for the relatively weak increase in cooperative strategies that we record when comparing PGG with IwYw. The additional comparison of PGGwP vs. CCwP reveals a similar pattern, with about 32.44% conditional cooperators and only 7.78% having switched from defections to conditional cooperation. We next turned to the impact of punishment opportunities.

Result 2. When participants have opportunities for punishment and counter-punishment, there is no statistically significant increase in aggregate cooperation and a decline in earnings.

Support for Result 2 is in Table 2. Evidence for Result 2 comes from a comparison between PGG vs. PGGwP treatments: the cooperation rates are 43.54% vs. 50.52% and earnings are 14.76 vs. 13.59 points. The difference in terms of cooperation is not statistically significant (Wilcoxon Ranksum test, p = 0.47, N = 42:21, 21).[8] Instead, differences in terms of net earnings are statistically significant (Wilcoxon Ranksum test, p = 0.02, N = 42:21, 21). Additional support for Result 2 comes from comparing two other treatments, IwYw vs. CCwP, in terms of cooperation rates (40.79% vs. 51.56%) and net earnings (14.47 vs. 13.86 points). The difference in terms of cooperation is not statistically significant (Wilcoxon Ranksum test, p = 0.13, N = 42:21, 21). Instead, differences in terms of net earnings are marginally statistically significant (Wilcoxon Ranksum test, p = 0.07, N = 42:21, 21).

A cursory look at Fig. 2 suggests that punishment and counter-punishment opportunities slightly increased the frequency of the Grand coalition outcome at the expense of the all-defect outcome. An analyses of the individual strategy profiles of PGGwP from Table 4 show about 24% of participants submit a punishment request of defectors. When taking into account that only cooperators could punish defectors, this reveals a willingness to pay of almost one out of two cooperators (47%). The desire to counter-punish is even stronger, with about 27% of participants submitting a counter-punishment request, which amounts of more than one out of two defectors (55%). Most of these requests are not implemented. Only half of the punishment requests are implemented because there are no defectors (about 12%, see Table B.1 in Appendix B) and less than one third of the counter-punishment requests because the defector has not been punished in the first place (about

[8] Because there is no conditional cooperation strategy, ex-ante and ex-post cooperation rates are identical.

8%). Still, in the PGGwP treatment the costs of these actions cause a large enough loss to more than offset the cooperation earnings gains.

The additional evidence from CCwP reveals a similar pattern, with punishment requests by about 29% of participants and counter-punishment requests by 20% of participants. In sum, by considering both PGGwP and CCwP treatments, about half cooperators show a will to punish defectors and about half of defectors a will to counter-punish.

Result 3. The climate Club achieves an aggregate cooperation rate that is about 22 percentage points above the baseline treatment, but aggregate earnings that are below.

Support for Result 3 is in Tables 2 and 5. In the Club treatment aggregate cooperation is 65.23% ex-ante and 56.45% ex-post, which makes it the most cooperative treatment and well above the PGG with 43.54%. This ex-post increase is marginally statistically significant (Wilcoxon Ranksum test, p = 0.07, N = 42:21, 21). In terms of net earnings instead, we stand at 13.74 points versus the 14.76 points of PGG. This decline is statistically significant (Wilcoxon Ranksum test, p = 0.03, N = 42:21, 21). An OLS regression on the last ten round that compares the Club vs. PGG treatments shows a statistically significant difference at the one percent level in terms of cooperation rates and at a five percent level in terms of net earnings. The differences are not statistically significant with other treatments, except IwYw (Table B.2).[9]

