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Public-Goods Games with Endogenous Institution-Formation: Experimental Evidence on the Effect of the Voting Rule

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Abstract: We report experimental results on voluntary contributions to public-goods provision from situations in which parties can create institutions to impose a certain contribution level on its members. We focus on a public-goods game where the joint decisions inside the institution are made based on the plurality voting rule. We show that, comparing to the unanimity voting rule, the plurality rule results in a significant and large decrease in the institution initiation rate, along with a significant and large increase in the institution implementation rate. In the end, as the two effects cancel each other out, the choice of the voting rule does not significantly affect the average contribution level or efficiency.

Keywords: institution formation; laboratory experiment; plurality voting; public-goods game; unanimity voting

JEL Classification: C91; C92; H41

1. Introduction

The provision of public goods relies on cooperation among agents who face a conflict between self-interest and social welfare. Neoclassical economic theory and game theory predict that such dilemma typically leads to inefficiency, which is the under-provision of the public goods. Experimental studies, however, have found that many people do voluntarily contribute to public goods. The average contribution rates range from 40% to 60% (of the initial endowment), although they typically decline over time as the interaction is repeated [1].

Both theoretical and experimental research have expanded tremendously over the past decades in the direction of identifying possible ways to solve the free-riding problem and to improve efficiency. One possible way around this "classical conundrum" (as Bowles [2] prefers to call the social dilemma) is to create and rely on institutions that enforce high contribution levels. One strand of the theoretical analysis is set in the context of the negotiation of international environmental agreements (IEAs). In the proposed models, participants first decide whether or not to participate in an institution which forces its members to contribute to the public goods at a level decided collectively. Non-members can decide how much to contribute on their own.

Theoretical results suggest that there is no substantial efficiency gain from this mechanism [3–5]. The reason is that if an institution was to maximise the joint benefits of its members, it would require the highest possible level of contribution to the public-goods provision from its members. Therefore, only a relatively small institution would be formed on a voluntary basis. Most people would have a strong incentive to free ride and would stay outside the institution.

These pessimistic conclusions have also been reflected in numerous real-life negotiations among countries regarding international trade, military cooperation and, in particular, IEAs. Countries have been meeting periodically to negotiate the cutting of greenhouse-gas emissions. However, little success has been achieved on establishing a legally binding and universal agreement on climate. The negotiation to have over 190 countries agree on an overarching goal is certainly not an easy task. Moreover, because those negotiations are typically governed by consensus, small groups of countries can often block progress.

Contrary to the pessimism from theoretical models, experimental results show that people are willing to form institutions and provide public goods if the institution is sufficiently large. Consequently, there exists a real chance for significant improvement on the efficiency level as compared to the non-cooperative status-quo. Furthermore, the implemented institution would often include all affected parties [6]. Yamagishi [7] argues and proves experimentally that people who share the goal of "elementary cooperation" (e.g., in a public-goods setting) are able to succeed through "instrumental cooperation" (i.e., by creating and contributing towards a sanctioning system). Interestingly, experimental evidence shows that, as the primary cooperation problem becomes more severe, people tend to cooperate more on the secondary level in creating a "punishment fund" [8]. Subsequent empirical research has confirmed the possibility of self-governance and has explored its necessary conditions. According to Ostrom et al. [9], the involved parties must have sufficient information and they "must also have an arena where they can discuss joint strategies and perhaps implement monitoring and sanctioning." As for the informational requirements, Rockenbach and Milinski [10] propose reputation building as a cheap and powerful decentralized substitute to costly punishment systems[1]. Markussen et al. [12] find that informal (decentralized) sanctioning systems are relatively popular as they constitute a successful and cheap alternative to formal (centralized) systems. Their study also delivers empirical support for a "democratic dividend": both sanctioning systems are more effective when chosen by majority as compared to when they are imposed externally.

In this paper, we focus on a mechanism of voluntary institution formation that involves a relatively large group of participants. The aim is to explore how the institution-formation mechanism works under different decision protocols. We conjecture that it is more difficult to form a grand coalition in larger groups. Moreover, the nature of the unanimity rule, which means that each and every member needs to approve the proposed institution, makes it less likely for the proposed institution to be implemented, especially when the size of the proposed institution is relatively small.

The plurality rule[2], on the other hand, is commonly used in group decision-making due to its simplicity and is shown to perform quite well in making accurate decisions [13]. Although the conventional game-theoretic approach suggests that the voting rule does not matter for institution formation (refer to Section 2), one might argue that, by removing veto power and by replacing the unanimity voting rule with the plurality rule, the chances of reaching an agreement within the institution are higher. At the same time, however, such a change in the voting rule, could come at the price of a relatively low participation rate in the first place, which could then result in a smaller institution and hence in an inefficient outcome. Our goal is to find out whether the proposed mechanism based on the plurality rule can successfully balance participation and commitment, and thus increase the contribution level and the provision of public goods[3].

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1 Guillen et al. [11] even claim that once elementary cooperation is achieved, the positive effects of the costly sanctioning system remain even after its removal (which would increase efficiency by saving costs). We advise a more cautious interpretation of their results because the typical declining trend of contribution levels does reappear in the absence of punishment possibilities.

2 Under the plurality rule, the candidate that receives the most votes is selected. When there are only two candidates, the majority rule and the plurality rule yield identical results.

3 In order to increase the incentives of joining the institution, we also include a less strict option of contribution level (half of the initial endowment) in our experimental design, following the theoretical implication of Finus and Maus [14].

Experimental studies of institution-formation are relatively few and tend to focus on relaxing the stringent requirement of full contribution and the consensus at voting. Dannenberg et al. [15], somewhat surprisingly, find that a moderate provision level (half of the endowment) imposed by the institution does not reduce the initial incentives to free ride. They observe that the average institution size is even slightly smaller than in the 100%-provision case[4].

Dannenberg et al. [16] study the minimum-contribution rule, where each institution member proposes a contribution level, and the minimum of which becomes binding for all members. They find a trade-off between participation and commitment in the coalition. While the minimum-contribution rule greatly facilitates cooperation when participation in the institution is exogenously forced on all agents, it loses its virtue when participation is voluntary. Even when the minimum-contribution rule applies to all agents, its success is not guaranteed, as the scheme is sensitive to players who consistently make low minimum proposals.

Dannenberg [17] further explores the influence of different voting schemes under the minimum contribution rule. Her results show that using a less demanding voting scheme for determining the binding minimum-contribution level (i.e., simple majority instead of full consensus) slightly improves the overall performance. However, participants facing the simple majority scheme are less likely to join the institution in the first place. This shows that "the coalitions under the unanimity rule are relatively large and implement moderate effort levels while the coalitions with majority votes implement very high effort levels but attract only few participants" [17] (p. 13).

Our experimental design essentially extends the one presented and analyzed by Kosfeld et al. [6]. Participants first voluntarily decide whether to join an institution. If more than one person decides to do so, a collective decision has to be made about the contribution level that the institution will impose on all of its members. Different from Kosfeld et al. [6], our design uses the plurality voting rule when members decide whether the institution should be formed and, if yes, the required contribution level. In addition, in our main treatment, in order to balance participation rate and contribution level (i.e., successful institution formation), we allow participants to vote for three different possibilities: to dissolve the institution, to form the institution with a 50% contribution rate, or to form the institution with a 100% contribution rate. This choice has been inspired by the theoretical analysis of the trade-off between the participation rate and the required contribution level inside the institution [3,14]. The idea is that with only two extreme options available, it can be difficult to achieve cooperation as people might be wary of investing the entire endowment in a risky public project. For that reason, by lowering the required contribution level, an institution could attract more participants to join. The choice of 50% as an alternative contribution level stems from the robust experimental evidence on linear public-goods game which suggests that participants initially contribute around 40% to 60% of their endowment to the public goods.

