The Effects of Voting on the Formation of Coalitions to Provide Public Goods – Experimental Evidence

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Abstract

The provision of global public goods, such as climate protection, relies on voluntary contributions and international cooperation. Negotiations of an international agreement however are often cumbersome due to a high number of bargaining parties deciding unanimously on the provision level. This paper experimentally analyzes the willingness to cooperate when countries have the possibilities to form coalitions and to vote on a binding minimum provision level of the public good. Different voting systems are compared to a standard voluntary contribution mechanism. The experiment shows that the formation of coalitions generally provides only minor efficiency gains thereby supporting the rather pessimistic conclusions from the theory (Hoel 1992, Barrett 1994, Carraro and Siniscalco 1993). Changing the majority required to implement the minimum provision level does not significantly change overall efficiency but alters the coalition: while unanimity leads to relatively large coalitions with moderate effort levels, majority voting produces small coalitions with very high effort levels.

Keywords: public goods, coalition formation, cooperation, voting

JEL: C72, C92, D71, H41

1. Introduction

When countries got together in Copenhagen in December 2009 to negotiate a new international climate agreement, the delegates once again failed to find a meaningful way to address the challenge of providing the global public good greenhouse gas abatement. In addition to diverging interests and strong free-riding incentives, the high number of negotiating parties might have prevented countries to move forward. About 190 parties took part in the negotiations in Copenhagen.[1] Moreover, international agreements usually apply the unanimity rule which means that countries agree on the smallest common denominator. As a result, negotiations are tedious and their outcomes are fragile to agents who impede proceedings by proposing very low public good provision levels. There are different reasons why agents may try to impede negotiations. It is often the asymmetry in terms of responsibility and economic ability that makes cooperation difficult. Laboratory experiments show that even in case of symmetric agents, i.e. with the same payoff function, players propose low public good provision levels because they hope that others will coordinate on a high provision level in spite of the existence of freeriders (Dannenberg et al. 2010). Even if a subset of countries (coalition) bargains, negotiations may suffer from these problems. The Kyoto Protocol which envisages only small abatement obligations compared to business-as-usual may serve as an example (Böhringer and Vogt 2004).

An intuitive solution to this problem may be the implementation of a majority voting system. That is, countries do not decide unanimously but the majority determines the public good provision level. The implementation of a majority voting system covering *all* countries in order to provide a global public good, such as climate protection, is unfeasible due to the lack of enforcement mechanisms to ensure compliance by sovereign states. However, majority voting may be implemented in a coalition of willing countries. Thus, countries first decide whether or not to join a coalition. If and only if a country becomes a member, it is bound to accept the decision of the majority of coalition members. In fact, the Kyoto Protocol includes a qualified majority vote. In article 20 (3) it states that "*[i]f all efforts at consensus have been exhausted, and no agreement*

[1] http://unfccc.int/resource/docs/2009/cop15/eng/misc01p01.pdf accessed in March 2010.

reached, the amendment shall as a last resort be adopted by a three-fourths majority vote of the Parties present and voting at the meeting“. This rule however does not apply to the decision of the abatement target and burden sharing.

Forming a coalition of sovereign countries generally involves (at least) two challenges: on the one hand, the institutional arrangement needs to attract members to the coalition (*extensive margin*). On the other hand, any given coalition should be able to internalize the mutual benefits among its members, i.e. increase the provision of the public good (*intensive margin*). The introduction of a majority voting system may have impacts along both margins. It may increase the efforts of the coalition and at the same time reduce the incentives to join the coalition because each member runs the risk of being outvoted. In that case the outvoted country would have to contribute more to the public good than it has initially offered. In this paper, I experimentally analyze whether these effects occur and if so, which effect dominates. To this end, I consider three different voting rules, namely unanimity, qualified majority and simple majority, and compare the resulting provision levels of the public good with those achieved by a voluntary contribution mechanism and institutions where participation in negotiations of a minimum provision level is exogenous.