In terms of coalition types, Club is in line with other treatments allowing for conditionally cooperative strategies: the frequency of unilateral contributions is very low (Fig. 2). An analyses of the individual strategy profiles of Club from Table 4 reveals about 35% of defection strategies instead of 56% of PGG, which capture almost all difference in terms of ex-ante aggregate cooperation rates. The treaty strategy has a share of about 31%, which is similar to that of the conditionally cooperative strategies in IwYw (34%) and CCwP (32%). Hence, tying conditional cooperation and punishment does not seem to make the strategy unattractive. Among those who did not choose the treaty strategy, we notice only a slight change in punishment patterns with respect to the CCwP, which is the closest treatment in terms of design. Unconditional cooperators punish defectors at rates of 44% in Club vs. 50% in CCwP and defector counter-punish at rates of 60% vs. 49%, respectively. One may wander if – by lurking participants who liked conditional cooperation into a treaty strategy that involves punishment – the effect was to increase the overall level of punishment in the economy. To address this question we will sum the frequencies of ex-post punishment and counter-punishment (Table B.1). Out of the three relevant treatments, we report for PGGwP a frequency of punishment and counter-punishment of 20.63%, for CCwP of 18.05% and for Club of 21.37%. The difference across treatments is minimal.

Result 4. In a Climate Club, the Small nation loses out while the Large nation does relatively better than in Baseline.

Support for Result 4 is in Tables 6 and B.3. When aggregating across all treatments, ex-post cooperation rates are lowest for Small and highest for Large (46.7% S, 48.7% M, and 50.4% L), although overall not statistically significant (Wilcoxon Ranksum test, p = 0.31, N = 210:105, 105). Large has on average higher net earnings than Small (14.3 for L, 14.1 for M, 13.8 for S), although overall only marginally statistically significant (Wilcoxon Ranksum test, p = 0.07, N = 210:105, 105). When we compare treatments, though, the situation is diversified. Large earn significantly more than Small in Club (14.7 vs. 12.8, Wilcoxon Ranksum test, p = 0.003, N = 21, 21) but earn less in PGG (14.3 vs. 15.3, Wilcoxon Ranksum test, p = 0.27, N = 42:21, 21). The reason is that, while Large did not substantially earn more in Club than in PGG, Small's earnings declines (Wilcoxon Ranksum test, p = 0.003, N = 42:21, 21), except in the PGG treatment, where the ranking is reversed. However, the higher cooperation rate of Large translate into statistically significantly lower earnings than Small (Table 6). Instead, in Club the net earnings of Large are statistically significantly higher than Small and by the highest amount across all treatments. A similar, smaller, but statistically significant effect is also reported for CCwP.

5. Conclusion

One proposal to ratchet up international efforts to mitigate climate change is to structure climate treaties as clubs. This proposal – put forward by Nordhaus (2015) – has recently gained attention (Hovi, Sprinz, Sælen, & Underdal, 2016; Tagliapietra & Wolff, 2021). According to Falkner (2015) a climate club redefines climate stability from a public-good into a quasi-private good.

We studied in a laboratory setting a stylized version of a climate club that embeds conditional contribution and the punishment of non-club members. To form the club, we offer participants the option to mitigate conditionally on others doing so. This possibility should reduce strategic uncertainty and the fear of being exploited, which can discourage contribution (Rapoport & Eshed-Levy, 1989). Overall, a climate club increases cooperation but to a lower extent than expected. Importantly, it does not increase total surplus with respect to voluntary cooperation in a baseline public good game because of the dead-weight loss of punishment given and received, which was substantial, unless the club formation resulted in the grand coalition.

Another noteworthy finding is that introducing the option to conditionally cooperate influences the type of ensuing coalitions by reducing the share of sole contributors to the public good, an issue which pulls outcomes towards either a small coalition or full defection.

Taken together, the above findings may be of interest to policymakers in shaping future climate agreements. Admittedly, one experiment is not enough to draw general conclusions and more research in this are is needed. The lab implementations of climate clubs leaves of course open the traditional question of enforcement mechanisms for international treaties (Barrett, 2013). In the lab we offer strong institutions to enforce the commitment of conditional cooperation, whereas in the field those institutions are oftentimes frail. Relaxing such choices by introducing more nuance in institutional enforcement in the lab may be a fruitful avenue forward.

CRediT authorship contribution statement

Marco Casari: Conceptualization, Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis. **Alessandro Tavoni:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis.

Data availability

Data will be made available on request.

Appendix A. Equilibria

See Tables A.1 and A.2.