In our experimental study, we find that, compared to the unanimity rule, the plurality rule induces a lower participation rate but makes it easier to reach an agreement and to form an institution. Interestingly, these opposing effects cancel each other out, which makes it impossible to rank the two voting rules by contribution levels or efficiency. As for the observed institution size, in line with Burger and Kolstad [18], who show that the grand coalition is rarely formed in large groups, we argue that it is closer to the minimum efficient institution size than to the size of the grand coalition. Comparison across papers is rather difficult. For example, Dannenberg [17] and Dannenberg et al. [16] do not use the "traditional" voluntary-contribution mechanism analysed by experimental economists but rely on a model from the coalition-formation literature [3,4]. Furthermore, in Dannenberg's case, the institution determines a binding minimum-contribution level instead of

[4] It is worth noticing that Dannenberg et al. [15] did not include a voting stage to decide the contribution level inside the institution. It means that by joining the institution, participants automatically commit to contribute all or half of their endowments (depending on the scenario). This is one of the main differences between their design and ours, where members of the institution can still jointly decide to contribute nothing and dissolve the institution.

the contribution level. Nevertheless, the main message is clear: the plurality voting rule combined with less stringent contribution requirements results in a trade-off between the institution size and the implementation rate, but no significant effect on efficiency.

2. Theoretical Predictions

Our experimental design is based on a simple linear public-goods game in which a group of $n(\geq 2)$ participants are required to decide individually how much to contribute to a public good and how much to keep for themselves from an initial endowment of $w(>0)$ monetary units[5].

Given the complete list of contributions $(g_1, g_2, \cdots, g_n)$, participant i's monetary payoff can be written as

$$\pi_i(g_1, \cdots, g_n) = w - g_i + a \sum_{j=1}^{n} g_j, \tag{1}$$

where a is the marginal per capita return (MPCR) from contributing to the public good. Note that whenever $a < 1$, contributing zero to the public good is a dominant strategy for each participant. In addition, as long as $\frac{1}{n} < a$, the group would do better if everybody contributed the entire initial endowment. In other words, for $\frac{1}{n} < a < 1$, the above game has a unique Nash equilibrium in dominant strategies where each participant contributes zero, while the welfare-maximising strategy profile is when everybody contributes the entire initial endowment.

The public-goods game with institution formation is a multi-stage game based on the previously described game. Players first express their willingness to form an institution that later in the contribution stage will enforce the jointly-determined contribution level on the institution's members.

- *Participation stage*: Players simultaneously and independently announce whether they are willing to join an institution which, in the last stage, is going to force its members to make a certain level of contribution (to be determined in the second stage). Players who choose to join are called members; those who choose not to join are called non-members.
- *Implementation stage*: Members are informed about the total number of members, and they are asked to vote simultaneously in order to decide the contribution level that the institution is going to enforce in the final stage. Note that members will not be allowed to deviate (positively or negatively) from the chosen contribution level. There are three possibilities to be considered in the institution:

  1. Project 0: the institution is dissolved,
  2. Project $\frac{1}{2}$: each member contributes half of the initial endowments[6], and
  3. Project 1: each member contributes the entire initial endowment.

  The decision in the institution is based on the plurality rule; the project that receives the most votes is implemented. All members must comply with the decision, which in the case of projects $\frac{1}{2}$ and 1 is costly. Costs are shared equally among the members of the institution.
- *Contribution stage*: If the institution is not dissolved in the implementation stage, all its members must make a contribution according to the chosen project. Non-members, after being informed

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5 Our experimental design incorporates repetition of the here-described game for a fixed number of times, which was announced to participants in the experimental instructions right at the beginning of each session. Although we do not explore the large set of equilibria of the supergame created by these repetitions, we do know that the supergame has a subgame-pefect Nash equilibrium in which players play according to the equilibrium of the analysed stage game in each repetition. It is also important to note that, in line with standard practice and the experimental design used by Kosfeld et al. [6], players in the experiment received information about their own payoffs after each and every repetition, but did not learn which strategy did exactly the other players play and how much they earned. Although groups were fixed, identities were completely hidden. This (usual) design feature creates a game that is practically impossible to analyze in the standard repeated-game framework.

6 Albeit theoretically rather irrelevant, Project $\frac{1}{2}$ is part of our design for behavioral reasons. Experiments on linear public-goods game tend to deliver robust findings: participants initially contribute a substantial part (around 40–60% on average) of the initial endowment to the public good, then as the interaction is repeated contribution levels fall and approach zero. With only two extreme options (contributing nothing and contributing everything) available, it might be too difficult to achieve cooperation for Project 1, being too risky of an investment.

of the size of the institution, decide individually how much to contribute to the public good. If the institution is not implemented (i.e., it is dissolved), all players decide their contribution individually and simultaneously.

Note that this game is essentially identical to the one introduced and studied by Kosfeld et al. [6]. The only difference is that, in our design, participants use the plurality rule (instead of unanimity) to reach a decision in the institution, and they choose from three projects. In addition, the game-theoretical analysis presented below follows closely the one by Kosfeld et al. [6]. Our main theoretical result is that the choice of the voting rule (unanimity versus plurality) does not matter in terms of institutional equilibrium outcomes, as long as players do not play dominated strategies.

In order to write player i's final payoff π_i, let S be the set of players who are members of the institution, s the size of the institution ($s = |S|$), and $c \geq 0$, the cost of enforcing project $\frac{1}{2}$ or project 1. If project 0 is chosen, we say that the institution is not implemented and consider S to be empty, so $s = 0$.

If $S \neq \emptyset$ (i.e., the institution is implemented), then player i's payoff is given by

$$\pi_i = \begin{cases} w - g_i + a\sum_{j=1}^{n} g_j - \frac{c}{s}, & \text{if } i \in S, \\ w - g_i + a\sum_{j=1}^{n} g_j, & \text{if } i \notin S. \end{cases} \tag{2}$$

Note that, by joining the institution, members commit to complying with the decision made collectively in the institution. Members' contribution level is determined by the chosen project, while non-members' is determined individually outside the institution.

If $S = \emptyset$ (i.e., the institution is not implemented), then player i's payoff is given by

$$\pi_i = w - g_i + a\sum_{j=1}^{n} g_j, \tag{3}$$

where all contribution levels are determined individually.

Following the idea of backward induction, let us consider the subgames that start in the contribution stage. Zero contribution is optimal for each player in the contribution stage if no institution is implemented (this subgame is identical to the public-goods games analyzed at the beginning of this section). If the institution is implemented, members do not make decisions in the final stage, their contribution level is determined in the previous stage by the vote, while it is still optimal for non-members to contribute zero.

A key insight of this model is that, although players individually have incentives to free ride in the public-goods game that appear in the final stage, they could increase both joint and individual payoffs by coordinating their contributions through an institution. In equilibrium, members earn $asw - \frac{c}{s}$ if the institution is implemented and project 1 is chosen, and $\frac{1}{2}asw - \frac{c}{s}$ if project $\frac{1}{2}$ is chosen. Given the incentives to free ride in the contribution stage, everybody earns w if the institution is not implemented. Note that voting for project $\frac{1}{2}$ is a weakly dominated strategy for all members (dominated by voting for 1).

Kosfeld et al. [6] consider institutions that make their decisions based on unanimity, which implies that each member's vote is pivotal. The use of the plurality rule instead of the unanimity rule increases the set of equilibria of the game because the change of a single member's vote will not always affect the collective decision inside the institution when the plurality rule is used (e.g., when all the others vote for the same project). In what follows, we are going to consider equilibria in weakly undominated strategies. This implies that members are going to vote for project 1 as long as the number of members s is such that

$$asw - \frac{c}{s} \geq w. \tag{4}$$

Solving for s gives the minimum institution size s^* for members in the implementation stage to vote for project 1 rather than project 0 to dissolve the institution.

Kosfeld et al. [6] show that, for any number of members s, there exists a status-quo equilibrium in which no institution is implemented because of the strong status-quo (i.e., project 0) bias of the unanimity rule. Although the plurality rule is less biased towards the status quo, when all (and at least three) members vote for project 0, a single deviation cannot change the outcome. Therefore, a similar no-institution equilibrium also exists in our game.

More importantly, there exist organisational equilibria in which an institution is implemented when $s \geq s^*$. Kosfeld et al. [6] also show that the institution-formation game has a unique strict subgame-perfect equilibrium in terms of the institution size. The strictness of the equilibrium requires that player play a unique best-response strategy in the equilibrium; players should be strictly worse off by deviating from the equilibrium strategy. In such an equilibrium, exactly s^* players become members of the institution[7].

In summary, by focusing on subgame-perfect Nash equilibria that are strict in the participation stage and do not include dominated strategies in the implementation stage, we expect that institutions of s^* will be implemented and that members will be required to contribute their entire initial endowment, while non-members will contribute nothing.