The experiment is based on a series of theoretical papers on coalition formation (Hoel 1992, Barrett 1994, Carraro and Siniscalco 1993) that were inspired by theories on cartel formation (d’Aspremont et al. 1983). These authors derive rather pessimistic predictions. As individual players (countries) have a strong incentive to freeride on the provision of public goods by others. Only a few countries are predicted to form a coalition. Consequently, no substantial efficiency gains compared to a voluntary contributions mechanism are predicted. Finus and Maus (2008) suggest that a coalition can attract more members by lowering the public good provision levels required from its members. That is, an institution that only partially internalizes the mutual benefits among its members, maybe acceptable to more players and thereby generate efficiency gains. This leads to a trade-off between the extensive and intensive margin, i.e. between the number of players agreeing to the institution and the degree to which they internalize their benefits and provide the public good.

There are only few experimental studies that analyze the formation of coalitions to provide public goods. They indicate that subjects often do not behave as predicted by the (standard) theory. McEvoy et al. (2008) experimentally evaluate the performance of coalitions in which members have the opportunity to violate their commitments and fund a third-party enforcer to maintain compliance. Contrary to theoretical predictions they find that member-financed enforcement decreases the average provision of the public good. Kosfeld et al. (2009) address endogenous institution formation with a sanctioning mechanism and show that agents are potentially able to voluntarily establish institutions that improve the provision of the public goods, but are less likely to do so if subsets of players attempt to freeride. Burger and Kolstad (2009) study the emergence of coalitions when agents have a discrete choice between contributing or not contributing to a public good and find that, contrary to theory, the coalition size increases when the public good benefits are higher. Dannenberg et al. (2010) study the formation of coalitions in which members negotiate the public good provision by agreeing on the smallest common denominator. They find that since coalition members do not fully internalize mutual benefits the coalition size is higher than predicted.

All coalition institutions covered in this paper involve an initial decision of players to join or abstain from the coalition. Each coalition member then can propose a minimum public good provision level. The institutions differ in which proposal becomes binding for all coalition members: First, the smallest suggested level is binding for all members (unanimity rule). This idea of players agreeing on the smallest common denominator closely follows many real world international agreements in which the player with the smallest proposal is pivotal and any country can voluntarily go beyond its obligations (Barrett 2003). Second, the level upon which three quarter of coalition members can agree by proposing this or a higher provision level becomes binding minimum for all members (qualified majority rule). Third, the level upon which more than half of coalition members can agree by proposing this or a higher provision level becomes binding minimum for all members (simple majority rule). This study is the first that experimentally analyses the effects of voting rules implemented inside coalitions to determine the coalitions' provision level of the public good. Walker et al. (2000) examine majority and unanimity rules in a symmetric, multi-stage common pool resource game.

Their participants propose rules how to allocate the common pool resource and anonymously vote on the proposed rules. The major finding is that both types of voting rules substantially increase efficiency relative to a baseline without voting. Since the participants do not vote on a threshold applying to all players but on proposals involving (different) individual appropriation rights, the distributional consequences of the majority and unanimity rules differ. Overall, adoption rates, efficiency and equity are higher with unanimity rule in comparison to majority rule.

The coalition institutions reviewed in this paper are compared with institutions that involve *all* players: First a standard voluntary contribution mechanism serves as control treatment. In addition, three institutions are considered in which *all* players are subject to negotiations about the minimum public good provision, i.e. participation is exogenous: a voluntary contribution mechanism combined with (i) unanimity; (ii) qualified majority vote; and (iii) simple majority vote. As the latter three institutions are obviously not applicable to solve global public good problems due to the lack of enforcement mechanisms, their purpose is merely to show the differences in effects of voting between endogenous and exogenous participation. All treatments consider a payoff structure that is linear in the total public good provision, but non-linear in the individual contributions. At the individual level, it reflects increasing marginal provision costs to the public good which may arise from budget constraints, i.e. decreasing marginal utility from numeraire consumption.