[9] The aggregate ex-ante cooperation is higher in Club than in CCwP but not statistically significant (58.30% vs 65.23%, Wilcoxon Ranksum test, p = 0.218, N = 42:21, 21). Similarly for the (smaller) ex-post cooperation rates (51.56% vs 56.45%, Wilcoxon Ranksum test, p = 0.443, N = 42: 21,21). The aggregate ex-post cooperation is higher in Club than in IwYw (30% vs 65.23%, Wilcoxon Ranksum test, p = 0.02, N = 42:21, 21) and for net earnings (Wilcoxon Ranksum test, p = 0.04, N = 42:21, 21).

Table A.1
Equilibria (strategy profiles and ensuing outcomes)

Treatment	Equilibria	
	Strategy profile	Outcome
Public Good Game (PGG)	**Full defection**	
	(D, D, D)	**(D, D, D)**
I will if you Will (IwYw)	**2/3 Cooperation**	
CC1= Cooperate if at least one else cooperates	(CC1, D, CC1)	**(C, D, C)**
	(D, CC1, CC1)	**(D, C, C)**
	Full Defection	
	(CC1, D, D)	**(D, D, D)**
	(D, D, D)	**(D, D, D)**
Public Good with Punishment (PGGwP)	**Full Cooperation**	
	(CP, CP, CP)	**(C, C, C)**
Players choose simultaneously the strategies on the following set {CP, CnP, DCP, DnCP}	**Full defection**	
CP=Cooperate & Punish	(DnCP, DnCP, DnCP)	
CnP=Cooperate & don't Punish	(DCP, DCP, DCP)	
DCP=Defect & Counter-Punish	(DCP, DnCP, DCP)	
DnCP=Defect & don't Counter-Punish	(DnCP, DCP, DCP)	
	(DnCP, DnCP, DCP)	**(D,D,D)**
	(DCP, DCP, DnCP)	
	(DCP, DnCP, DnCP)	
	(DnCP, DCP, DnCP)	
Conditional Cooperation with Punishment (CCwP)	**Full Cooperation**	
CC1P= Cooperate if at least one else cooperates & Punish	(CP, CP, CP)	
CC1nP= Cooperate if at least one else cooperates & don't Punish	(CP, CC1P, CP)	
	(CC1P, CP, CP)	
	(CC1P, CC1P, CP)	**(C,C,C)**
	(CP, CP, CC1P)	
	(CP, CC1P, CC1P)	
	(CC1P, CP, CC1P)	
	(CC1P, CC1P, CC1P)	
	2/3 Cooperation	
	(CC1nP, DnCP, CC1nP)	**(C,D,C)**
	(CC1nP, DCP, CC1nP)	
	(DCP, CC1nP, CC1nP)	**(D,C,C)**
	(DnCP, CC1nP, CC1nP)	
	Full Defection	
	(CC1P, DCP, DCP) (DnCP, DnCP, DCP)	
	(CC1NP, DCP, DCP) (CC1P, DCP, DnCP)	
	(DCP, DCP, DCP) (CC1NP, DCP, DnCP)	
	(DnCP, DCP, DCP) (DCP, DCP, DnCP)	
	(CC1P, DnCP, DCP) (DCP, DnCP, DCP)	**(D,D,D)**
	(CC1NP, DnCP, DCP) (DCP, DCP, DnCP)	
	(DnCP, DCP, DnCP) (CC1P, DnCP, DnCP)	
	(DCP, DnCP, DnCP) (DnCP, DnCP, DnCP)	
	(CC1NP, DnCP, DnCP)	

Notes: The order of actions corresponds to (S, M, L). In the outcome, for the sake of space, we restrict attention to whether players contribute or not, disregarding punishment (if C) and counter-punishment (if D). Hence, in Club an outcome classified as (C, C, C) can arise from strategies (CP, CP, CP) and from (T, CNP, CP). Similarly, both (DCP, DCP, DCP) and (DnCP, DnCP, DnCP) are classified as (D, D, D). Note that in equilibrium non punishment (or counter-punishment) is actually administered.

Table A.2
Equilibria (continued).