3. Experimental Procedure

As discussed in the previous section, the core of our experimental study is a linear public-goods game with institution formation adopted from Kosfeld et al. [6]. In the baseline game (hereafter referred to as the PLU3 game), ten participants ($n = 10$) with initial endowments of 20 points ($w = 20$) played the public-goods game with voluntary institution formation and used the plurality rule to choose one among the three available public projects inside the institution[8]. Participants were informed about the number of people who decided to join the institution (which had a total cost of 2, i.e., $c = 2$) in the participation stage.

In the implementation stage, members of the institution[9] had to decide whether to dissolve the institution and not force its members to contribute anything to the public good (Project 0), or force all members to contribute exactly half of their initial endowment (Project $\frac{1}{2}$: 10 points), or force all members to contribute their entire initial endowment to the public good (Project 1: 20 points). Participants did not incur the cost of forming the institution if Project 0 was chosen.

Participants who had not joined the institution did not make any decisions at the implementation stage and were not informed about the decision reached by the members of the institution either, although they were informed about the size of the implemented institution. They (and also including those who joined the institution but Project 0 was selected) were required to decide how much to contribute to the public goods in the final, contribution stage. The MPCR from contributing to the public good was set to 0.4 ($a = 0.4$). Note that, given these parameter values, the minimal institution size for an organisational equilibrium, i.e., for members to vote for implementation (rather than dissolution), is $s^* = 3$.

In order to investigate the effect of institution formation and different voting rules on subjects' behavior in the public-goods game, we conducted a total of twelve sessions of nine treatments involving variations of the above PLU3 game.

To make sure that our database allows for some comparison with existing results in the literature, we include the following games:

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7 As long as $s - 1 \geq s^*$, there will exist a player in S who can choose not to join the institution and free ride instead. Thus, in equilibrium, only institutions of size equal to s^* will be implemented.

8 In case of a tie, a project was randomly chosen from those that got the most votes.

9 At least two participants who chose to join the institution were required to bring the game into the implementation stage. If less than two participants chose to join, all participants would go to the contribution stage simultaneously.

- Game VCM, which is the classic public-goods game with voluntary contribution mechanism, establishes a baseline for the efficiency level with a relatively large group of ten people and an MPCR of 0.4. Institution formation is not allowed in game VCM.
- Game UNA2 replicates the Kosfeld et al. [6] design and allows for institution formation, with a group size of 10 people (instead of 4).
- Game PLU2 is identical to the UNA2 game except that members of the institutions vote under the plurality rule (i.e., the majority rule since there are only two available projects).
- Game UNA3 is identical to the UNA2 game except that Project $\frac{1}{2}$ becomes available to the members of the institutions.
- Game PLU3, which is our main game, is identical to the UNA3 game except that members of the institutions vote under the plurality rule.
- Game PLU3SUB is a subgame of the PLU3 game, where all participants are exogenously forced to join the institution at the participation stage of the game. The rest of the game is as in the original PLU3 game.

Table 1 gives a summary of all the games. At the beginning of each session, subjects were randomly divided into groups of ten. Like in the experiment reported by Kosfeld et al. [6], our participants played 20 rounds of each game with the same group of players (partner matching). The games and their order varied across experimental treatments in order to control for possible order and experience effects. Table 2 offers an overview of how the above-described games were arranged into our nine treatments.

Table 1. Games summary.

	VCM	PLU2	PLU3	PLU3SUB	UNA2	UNA3
NUM. OF PROJECTS	-	2	3	3	2	3
VOTING RULE	-	PLU	PLU	PLU	UNA	UNA
NUM. OF GROUPS	3	6	14	8	7	7
NUM. OF OBS. (INEXP)	60	80	120	80	60	140
NUM. OF OBS. (EXP)	-	40	160	80	80	-

Note: PLU: plurality rule; UNA: unanimity rule.

Table 2. Treatments summary.

	PLU3	PLU3RS	PLU3SUB	PLU2	PLU2RS	UNA	UNA2	UNA3	VCM
NUM. OF SESSIONS	1	2	2	1	1	2	1	1	1
GAMES	PLU3	PLU3 PLU3	PLU3SUB PLU3SUB PLU3	PLU2	PLU2 PLU2	UNA3 UNA2	UNA2	UNA3	VCM
NUM. OF PARTICIPANTS	20	20	20	20	20	20	30	30	30
NUM. OF GROUPS	2	2	2	2	2	2	3	3	3
NUM. OF ROUNDS	20	2×20	3×20	20	2×20	2×20	20	20	20
NUM. OF PLU3 OBS.	40	80	40	-	-	-	-	-	-

- In treatment PLU3, participants played the PLU3 game in fixed groups for 20 rounds.
- In treatment PLU3RS, participants first played the PLU3 game in fixed groups for 20 rounds. Then, in newly assigned groups, they played another 20 rounds of the PLU3 game.
- In treatment PLU3SUB, participants first played the subgame PLU3SUB for 40 rounds (in fixed groups for two sequences of 20 rounds). After round 40, participants were reassigned to groups and played the PLU3 game for another 20 rounds.
- The structure of treatments PLU2 and PLU2RS are similar to that of treatments PLU3 and PLU3RS, respectively, with the game PLU3 replaced by game PLU2.
- Treatment UNA consisted of two games. Participants played in fixed groups 20 rounds of the UNA3 game and, in reassigned fixed groups, another 20 rounds of the UNA2 game.
- Treatments UNA2, UNA3 and VCM are single-game treatments and each contains the game UNA2, UNA3, and VCM, respectively.

The experiment was computerised with zTree [19] and participants were not allowed to communicate with each other[10]. All the experiments were run at the experimental laboratory at Waseda University (Tokyo, Japan). In total, 270 subjects participated in our experiment. No one was allowed to participate in more than one session. On average, sessions lasted around 90 min. Individual earnings accumulated during the experiments were converted to Japanese yen at the rate of 2 points to 1 yen, and participants earned around 1700 JPY (about $17 including show-up fee). Participants were paid individually and privately at the end of the session.

4. Experimental Results

This section presents the results from the statistical data analysis of our experimental data. Before the detailed explanation through the subsequent subsections, we summarize the main findings in the list below:

- As compared to the unanimity rule, the plurality rule significantly decreases the initiation rate, but, at the same time, it also significantly increases the implementation rate. The two effects cancel each other out, which results in the change of the voting rule having no significant effect on contribution levels or efficiency.
- The odds of successful implementation of the institution are closely and positively related to the size of the initiated institution and how that compares to the theoretical threshold for efficient institution formation.
- In sharp contrast to findings presented by Kosfeld et al. [6], the grand coalition in not likely to form when groups are large.
- The theoretically irrelevant Project $\frac{1}{2}$ is popular among inexperienced participants under the plurality rule when the initiated institution is small.

In the data analysis, we focus on the PLU3 game, i.e., the public-goods game with voluntary institution formation under the plurality voting rule with three available projects, but we also report results for all other games. The statements and results are based on parametric statistical tests and are significant at least at 5% significance level, unless stated otherwise.

We refer to behavior in the initial 20 rounds of a session as inexperienced play, and to behaviour for any other rounds as experienced play even if the experience that participants gained differed in some cases[11].

Given that statistical tests (both parametric and non-parametric, e.g., Wilcoxon-Mann-Whitney test) find some significant differences between experienced and inexperienced play in terms of contribution levels, we are not only going to present statistical results for the entire database, but also for the two subsets separately, even if the size of the detected differences is not always very large. Moreover, after descriptive statistics and two-by-two comparisons, we use regression analysis in order to control for possible order and learning effects.

Tables 3 and 4 offer a detailed descriptive summary of our experimental results. It also shows the main findings from related works in the literature for comparison. In the second panel on initiation rates, in line with prior evidence, overall initiation rates are close to 100% in all treatments with some fluctuations and variations between initial (first five rounds) and final play (last five rounds) in the treatments based on the plurality rule[12]. Tables A1 and A2 in the appendix complement the statistical results with summary statistics on the first 5 and last 5 rounds separately.

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[10] A sample of the instructions that were used in the experiment is in Appendix B. Full instructions and zTree codes are available upon request from the authors.

[11] There is no statistically significant difference in terms of contribution and participation (in the institution) between the two kinds of experience. The Wilcoxon–Mann–Whitney tests for equal contributions and equal number of people joining the institution in the experienced PLU3 game from the two treatments yield $p = 0.3523$ and $p = 0.6314$, respectively. See Appendix A for detailed analysis on the effect of experience.