The experiment shows that compared to the standard voluntary contribution mechanism only minor efficiency gains occur from the formation of coalitions. The coalitions under the unanimity rule are relatively large and implement moderate effort levels. The coalitions with majority votes implement high effort levels, but they attract only few members. Hence, there is a trade-off between the extensive and intensive margin, i.e. between the number of players agreeing to the institution and the degree to which they internalize their benefits and provide the public good. The institutions which exogenously bring together *all* players to negotiate a minimum public good provision level perform much better. Here, the reduction of the majority required to determine the minimum provision level leads to substantial efficiency gains.

This paper is structured as follows: Section 2 provides a short overview of the coalition formation theory. The experimental design is presented in section 3. Section 4 reports the experimental results and section 5 finally concludes.

2. Theory and Predictions

An economy is considered that is populated by agents, $i = 1,...,n$, with utility functions of the form

$$u_i = y_i + \gamma Q \qquad (1)$$

where y_i is a numeraire, $Q = \sum_{j=1}^{n} q_j$ represents the total provision level of the public good, and γ denotes the (constant) marginal utility from the public good. Subjects can allocate their initial income w to personal consumption or public good provision with the budget constraint given by

$$y_i + q_i^2 \leq w \qquad (2)$$

The utility function given by (1) and (2) is standard in the coalition formation literature (Carraro and Siniscalco 1993, Barrett 1994). Throughout, interior solutions are assumed which require $w \geq n\gamma / 2$.

Coalition formation and voting rules

Individual utility maximization immediately yields the individual Nash provision level $q_i^{NE} = \gamma/2$ with the total contributions given by $Q^{NE} = n\gamma/2$. The Nash equilibrium involves dominant strategies such that each individual's actions do not depend on the provision levels chosen by the remaining players. The social optimum maximizes total payoff and is given by $q_i^{SO} = n\gamma/2$ and $Q^{SO} = n^2\gamma/2$.

The coalition institutions in this setting generally involve three stages: In the first stage, each subject decides about membership in the coalition. Let S be the set of players who are members of the coalition with $|S| = k$ and $1 \leq k \leq n$. In the second stage, coalition members negotiate the minimum public good provision of the coalition. Negotiations take the form that all coalition members anonymously vote on minimum provision levels, starting from the level that fully internalizes the mutual benefits of the coalition, $q_i^{\min} = k\gamma/2$, and decreasing until the required majority of members agrees with a certain provision level. This level, $q^{\min}$, then becomes binding minimum provision level for *all* coalition members. In the third stage, the individual public good provision is chosen. Non-members are free to choose their public good provision level. Due to the assumed linearity of the public good, their payoff-maximizing decision does not depend on the coalition efforts and is again given by $q_i^{NC} = \gamma/2$, i.e. they completely freeride on the coalition's effort. The choice of public good provision by the members of the coalition depends on the negotiations inside the coalition. Three different voting rules are considered, namely unanimity, three quarter majority, and simple majority.

In the experiment negotiations are implemented by requesting all coalition members to suggest a minimum public good provision level. After these minimum proposals $q_i^{\min}$ are received from all participating parties, the agreement will require all agents in the coalition to provide at least (i) the smallest suggested level $\min_{j\in S} q_j^{\min}$ (unanimity), (ii) the suggested level $q_j^{\min}$ upon which three quarter of members agree by proposing this or a higher minimum level (three quarter majority), or (iii) the suggested level $q_j^{\min}$ upon which more than half of members agree by proposing this or a higher minimum level (simple majority). In all three coalition treatments coalition members are bound to provide $q_i \geq q^{\min}$.