Treatment	Equilibria	
	Strategy profile	Outcome
Club	**Full Cooperation**	
Players choose simultaneously the strategies on the following set: *{CP, CnP, DCP, DnCP, T}* *T=Treaty=(CC1P, otherwise DnCP)*	(T, T, CnP) (CnP, T, T) (T, CnP, T) (T, T, T) (CP, CP, CP) (T, CP, CP) (CP, T, CP) (T, CNP, CP) (CP, CP, T) (T, CP, T) (CP, T, T)	**(C,C,C)**
	Full Defection	
	(DCP, T, DCP) (DCP, DCP, DCP) (DnCP, DCP, DCP) (T, DnCP, DCP) (DCP, DnCP, DCP) (DnCP, DnCP, DCP) (DCP, T, DnCP) (DCP, DCP, DnCP) (DnCP, DCP, DnCP) (T, DnCP, DnCP) (DCP, DnCP, DnCP) (DnCP, DnCP, DnCP) (DCP, DCP, T) (DCP, DnCP, T)	**(D,D,D)**

Notes: The order of actions corresponds to (S, M, L). In the outcome, for the sake of space, we restrict attention to whether players contribute or not, disregarding punishment (if C) and counter-punishment (if D). Hence, in Club an outcome classified as (C, C, C) can arise from strategies (CP, CP, CP) and from (T, CNP, CP). Similarly, both (DCP, DCP, DCP) and (DnCP, DnCP, DnCP) are classified as (D, D, D). Note that in equilibrium non punishment (or counter-punishment) is actually administered.

Appendix B. Additional regressions

See Tables B.1–B.3.

Table B.1
Individual outcomes (ex-post)

Outcome → Treatment ↓	D	D-P	UC	UC-P	CC-nP	CC-P	Treaty-nP	Treaty-P	Totals
PGG	1067	–	823	–	–	–	–	–	1890
	56.46%		43.54%						100%
IwYw	1119	–	294	–	477	–	–	–	1890
	59.21%		15.56%		25.24%				100%
PGGwP	780	155	720	235	–	–	–	–	1890
	41.27%	8.20%	38.09%	12.43%					100%
CCwP	795	119	380	109	374	113	–	–	1890
	42.06%	6.30%	20.11%	5.77%	19.79%	5.98%			100%
Club	722	101	543	97	–	–	221	206	1890
	38.02%	5.34%	28.73%	5.13%			11.69%	10.90%	100%

Notes: treatments: Public Goods Game (PGG), Public Goods Game with Punishment (PGGwP), I-Will-If-You-Will (IwYw), Conditional Cooperation with Punishment (CCwP) and Club. *Outcomes:* Defect (D), Defect & Punish (D-P), Unconditionally Cooperate (UC), Unconditionally Cooperate & Punish (UC-P), Conditionally Cooperate without Punishment (CC-nP), Conditionally Cooperate & Punish (CC-P), Treaty with grand coalition (Treaty-nP), Treaty with punishment (Treaty-P).

Table B.2
CCwP vs. Club in terms of cooperation and earnings.

	Cooperation (1)	Cooperation (2)	Net Earnings (3)	Net Earnings (4)
Club	0.057	−0.129	−0.290	2.219
	(0.039)	(0.360)	(0.320)	(2.646)
Period	−0.008	−0.012	−0.102**	−0.053
	(0.007)	(0.010)	(0.051)	(0.068)
Club ×Period		0.007		−0.098
		(0.014)		(0.102)
Constant	0.671***	0.765***	16.242***	14.987***
	(0.180)	(0.245)	(1.337)	(1.768)
R-squared	0.004	0.002	0.005	0.005
Observations	420	420	420	420

Notes: OLS regressions. Last 10 periods only. The unit of observation is a group of three participants (S, M, L) in a period. Robust standard errors. Columns 1 and 2 the dependent variable takes values 0 if subject decided to defect or ended up defecting and 1 if the subject decided to cooperate either conditionally or unconditionally. For columns 3 and 4 the outcome variable is net earnings. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table B.3
Ex-ante cooperation by nation size.