[12] The initiation rate is the proportion of groups (throughout the 20 rounds among all groups) in which at least one participant decides to join the institution in the first stage of the game.

Table 3. Summary of experimental results (part 1).

	PLU3 POOLED	PLU3 INEXP.	PLU3 EXP.	PLU2 POOLED	PLU2 INEXP.	PLU2 EXP.	UNA2 POOLED
NUM. OF OBSERVATIONS	280	120	160	120	80	40	140
GROUP SIZE	10	10	10	10	10	10	10
MPCR	0.4	0.4	0.4	0.4	0.4	0.4	0.4
NUM. OF PROJECTS	3	3	3	2	2	2	2
VOTING RULE	PLU	PLU	PLU	PLU	PLU	PLU	UNA
INITIATION RATE (%)							
AVERAGE	97	94	99	97	95	100	100
IMPLEMENATION RATE (%)							
AVERAGE	62	63	61	62	63	60	49
INSTITUTION SIZE							
AVERAGE	4.2	4.0	4.3	3.8	3.9	3.8	5.2
MAXIMUM	8	6	8	7	7	5	8
CONTRIBUTION (% OF INIT. ENDOWMENT)							
AVERAGE	37	42	33	33	35	29	32
AVERAGE (IN)	92	87	95	100	100	100	100
AVERAGE (OUT)	19	28	12	13	15	8	9
EFFICIENCY (%)							
AVERAGE	37	42	33	32	34	29	32

Note: PLU2/3: all PLU2/3 games with or without experience; PLU2/3 inexp.: PLU2/3 games from the first 20 rounds in session PLU2/3RS; PLU2/3 exp.: PLU2/3 games from the last 20 rounds in sessions PLU2/3RS and PLU3SUB; KOR: results from treatment IF40 in Kosfeld et al. [6]; BK1 and BK2: results from Burger and Kolstad [18]. All variables are as defined in the main text.

The implementation rates are presented in the third panel of Tables 3 and 4[13]. From all the initiated institutions, on average, roughly 62% get established in all our treatment based on the plurality rule. Treatments that require unanimity for institution formation perform worse in terms of the implementation rate, although experienced play with two projects does not seem to differ much from the plurality-rule treatments. While an additional project does not have any significant effect on implementation rate under plurality rule, it does cause an adverse consequence under the unanimity rule. For being the lowest among all treatments, we highlight the UNA3 game where implementation rate is merely 10%. Just like in the other treatments, this rate experiences a significant and important drop if the first five periods are compared to the last five, but even during the initial round it is located (at 17%) well below the comparable rates from other treatments. We believe that the relatively large number of participants and a third available project made reaching a joint decision very difficult in our experiments, especially because communication was not allowed before the voting stage. Moreover, the joint decision-making turned out to be problematic when unanimity was required even with only two available projects[14]. We shall look into these results with the help of regression analysis later.

The average institution is composed by 3–4 members in treatments based on the plurality voting scheme and by 5+ in the treatments based on the unanimity rule (fourth panel of Tables 3 and 4). In some treatments (UNA2, UNA3, and PLU3 games), the institution size reached a remarkable maximum of eight members.

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13 The implementation rate is the proportion of groups (throughout the 20 rounds among all groups that initiated an institution) in which the members of the institution managed to choose (with the help of the imposed voting scheme) a project other than Project 0.

14 The implementation rate from inexperienced play under unanimity rule is significantly lower, at 30%, than that of any subgroup under plurality rule, while the rate springs up to 64% in the experienced play. Note that in the experienced play of UNA2 game, the subjects has the experience of 20 rounds of UNA3 game. The extremely low implementation rate and low efficiency level in UNA3 game seems to have a warning effect, which urges subjects to form institutions in order to avoid the disastrous outcome caused by miscoordination in a UNA3 game.

The fifth panel of Tables 3 and 4 describe contribution levels across treatments. The overall contribution levels to the public good are around 20–42% of the initial endowment. They are consistently very high (roughly 87–100%) inside the institution and very low (3–39%) with a decreasing trend outside the institution. Efficiency rates[15] across treatments show a very similar picture, with UNA3 being the least efficient game overall (last panel of Tables 3 and 4). Given that efficiency is measured with the help of group earnings and the cost of forming an institution is relatively low in our games, contribution levels and efficiency rates are very similar.

Table 4. Summary of experimental results (part 2).

	UNA2 INEXP.	UNA2 EXP.	UNA3	VCM	KOR	BK1	BK2
NUM. OF OBSERVATIONS	60	80	140	60	220	80	80
GROUP SIZE	10	10	10	10	4	10	10
MPCR	0.4	0.4	0.4	0.4	0.4	0.3	0.6
NUM. OF PROJECTS	2	2	3	-	2	2	2
VOTING RULE	UNA	UNA	UNA	-	UNA	PLU	PLU
INITIATION RATE (%)							
AVERAGE	100	100	100	-	100	-	-
IMPLEMENATION RATE (%)							
AVERAGE	30	64	10	-	43	-	-
INSTITUTION SIZE							
AVERAGE	5.1	5.2	4.6	-	3.9	3.5	5.1
MAXIMUM	6	8	8	-	4	6	7
CONTRIBUTION (% OF INIT. ENDOWMENT)							
AVERAGE	25	37	20	23	53	38	58
AVERAGE (IN)	100	100	100	-	-	-	-
AVERAGE (OUT)	12	6	16	-	-	-	-
EFFICIENCY (%)							
AVERAGE	22	37	21	26	51	-	-

Note: PLU2/3: all PLU2/3 games with or without experience; PLU2/3 inexp.: PLU2/3 games from the first 20 rounds in session PLU2/3RS; PLU2/3 exp.: PLU2/3 games from the last 20 rounds in sessions PLU2/3RS and PLU3SUB; KOR: results from treatment IF40 in Kosfeld et al. [6]; BK1 and BK2: results from Burger and Kolstad [18]. All variables are as defined in the main text.

4.1. *The Effect of the Voting Rule*

In order to analyse the impact of the voting rule on decisions in various stages of the game, we control for the effects of our treatment and other variables, such as experience, the number of available projects, the voting rule, etc. Table 5 reports odds-ratio estimates from logit models on institution-formation and implementation decisions in the first two stages of the game. It also reports coefficient estimates from a linear-regression model on group efficiency and individual contributions in the last stage of the game. Note that all regressions exclude observations from the PLU3SUB game and the VCM game[16]. In the case of implementation and group efficiency, observations are for groups, while, in all the other cases, they are for participants. This is why the number of observations differs radically in regression (3) and (4). Individual voting decisions will be analysed later in the text.

All the regressions that analyse individual decisions incorporate a large number of control variables. They have been created with the help of the answers participants gave in the post-experiment questionnaire. Most of the questions are related to demographics and attitude towards cooperation and

15 Following Kosfeld et al. [6], the efficiency rate is defined as $(\sum_i \pi_{observed} - \sum_i \pi_{min})/(\sum_i \pi_{max} - \sum_i \pi_{min})$, where $\sum_i \pi_{observed}$ denotes the observed group earnings, $\sum_i \pi_{min}$ is the theoretical minimum group earnings (200 in all our games), and $\sum_i \pi_{max}$ is the theoretical maximum group earnings (800 in all our games).

16 The reason for excluding observations on the PLU3SUB game is that its rules forced participants to join the institution. Similarly, given our interest in institution formation, we ignore the VCM game because its inclusion in the analysis would make a careful comparison between the two voting rules impossible. We would not be able to control in our regressions for the number of projects, the size of the institution, etc.

competition (refer to Appendix C for details and the complete list)[17]. The reported hypothesis tests are based on clustered standard errors because our observations stem from (groups of) participants who have interacted repeatedly with each other (Cameron and Miller [20]).

Table 5. Regression analysis of strategic behaviour (institution formation and contribution).

	(1)	(2)	(3)	(4)	(5)
	JOIN LOGIT, OR	JOIN LOGIT, OR	FORMED LOGIT, OR	EFFICIENCY OLS	CONTR. OLS
PERIOD	0.9907 *	0.9794 ***	0.9674 *	−0.8120 ***	−0.2148 ***
PLURALITY	0.3426 ***	0.6251 ***	16.7665 ***	2.9290	0.5199
EXPERIENCE	1.0042	0.9534	2.2301 **	−6.5263 ***	−1.7934 ***
NUM. OF PROJECTS	1.3114	1.1811 ***	0.3033 ***	3.2416 *	0.5756 *
JOIN (LAG1)		8.1853 ***			
JOIN (LAG2)		4.0763 ***			
EARNING (LAG1)		0.9824 ***			
EARNING (LAG2)		0.9909 ***			
NUM. JOINED			1.7533 ***		
INST.SIZE				8.1090 ***	0.4590 **
INST.SIZE^2				0.0098	−0.0134
INSIDE					7.8675 ***
PERIOD * INSIDE					0.2619 ***
EXPERIENCE * INSIDE					2.0226 ***
INST.SIZE * INSIDE					0.9517 *
INST.SIZE^2 * INSIDE					−0.0134
CONS.	5.0240 ***	1.1720	0.3737	15.9884 ***	4.0839 ***
CONTROLS	YES	YES	NO	NO	YES
R^2	0.0886	0.3887	0.2096	0.8185	0.6568
num. of obs.	6800	6120	680	680	6800
obs. units	SUBJECTS	SUBJECTS	GROUPS	GROUPS	SUBJECTS

Note: Coefficient significantly different from zero at *** 1%, ** 5%, * 10% significance level. Standard errors are clustered around subjects (regressions 1, 2, and 5) or groups (regressions 3 and 4). Estimated odds ratios are reported for the logit regressions. Observations from the PLU3SUB are excluded. JOIN: 1 if the participants decides to join the first stage, 0 otherwise; FORMED: 1 if the institution is formed, 0 otherwise; CONTR.: individual contribution level. PLURALITY: 1 if the plurality rule is applied, 0 when unanimity is required; EXPERIENCE: 1 during experienced play (second sequence of 20 rounds), 0 otherwise; NUM. JOINED: number of participants who join in the first stage; INSIDE: 1 if the participant is a member of the institution, 0 otherwise; INST.SIZE: size of the implemented institution. When indicated, we used answer to the post-experimental questionnaire as CONTROLS.

The odds ratios estimated for the PLURALITY dummy, which captures the effect of the voting rule changing from unanimity rule to plurality rule, are not only highly significant, but also important in their size. The use of the plurality rule reduces the odds of joining somewhere between a third and two thirds of the odds otherwise (regressions (1) and (2) in Table 5)[18]. At the same time, it also makes the odds of successfully forming an institution roughly 17 times larger (regression (3) in Table 5).

As compared to the unanimity rule studied by Kosfeld et al. [6], the plurality rule serves as a filtering device: only those who would strongly like to form an institution join in the first stage since

[17] Although participants were required to report their major to an open-ended question, we decided to use answers to the more specific questions about whether they studied Economics, Microeconomics, or Game Theory instead. In addition, due to problems of multicollinearity, we excluded the variable related to membership in associations (and student circles), given that all of the participants reported to be a member of at least one.

[18] The variable PLURALITY takes value 1 when the game uses the plurality voting rule and takes value 0 when the game uses the unanimity rule. To increase the interpretability of the results, we report odds ratios both in regressions (1) and (2). For that reason, numbers smaller than 1 indicate a negative effect of the regressor on the dependent variable, while numbers larger than 1 indicate a positive effect. The difference between the two logit regressions for joining decision is that the second includes some lagged variables among its regressors.

it is rather difficult to withdraw and abandon the institution later. The unanimity rule completely eliminates the risk involved in the first-stage decision because each participant has veto power when deciding the future of the institution. Kosfeld et al. [6] report 100% initiation rate, which is exactly what we observed in our UNA2 and UNA3 games. These results are consistent with the column-to-column average comparisons that we described above based on the numbers in Tables 3 and 4. It is still remarkable that the average initiation rate is at least 90% in all our games in spite of the risk of having to follow the majority even if one does not agree with its decision.

As for the end result, the use of the plurality voting rule does not generate a statistically significant improvement on realised group efficiency and individual contributions as compared to the unanimity rule. The negative impact of the plurality voting rule on the first-stage joining decisions is largely offset by its positive impact on successful institution formation (see regressions (4) and (5) in Table 5). The following subsections discuss the details of the observed joining, voting and contributing behaviour in order to disentangle the impact of our treatment variables (voting rule, number of projects, and experience).

4.2. Institution Formation

The numbers in Table 5 indicate a significant but rather small negative time trend in all decisions. In other words, over time on average, participants are less likely to join, institutions are less likely to be formed (the odds ratio is below 1 in the first three regressions) and contributions and efficiency are likely to decrease (refer to the PERIOD row in Table 5). We interpret these effects as the result of getting to know one's interacting partners and their behaviour better. This experience is different from the effect of learning the rules of the game better. The latter (captured by the EXPERIENCE regressor) does not seem to matter for the joining decision in the first stage, but it does make the implementation of the institution significantly more likely (it induces a twofold increase in the odds). It also reduces the contribution level significantly by roughly 1–2 points. This effect might look surprising at the first sight, but we believe it captures the sharp decrease in contribution outside the institution. In other words, it shows that experienced participants are more likely to play the dominant strategy outside the institution, which is not to contribute at all (also refer to the fourth panel of Tables 3 and 4).

The odds of successfully forming an institution are closely (significantly and in an important way) related to the number of participants who show their willingness to join in the first stage of the game (regression (3) in Table 5). On average, each extra member causes a twofold increase in those odds. For a more accurate picture, we have disaggregated the implementation rates according to institution size in Table 6. Recall that, in our experimental design, the minimum efficient institution size is three members, and it is technically impossible to form an institution with only one member.

In the PLU2 and PLU3 games, even inefficient institutions are getting implemented in around 50% of the cases. This relatively large rate, which is remarkably similar to the case for the minimum efficiency size ($s^* = 3$), might have been inflated by the random tie-breaking rule that would determine the fate of the institution if one member votes for while the other against its implementation. Among all the initiated institutions with two members (55 in the PLU3 games), only 11 are implemented such that neither of the members votes for Project 0, i.e., to dissolve the institution. This corresponds to an implementation rate of 20%. In the PLU2 game, a similar calculation delivers a much lower implementation rate of $2/26 \approx 8\%$.

Even if the implementation rate is far from the ideal (efficient) 100%, the most frequent institution size for both initiated and implemented institutions in the PLU2 and PLU3 games is three, which is exactly the minimum efficient size (Table 6). When the number of potential members is four or more, the implementation rate jumps above 70% and reaches a constant 100% if at least half of the group, i.e., five people, decides to join. The grand coalition of ten members was not formed in any of our treatments (or games).

Table 6. Relative frequency initiation and implementation, and implementation rate by institution size.

INST. SIZE	PLU3 POOLED			PLU3 INEXPERIENCED			PLU3 EXPERIENCED		
	INIT.	IMPL.	IMPL.%	INIT.	IMPL.	IMPL.%	INIT.	IMPL.	IMPL.%
0	3	0	0	6	0	0	1	0	0
1	10	0	0	13	0	0	8	0	0
2	20	15	45	17	15	55	22	15	40
3	26	23	53	26	24	55	27	23	51
4	17	22	77	15	21	83	18	22	72
5	11	18	100	14	24	100	8	14	100
6	9	16	100	9	15	100	9	16	100
7	4	6	100	-	-	-	6	10	100
8	0	1	100	-	-	-	1	1	100
TOTAL	100	100	60	100	100	59	100	100	60

INST. SIZE	PLU2 POOLED			PLU2 INEXPERIENCED			PLU2 EXPERIENCED		
	INIT.	IMPL.	IMPL.%	INIT.	IMPL.	IMPL.%	INIT.	IMPL.	IMPL.%
0	3	0	0	5	0	0	-	-	-
1	8	0	0	9	0	0	5	0	0
2	22	17	46	25	21	50	15	8	33
3	31	26	51	28	27	59	38	25	40
4	18	26	86	13	17	80	30	46	92
5	13	21	100	13	21	100	13	21	100
6	4	7	100	6	10	100	-	-	-
7	2	3	100	3	4	100	-	-	-
TOTAL	100	100	60	100	100	60	100	100	60

INST. SIZE	UNA2 POOLED			UNA2 INEXPERIENCED			UNA2 EXPERIENCED			UNA3		
	INIT.	IMPL.	IMPL.%	INIT.	IMPL.	IMPL.%	INIT.	IMPL.	IMPL.%	INIT.	IMPL.	IMPL.%
2	4	2	20	5	0	0	4	2	33	1	0	0
3	10	2	8	10	0	0	10	2	13	3	10	33
4	19	13	35	20	18	25	19	12	40	9	30	27
5	38	58	80	25	64	70	44	57	83	14	30	18
6	21	15	36	35	18	14	14	14	64	33	20	5
7	7	8	63	5	0	0	8	10	83	18	0	0
8	2	3	100	-	-	-	3	4	100	14	10	6
9	-	-	-	-	-	-	-	-	-	8	0	0
10	-	-	-	-	-	-	-	-	-	1	0	0
TOTAL	100	100	52	100	100	27	100	100	64	100	100	8

Note: PLU3: all PLU3 games with or without experience; PLU3 INEXP.: PLU3 games from the first 20 rounds in session PLU3RS; PLU3 exp.: PLU3 games from the last 20 rounds in sessions PLU3RS and PLU3SUB. INIT.: number of initiated institutions; IMPL.: number of implemented institutions; IMPL.%: implementation rate.