	PGG	IwYw	PGGwP	CCwP	Club
M	0.043	. 0.052	0.029	−0.062	0.052
	(0.044)	(0.045)	(0.048)	(0.049)	(0.049)
L	0.076*	−0.019	0.057	−0.014	0.014
	(0.045)	(0.044)	(0.048)	(0.049)	(0.049)
Period	−0.028***	−0.016**	−0.025***	−0.012*	−0.005
	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)
Constant	1.002***	0.688***	1.052***	0.790***	0.613***
	(0.164)	(0.163)	(0.175)	(0.180)	(0.181)
R-squared	0.030	0.009	0.019	0.003	−0.002
Observations	630	630	630	630	630

Notes: OLS regressions. Last 10 periods only. The unit of observation is a participant in a period. The dependent variable takes values 0 if subject decided to defect or ended up defecting and 1 if the subject decided to cooperate either conditionally or unconditionally. Robust standard errors. * p < 0.10, ** p < 0.05, *** p < 0.01.

References

Alberti, F., & Cartwright, E. J. (2016). Full agreement and the provision of threshold public goods. *Public Choice*, *166*(1), 205–233.

Almer, C., & Winkler, R. (2017). Analyzing the effectiveness of international environmental policies: The case of the Kyoto Protocol. *Journal of Environmental Economics and Management*, *82*, 125–151.

Bachram, H. (2004). Climate fraud and carbon colonialism: The new trade in greenhouse gases. *Capitalism Nature Socialism*, *15*(4), 5–20.

Bardsley, N., & Moffatt, P. G. (2007). The experimetrics of public goods: Inferring motivations from contributions. *Theory and Decision*, *62*(2), 161–193.

Barrett, S. (1994). Self-enforcing international environmental agreements. *Oxford Economic Papers*, 878–894.

Barrett, S. (2013). Climate treaties and approaching catastrophes. *Journal of Environmental Economics and Management*, *66*(2), 235–250.

Barrett, S., & Dannenberg, A. (2014). Sensitivity of collective action to uncertainty about climate tipping points. *Nature Climate Change*, *4*(1), 36–39.

Böhringer, C. (2003). The Kyoto Protocol: A review and perspectives. *Oxford Review of Economic Policy*, *19*(3), 451–466.

Bosetti, V., Heugues, M., & Tavoni, A. (2017). Luring others into climate action: Coalition formation games with threshold and spillover effects. *Oxford Economic Papers*, *69*(2), 410–431.

Burlando, R. M., & Guala, F. (2005). Heterogeneous agents in public goods experiments. *Experimental Economics*, *8*(1), 35–54.

Calzolari, G., Casari, M., & Ghidoni, R. (2018). Carbon is forever: A climate change experiment on cooperation. *Journal of Environmental Economics and Management*, *92*, 169–184.

Carraro, C., & Siniscalco, D. (1993). Strategies for the international protection of the environment. *Journal of Public Economics*, *52*(3), 309–328.

Cherry, T. L., & McEvoy, D. M. (2013). Enforcing compliance with environmental agreements in the absence of strong institutions: An experimental analysis. *Environmental and Resource Economics*, *54*(1), 63–77.

Dannenberg, A., Löschel, A., Paolacci, G., Reif, C., & Tavoni, A. (2015). On the provision of public goods with probabilistic and ambiguous thresholds. *Environmental and Resource Economics*, *61*(3), 365–383.

Dreber, A., Rand, D. G., Fudenberg, D., & Nowak, M. A. (2010). Winners don't punish. *Nature*, *452*(7185), 348–351.

Falkner, R. (2015). *A minilateral solution for global climate change? On bargaining efficiency, club benefits and international legitimacy*. Centre for Climate Change Economics and Policy and Grantham Research.

Feige, C., Ehrhart, K.-M., & Krämer, J. (2018). Climate negotiations in the lab: A threshold public goods game with heterogeneous contributions costs and non-binding voting. *Environmental and Resource Economics*, *70*(2), 343–362.

Finus, M. (2008). The enforcement mechanisms of the Kyoto Protocol: Flawed or promising concepts? *Letters in Spatial and Resource Sciences*, *1*(1), 13–25.

Fischbacher, U., & Gächter, S. (2008). Heterogeneous social preferences and the dynamics of free riding in public good experiments.

Fischbacher, U., Gächter, S., & Fehr, E. (2001). Are people conditionally cooperative? Evidence from a public goods experiment. *Economics Letters*, *71*(3), 397–404.