The largest institution both initiated and/or implemented has eight members in the PLU3 games and seven in the PLU2 games, which confirms our conjecture that when the group size is substantially larger than the minimum efficient size, it is unlikely for the grand coalition to form[19].

Exogenously determined membership (like in our PLU3SUB games) makes the institution formation almost always successful. However, it is worth noting that there are players (among the 10 participants) who persistently vote to dissolve the institution. In the presence of these participants, the unanimity rule would always result in the dissolution of the institution. The plurality rule is less responsive to individual votes and that is how participants managed to always achieve full efficiency in those games.

[19] This is in sharp contrast with the results reported by Kosfeld et al. [6] for a design where the group size is four and the minimum efficient size is three. They stress that "the majority (on average, around 75%) of the organisations implemented are grand organisations".

With the unanimity rule, implemented institutions tend to be larger, with 5 being the most frequent size. It is interesting that implementation rates under the unanimity rule do not increase monotonically with institution size.

Burger and Kolstad [18] used a large group size (10 as in our design), a lower MPCR of 0.3 and only two projects. They report an average institution size of 3.5, which is lower than our 4.2 in the PLU3 games. The PLU2 games have a lower average institution size of 3.8. We hypothesise that an additional project could have lured more subjects to participate in the first stage, leading to a higher average institution size. This is in line with our regression analysis results in Table 5 and the numbers reported in Table 6: the unanimity rule makes initiation easier but implementation more difficult; having three (instead of only two) available projects has a similar but somewhat less pronounced effect.

In the PLU3 game, at an individual level, 58 (21%) out of 280 participants never chose to join in the first stage, and another 88 (31%) participants chose to join five times or less[20]. In the PLU2 game, these proportions are $34/120 \approx 28\%$ and $30/120 = 25\%$, respectively. On the other hand, only 10 (4%) subjects chose to join all the time, and only 44 (16%) participants chose to join 15 times or more in the PLU3 game. In the PLU2 game, these ratios are $6/120 = 5\%$ and $16/120 \approx 13\%$, respectively.

In the games with unanimity rule (i.e., UNA2 and UNA3) 20 (17%) and 16 (13%) out of 120 always stayed out, and another 28 (23%) and eight (7%) participants chose to join five times or less, respectively. These proportions are not drastically different from the previously discussed ones. However, in the UNA2 and UNA3 games, many more participants decided to join almost all the time. Eighteen (15%) did so in all 20 rounds in each of the two games, and, in total, 46 (38%) and 66 (55%) participants chose to join 15 times or more, respectively.

4.3. Voting

Voting, from a game-theoretical point of view, constitutes a rather complicated coordination problem, especially in the case of the plurality rule with more than two projects. In all games, we expect participants to vote for Project 1 if and only if enough (i.e., $s \geq 3$) participants join the institution in the first stage. Even if Project $\frac{1}{2}$ is available in some game, it should never be voted for according to the previously discussed theoretical argument.

Table 7 presents the distribution of votes observed in our experiments according to the size of the initiated institution. The numbers confirm the regression results by showing that, after its initiation, institution formation is especially difficult when unanimity is required and when there are more projects.

It is worth noting that the theoretical threshold for efficient institution formation ($s^* = 3$) is barely enough for forming an institution even under the plurality rule. Inexperienced participants needed more than four members for at least half of them to vote for Project 1 as Project $\frac{1}{2}$ was particularly popular among them. In games based on the plurality rule, we observe that as the number of participants who join in the first stage increases, members feel more confident (or optimistic) about the prospects of an institution. Consequently, the vast majority vote for Project 1. Project $\frac{1}{2}$ is only popular among inexperienced participants and when the initiated institution is small. It could also be the case that participants do realise that the institution could be efficiently formed. However, they are reluctant to do so when too many participants have decided to stay out, making it very likely that those who stayed out are going to free ride on contributions forcefully extracted by the institution. Project $\frac{1}{2}$ might represent a compromise solution to these members' dilemma.

Interestingly, Project $\frac{1}{2}$ turns out to be popular, irrespective of institution size, whenever it is available under unanimity rule. In that case, theoretical efficiency is not enough as a coordination device when voters have to consider more than two projects.

[20] The above calculation considers the same person repeatedly if s/he participated in several 20-round sequences of the game.

A surprising result is that even in the PLU3SUB game, where all are forced to join the institution, not all participants vote for Project 1, which is the obvious optimal strategy. Although 77.75% of the votes went for Project 1 in those (sub)games, 19.75% went for Project 0 and 2.5% to Project $\frac{1}{2}$.

Table 7. Distribution of votes (%) among projects by institution size.

INST. SIZE	PLU3 POOLED			PLU3 INEXP.			PLU3 EXP.			PLU2 POOLED			PLU2 INEXP.		
	0	**$\frac{1}{2}$**	1	**0**	**$\frac{1}{2}$**	**1**	**0**	**$\frac{1}{2}$**	**1**	**0**	**$\frac{1}{2}$**	**1**	**0**	**$\frac{1}{2}$**	**1**
2	55	14	31	53	25	23	57	7	36	63	-	37	58	-	43
3	45	15	40	41	16	43	49	14	37	50	-	50	41	-	59
4	25	27	48	21	39	40	28	20	53	18	-	82	23	-	78
5	11	14	75	9	15	75	12	12	75	13	-	87	14	-	86
6	3	18	79	5	29	67	2	10	88	3	-	97	3	-	97
7	0	7	93	-	-	-	0	7	93	0	-	100	0	-	100
8	0	0	100	-	-	-	0	0	100	-	-	-	-	-	-
INST. SIZE	**PLU2 EXP.**			**UNA2 POOLED**			**UNA2 INEXP.**			**UNA2 EXP.**			**UNA3**		
	0	**$\frac{1}{2}$**	**1**	**0**	**$\frac{1}{2}$**	**1**	**0**	**$\frac{1}{2}$**	**1**	**0**	**$\frac{1}{2}$**	**1**	**0**	**$\frac{1}{2}$**	**1**
2	83	-	17	70	-	30	75	-	25	67	-	33	0	50	50
3	62	-	38	44	-	56	67	-	33	33	-	67	22	11	67
4	15	-	85	22	-	78	28	-	72	18	-	82	14	30	57
5	12	-	88	5	-	95	10	-	90	3	-	97	9	28	62
6	-	-	-	15	-	85	21	-	79	6	-	94	6	37	58
7	-	-	-	13	-	88	43	-	57	2	-	98	3	32	65
8	-	-	-	0	-	100	-	-	-	0	-	100	1	29	70
9	-	-	-	-	-	-	-	-	-	-	-	-	1	23	75
10	-	-	-	-	-	-	-	-	-	-	-	-	10	30	60

Note: PLU2/3: all PLU2/3 games with or without experience; PLU2/3 inexp.: PLU2/3 games from the first 20 rounds in session PLU2/3RS; PLU2/3 exp.: PLU2/3 games from the last 20 rounds in sessions PLU2/3RS and PLU3SUB.

4.4. Contributions and Efficiency

Efficiency in our games is tightly linked to individual contribution levels and successful (efficient) institution formation. We define efficiency as the proportion of the additional profit above the absolute minimum level that a group of participants achieve from the additional profit that they could have achieved.

The last two panels in Tables 3 and 4 reveal that the average contribution level is below half of the initial endowment in games with the plurality rule (approximately 29–42%); therefore, observed efficiency is also rather low (29–42%).

For a deeper analysis and comparison across treatments, we turn to the regression results in the last two columns of Table 5. Just like in the usual linear public-goods experiment (e.g., [21]), our regression reveals a significant, although not very steep, negative trend in contribution levels. Experience with a similar game or subgame reduces contributions more radically—roughly 1–2 points (out of 20 points of initial endowment) on average. This effect is similar to the restart effect discussed in other studies [22], given that experience here means having played the same or a very similar game with a different group of participants. Even if contribution levels decay with time, a restart usually sends them back to a relatively high level, which is typically below to the one at the previous starting level. Another interpretation, based on the coefficient estimates in the regression (5) of Table 5, is that experience makes game-theoretical incentives clearer. Therefore, participants outside the institution contribute less with experience (it is a dominant strategy for them to free ride after all), while experienced participants inside the institution contribute more with experience (as they realise that voting for Project 1 is the best strategy whenever the institution is large enough).

Interestingly, the voting rule has no significant effect on contributions or efficiency. Its influences on initiation and institution formation, with opposing signs as discussed before, entirely cancel each other out. It is important to underline, though, that contribution levels are significantly and remarkably higher inside the institution. If we look at regression (5) in Table 5 and add the constant and the coefficient of INSIDE, which measures the average difference in contribution levels between inside and outside the institution, we get 12 points. Without controlling for the size of the implemented institution, this already amounts to 60 percent of of the 20 points that were available to each participant in each period.

The effect of institution size differs inside and outside the institution, as shown by the four related coefficient estimates. Inside the institution, it is positive and significant (at 10% significance level); it is likely to be explained by the previously discussed voting and institution-formation behavior which converges toward the equilibrium Project 1 as the number of members in the institutions increases. Outside the institution, the institution size has a positive but much smaller impact. In other words, these results show that relatively small institutions generate a moderate yet significant positive externality on contribution levels outside their boundaries. We do not have a plausible explanation for this. The number of projects also seems to have a significant but rather small positive effect on contribution levels.

5. Conclusions

We studied experimentally a linear public-goods game with endogenous institution formation. Participants were asked to decide whether to join an institution before deciding on their contribution to the public good. Institution members were required to contribute the amount voted for by its members. While previous studies have shown that institution formation has a positive effect on the overall efficiency [6,18], our experimental design focuses on the effect of the voting rule used by the institution for collective decision-making. In the literature and numerous real-life situations, the unanimity rule is the most commonly used voting rule. However, following the breakdown of various international negotiations and increasing dispute in the European Union about the sluggishness of its decision-making process, the unanimity rule has been criticised for being too restrictive and therefore hinders cooperation. In our experimental design, we replaced the unanimity rule with a more flexible plurality rule and investigated its effects on institution initiation, institution formation and contribution levels.

Firstly, our observations show that the plurality rule significantly decreases the initiation rate, but, at the same time, also significantly increases the implementation rate of institutions. These two effects cancel each other out in the end. This suggests that the choice of the voting rule (unanimity or plurality/majority) does not matter for the average contribution level or efficiency.

Secondly, our experiment with an increased group size shows that the grand coalition, even if it would be an efficient outcome, does not form. This suggests that what matters for institution formation is whether the to-be-formed institution has enough potential members, as compared to the theoretically minimum efficient institution size. Whether that is closer or farther from the size of the grand coalition is of secondary importance. Interestingly, the theoretical minimum size is not enough to guarantee that an institution would be formed in the experimental laboratory.

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Appendix A. Additional Results

Appendix A.1. Experience

In sessions PLU3RS and PLU3SUB, participants were required to make various decisions before playing the PLU3 game in the final 20 rounds. In treatment PLU3RS, subjects played 20 rounds of the entire PLU3 game, and two sets (groups reshuffled after each set) of 20 rounds of a subgame in the treatment PLU3SUB. There is no statistically significant difference in terms of contribution and institution participation between the two kinds of experience. (The Wilcoxon–Mann–Whitney tests for equal contribution and equal number of people joining the institution in the experienced PLU3 game from the two treatments yield $p = 0.3523$ and $p = 0.6314$, respectively.) The average size of institutions formed by subjects with experience of the subgame is smaller than those with experience of game PLU3. In session PLU2RS, participants played two 20-round sequences of the PLU2 game. In session UNA, participants played 20 rounds of game UNA3 before playing 20 rounds of game UNA2 (c.f. Table 2).

Interestingly, experience has different effects on efficiency in UNA2 and PLU3 games. Experience increased the efficiency of una2 game, mainly due to the high implementation rate and relatively large institution size. In the end, the loss in efficiency due to the lower contribution outside institution caused by experience is more than offset by the gain from the establishment of a relatively large institution and the high contribution of its members.

Appendix A.2. Early vs. Late Rounds

The two tables below extend the information contained in Tables 3 and 4 in the main text by including summary statistics for the first 5 and last 5 rounds separately.

Table A1. Summary of experimental results (part 1).

	PLU3 POOLED	PLU3 INEXP.	PLU3 EXP.	PLU2 POOLED	PLU2 INEXP.	PLU2 EXP.	UNA2 POOLED
NUM. OF OBSERVATIONS	280	120	160	120	80	40	140
GROUP SIZE	10	10	10	10	10	10	10
MPCR	0.4	0.4	0.4	0.4	0.4	0.4	0.4
NUM. OF PROJECTS	3	3	3	2	2	2	2
VOTING RULE	PLU	PLU	PLU	PLU	PLU	PLU	UNA
INITIATION RATE (%)							
AVERAGE	97	94	99	97	95	100	100
AVERAGE (PERIODS 1–5)	97	100	95	90	85	100	100
AVERAGE (PERIODS 16–20)	94	87	100	100	100	100	100
IMPLEMENATION RATE (%)							
AVERAGE	62	63	61	62	63	60	49
AVERAGE (PERIODS 1–5)	69	70	68	67	65	70	60
AVERAGE (PERIODS 16–20)	53	54	53	53	55	50	46
INSTITUTION SIZE							
AVERAGE	4.2	4.0	4.3	3.8	3.9	3.8	5.2
MAXIMUM	8	6	8	7	7	5	8
AVERAGE (PERIODS 1–5)	4.4	4.0	4.7	4.4	4.3	4.6	5.5
MAXIMUM (PERIODS 1–5)	8	6	8	6	6	5	8
AVERAGE (PERIODS 16–20)	3.9	3.7	4.1	3.7	3.7	3.6	4.6
MAXIMUM (PERIODS 16–20)	7	6	7	7	7	4	7

Table A1. *Cont.*

	PLU3 POOLED	PLU3 INEXP.	PLU3 EXP.	PLU2 POOLED	PLU2 INEXP.	PLU2 EXP.	UNA2 POOLED
CONTRIBUTION (% OF INIT. ENDOWMENT)							
AVERAGE	37	42	33	33	35	29	32
AVERAGE (IN)	92	87	95	100	100	100	100
AVERAGE (OUT)	19	28	12	13	15	8	9
AVERAGE (PERIODS 1–5)	46	51	43	43	43	43	44
AVERAGE (IN, PERIODS 1–5)	90	80	97	100	100	100	100
AVERAGE (OUT, PERIODS 1–5)	28	39	19	22	25	16	17
AVERAGE (PERIODS 16–20)	28	31	26	25	25	25	24
AVERAGE (IN, PERIODS 16–20)	94	93	95	100	100	100	100
AVERAGE (OUT, PERIODS 16–20)	12	18	8	7	6	8	4
EFFICIENCY (%)							
AVERAGE	37	42	33	32	34	29	32
AVERAGE (PERIODS 1–5)	46	50	43	42	42	42	45
AVERAGE (PERIODS 16–20)	28	31	26	25	25	25	24

Note: PLU2/3: all PLU2/3 games with or without experience; PLU2/3 inexp.: PLU2/3 games from the first 20 rounds in session PLU2/3RS; PLU2/3 exp.: PLU2/3 games from the last 20 rounds in sessions PLU2/3RS and PLU3SUB; KOR: results from treatment IF40 in Kosfeldet al. [6]; BK1 and BK2: results from Burger and Kolstad [18]. All variables are as defined in the main text.

Table A2. Summary of experimental results (part 2).