Gavrilets, S. (2015). Collective action problem in heterogeneous groups. *Philosophical Transactions of the Royal Society, Series B (Biological Sciences)*, *370*(1683), Article 20150016.

Ghidoni, R., Calzolari, G., & Casari, M. (2017). Climate change: Behavioral responses from extreme events and delayed damages. *Energy Economics*, *68*, 103–115.

Giamattei, M., Yahosseini, K. S., Gächter, S., & Molleman, L. (2020). LIONESS Lab: A free web-based platform for conducting interactive experiments online. *Journal of the Economic Science Association*, *6*(1), 95–111.

Greiner, B. (2015). Subject pool recruitment procedures: Organizing experiments with ORSEE. *Journal of the Economic Science Association*, *1*(1), 114–125.

Haya, B., et al. (2012). *Failed mechanism: How the CDM is subsidizing hydro developers and harming the Kyoto Protocol: Technical report*.

Hovi, J., Sprinz, D. F., Sælen, H., & Underdal, A. (2016). Climate change mitigation: A role for climate clubs? *Palgrave Communications*, *2*(1), 1–9.

Lee, H., & Romero, J. (2023). *Climate change 2023: Synthesis report. Contribution of working groups I, II and III to the sixth assessment report of the Intergovernmental Panel on Climate Change*. Geneva, Switzerland: IPCC.

MacKay, D. J. C., Cramton, P., Ockenfels, A., & Stoft, S. (2015). Price carbon – I will if you will. *Nature*, *526*, 315–316.

Marchiori, C., Dietz, S., & Tavoni, A. (2017). Domestic politics and the formation of international environmental agreements. *Journal of Environmental Economics and Management*, *81*, 115–131.

Nordhaus, W. (2015). Climate clubs: Overcoming free-riding in international climate policy. *American Economic Review*, *105*(4), 1339–1370.

Ones, U., & Putterman, L. (2007). The ecology of collective action: A public goods and sanctions experiment with controlled group formation. *Journal of Economic Behaviour and Organization*, *62*(4), 495–521.

Prins, G., & Rayner, S. (2007). Time to ditch Kyoto. *Nature*, *449*(7165), 973–975.

Raiser, K., Kornek, U., Flachsland, C., & Lamb, W. F. (2020). Is the Paris Agreement effective? A systematic map of the evidence. *Environmental Research Letters*, *15*(8), Article 083006.

Rapoport, A., & Eshed-Levy, D. (1989). Provision of step-level public goods: Effects of greed and fear of being gypped. *Organizational Behavior and Human Decision Processes*, *44*(3), 325–344.

Rogelj, J., Popp, A., Calvin, K. V., Luderer, G., Emmerling, J., Gernaat, D., et al. (2018). Scenarios towards limiting global mean temperature increase below 1.5 c. *Nature Climate Change*, *8*(4), 325–332.

Schneider, L., et al. (2007). *Is the CDM fulfilling its environmental and sustainable development objectives? An evaluation of the CDM and options for improvement*. Berlin: Öko-Institut.

Sethi, R., & Somanathan, E. (1996). The evolution of social norms in common property resource use. *American Economic Review*, *86*(4), 766–788.

Tagliapietra, S., & Wolff, G. B. (2021). *Form a climate club: United States, European Union and China*. Nature Publishing Group.

Tavoni, A., Dannenberg, A., Kallis, G., & Löschel, A. (2011). Inequality, communication, and the avoidance of disastrous climate change in a public goods game. *Proceedings of the National Academy of Sciences*, *108*(29), 11825–11829.

Tavoni, A., & Winkler, R. (2021). Domestic pressure and international climate cooperation. *Annual Review of Resource Economics*, *13*(1), 225–243.

Victor, D. G. (2011). *The collapse of the Kyoto Protocol and the struggle to slow global warming*. Princeton University Press.

Wara, M. W., & Victor, D. G. (2008). A realistic policy on international carbon offsets. In *Program on Energy and Sustainable Development Working Paper: Vol. 74*, (pp. 1–24).

Zhang, J., & Wang, C. (2011). Co-benefits and additionality of the clean development mechanism: An empirical analysis. *Journal of Environmental Economics and Management*, *62*(2), 140–154.