	UNA2 INEXP.	UNA2 EXP.	UNA3	VCM	KOR	BK1	BK2
NUM. OF OBSERVATIONS	60	80	140	60	220	80	80
GROUP SIZE	10	10	10	10	4	10	10
MPCR	0.4	0.4	0.4	0.4	0.4	0.3	0.6
NUM. OF PROJECTS	2	2	3	-	2	2	2
VOTING RULE	UNA	UNA	UNA	-	UNA	PLU	PLU
INITIATION RATE (%)							
AVERAGE	100	100	100	-	100	-	-
AVERAGE (PERIODS 1–5)	100	100	100	-	100	-	-
AVERAGE (PERIODS 16–20)	100	100	100	-	100	-	-
IMPLEMENATION RATE (%)							
AVERAGE	30	64	10	-	43	-	-
AVERAGE (PERIODS 1–5)	33	80	17	-	-	-	-
AVERAGE (PERIODS 16–20)	27	60	9	-	-	-	-
INSTITUTION SIZE							
AVERAGE	5.1	5.2	4.6	-	3.9	3.5	5.1
MAXIMUM	6	8	8	-	4	6	7
AVERAGE (PERIODS 1–5)	4.6	5.8	5.0	-	-	-	-
MAXIMUM (PERIODS 1–5)	5	8	6	-	-	-	-
AVERAGE (PERIODS 16–20)	5	4.5	5.0	-	-	-	-
MAXIMUM (PERIODS 16–20)	6	7	8	-	-	-	-
CONTRIBUTION (% OF INIT. ENDOWMENT)							
AVERAGE	25	37	20	23	53	38	58
AVERAGE (IN)	100	100	100	-	-	-	-
AVERAGE (OUT)	12	6	16	-	-	-	-
AVERAGE (PERIODS 1–5)	37	50	36	37	-	-	-
AVERAGE (IN, PERIODS 1–5)	100	100	100	-	-	-	-
AVERAGE (OUT, PERIODS 1–5)	25	7	30	-	-	-	-
AVERAGE (PERIODS 16–20)	16	31	11	12	-	-	-
AVERAGE (IN, PERIODS 16–20)	100	100	100	-	-	-	-
AVERAGE (OUT, PERIODS 16–20)	3	5	7	-	-	-	-
EFFICIENCY (%)							
AVERAGE	22	37	21	26	51	-	-
AVERAGE (PERIODS 1–5)	34	50	39	38	-	-	-
AVERAGE (PERIODS 16–20)	11	30	10	15	-	-	-

Note: PLU2/3: all PLU2/3 games with or without experience; PLU2/3 inexp.: PLU2/3 games from the first 20 rounds in session PLU2/3RS; PLU2/3 exp.: PLU2/3 games from the last 20 rounds in sessions PLU2/3RS and PLU3SUB; KOR: results from treatment IF40 in Kosfeld et al. [6]; BK1 and BK2: results from Burger and Kolstad [18]. All variables are as defined in the main text.

Appendix B. Instructions: Treatment PLU3SUB

This section presents the English translation of the instructions that we used in the session in which participants played three sequences of two games, and the post-experimental questionnaire. In the first two sequences, the interaction started at the implementation stage (and the participation stage was automatised by forcing everyone into the institution). In the third sequence, the complete three-stage game was implemented as explained in the main text. Instructions for other sessions and the original Japanese versions are available upon request.

Appendix B.1. General Instructions

Welcome to our experiment!

You are about to participate in an experiment, which will help us to study decision-making and economic behaviour. In this experiment, we will first ask you to read the instructions which explain the rules. Then, you will be asked to make a series of decisions that will allow you to earn money. Your earnings will depend on the decisions you make and also on the decisions others make. During the experiment, your earnings are counted in points. At the end of the experiment, your earnings in points will be exchanged into Japanese yen at a rate of

2 Points = 1 JPY.

We will pay you at the end of the experiment in cash. Your identity, decisions and earnings will be kept strictly anonymous and confidential.

It is important that you remain silent and do not look at other people's work. If you have any questions or need assistance of any kind, please raise your hand, and an experimenter will come to you. If you talk, exclaim out loud, etc., you will be asked to leave and you will forfeit your earnings.

There are 20 people participating in today's experiment. You will later be divided into two groups of 10 people. The experiment is divided into three sections. Each section consists of 20 rounds. You will interact with the same group of people in one section, but after each section, the members in your group will be changed. Other members of your group will face the same situation as yours. You will receive detailed instructions at the beginning of each section.

Appendix B.2. Instructions for Section I and II

In each round, you will receive 20 points, and you will be required to decide how many of them to keep to yourself and how many to contribute to a public project.

We first explain how the contribution you make to the public project benefit you and other members of the group. Your earnings in each round is the sum of the money you keep for yourself and the benefit from the public project, minus a cost. Expressed with the help of aformula:

1. Earnings = points you keep + benefit from the project − cost.

The benefit from the public project is the same for each group member, and it is determined in the following way:

2. Benefit from the project = 0.4 ∗ (total contribution by group members).

Now, we explain how the value of cost is determined. The cost is of either 0 or 0.2 points, depending on the situation the group is facing. At the beginning of the game, you are automatically in an institution with all the other members of your group. The institution operates with a cost of 2 points that are shared by its 10 members. All members of this institution must vote in order to determine the level at which every member must contribute to the public project.

There are three options: "level 100%", "level 50%", and "level 0%". The option that gets the most votes will be chosen. In case of a tie, an option will be selected randomly among those that got the most votes. If "level 100%" is chosen, each member must contribute all 20 points and pay a cost of 0.2 points.

If "level 50%" is chosen, each member must contribute half of his/her points (that is 10 points) to the public project and pay a cost of 0.2 points. If "level 0%" is chosen, the institution will be dissolved, which means there is no cost to be paid and all the members will be asked to decide on their own how many points to contribute to the public project.

Remember that earnings are calculated in the same way for each member of the group. Thus, for each point you keep for yourself, you earn 1 point, but for each point you contribute to the project, each member of the group earns 0.4 points and the total earnings of the group increase by 4 points. Thus, your contribution to the project raises the earnings of everyone in the group. Other members' contribution increases your earnings in the same way. You earn 0.4 points for every extra point contributed to the public project by a members in the group.

You will receive information on your earnings at the end of each round.

Any questions? If you have a question during the experiment, please raise your hand.

Appendix B.3. Instructions for Section III

In each round, you will receive 20 points, and you will be required to decide how many of them to keep to yourself and how many to contribute to a public project.

Earnings are going to be calculated in the same way as in Section I and II. However, in this section, at the beginning of each round, you will have the opportunity to decide whether to join the institution or not. If you join the institution, you must contribute your points according to the option that is most voted by the members of the institution, and share the cost with the other members who also joined the institution like in Section I. If you stay out of the institution, you can decide on your own how much to contribute to the public project. After your decision, you will be informed about how many participants decided to join the institution. If there are less than 2 people who choose to join, the institution is not formed, which means no cost is to be paid and everyone in the group will decide on their own how much to contribute to the public project.

Any questions? If you have a question during the experiment, please raise your hand.

Appendix C. Post-Experimental Questionnaire

1. Age ______ Gender ______ Major ___________
2. Have you studied (or currently studying) Microeconomics?

   Yes No
3. Have you studied (or currently studying) Game Theory?

   Yes No
4. Have you studied (or currently studying) Economics?

   Yes No
5. Have you ever heard of the Prisoners' Dilemma?

   Yes No
6. Is your hometown located in any of the following major metropolitan areas? Tokyo, Nagoya, Osaka, Sapporo, Sendai, Yokohama, Kyoto, Kobe, Hiroshima, Fukuoka.

   Yes No
7. Do you live with your family?

   Yes No

8. Do you consider yourself a cooperative person?

   Yes No

9. Do you think that most people are usually cooperative?

   Yes No

10. What do you think is the most efficient way to achieve a social goal?

    Cooperation Competition

11. What was your goal in this experiment?

    Maximum payoff Maximum satisfaction Hurt the opponent Other

12. Which of the following kind of associations (student circles) are you a member of?

    Sports (excluding gym) Cultural (music, theater...) Environmental (Greenpeace...)
    Other (please specify) ___________

13. How often do you use social networking websites, such as Facebook, Mixi, Twitter?

    Many times a day Normally once a day Several times a month Almost never

14. Have you ever taken advantages of someone?

    Yes No

15. How much do you agree with the saying "good things happen to good people"?

    Strongly disagree Disagree Agree Strongly agree

16. How much do you agree with the saying "no pain, no gain"?

    Strongly disagree Disagree Agree Strongly agree

17. To what extent do you think your opinion matters to the society?

    Very much Just slightly Not at all

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