The individually payoff-maximizing provision level at this last stage is given by $q_i = \max\left[q^{\min}, \gamma/2\right]$. That is coalition members provide exactly the binding minimum as long as $q^{\min} \geq \gamma/2$. This implies that it is weakly dominant to suggest a minimum provision level of $q_i^{\min} = k\gamma/2$: this maximizes the payoff if other players in the coalition suggest $q_j^{\min} \geq k\gamma/2$, suggesting a smaller level would potentially lower the binding minimum and hence negatively affect all profits. However, there are other equilibria in weakly dominated strategies. In case of unanimity, any binding minimum $q^{\min} < k\gamma / 2$ is established as equilibrium if at least two players suggest that level while other players suggest a larger minimum. Changing the voting rule only changes the number of equilibria in weakly dominated strategies. For example, if only the simple majority is required to implement the binding minimum provision level inside the coalition, any binding minimum $q^{\min} < k\gamma / 2$ is established as equilibrium if at least $0.5k + 1$ players suggest that level while other players suggest a larger minimum. Any such equilibrium under the simple majority rule is also an equilibrium under the unanimity rule while equilibria under unanimity need not to be equilibria under simple majority. Hence, the unanimity rule generates more equilibria in weakly dominated strategies. In general, the larger the required majority the higher the number of weakly dominated equilibria.

This logic immediately implies that the minimum stage played for *all* players, i.e. in combination with a voluntary contribution mechanism, generates the efficient outcome in weakly dominant strategies.

Membership game

The decision about the provision level inside the coalition leads to specific incentives for agents to join the coalition. We can denote the total payoff to members of the coalition given a coalition size of k by $\prod^{C}(k)$, the payoffs to non-members by $\prod^{NC}(k)$. Using the terminology from the coalition formation literature, a coalition of size k is externally stable if no player outside the coalition has an incentive to join, i.e. if $\prod^{NC}(k) > \prod^{C}(k+1)$.[2] The coalition is internally stable if no member has an incentive to leave, i.e. if $\prod^{C}(k) \geq \prod^{NC}(k-1)$. The payoffs in the stage following the membership decision depend on whether the agents are able to fully internalize the mutual benefits of the coalition, i.e. whether they choose the weakly dominant strategy. Let us define an internalization ratio α with $0 \leq \alpha \leq 1$. That is, the individual provision level inside the coalition given coalition size k is $q_i^C(k,\alpha) = \alpha\gamma k / 2$. The effect of partial internalization

[2] It is assumed that a player would join the coalition if he or she is indifferent as this increases payoffs to all other agents.

has been studied by Finus and Maus (2008). Using the concept of internal and external stability it can easily be shown that a coalition that is internally and externally stable satisfies $k \leq \frac{2+\sqrt{3-2\alpha}}{\alpha}$ and $k+1 > \frac{2+\sqrt{3-2\alpha}}{\alpha}$.

For a coalition that fully internalizes mutual benefits ($\alpha = 1$), this implies that only 3 agents form the coalition ($k = 3$). Figure 1 shows how the predicted size of stable coalitions depends on α. The decreasing relation corresponds to a trade-off between intensive and extensive margins: For example, coalitions of $k = 6$ players could be stabilized for $\alpha = 0.5$ while only 3 players form a coalition when external benefits are fully internalized. The increased coalition size can thereby also generate efficiency gains, i.e. increases in total payoff to all agents and in the payoff to the average coalition member. The example of $k = 6$ and $\alpha = 0.5$ illustrates this result: compared to the $k = 3$ solution when $\alpha = 1$, the same total provision level results while the provision efforts are being distributed across more players. Due to the increasing marginal provision costs, gains in total payoffs result.

Since the weakly dominant strategy in the stage following the membership decision involves full internalization of mutual benefits, the only subgame perfect equilibrium in weakly dominant strategies implies $k = 3$. However, it is not clear that the coalition members will choose the weakly dominant strategy in the minimum stage. Therefore, less than full internalization could result. Consequently any coalition size could be stabilized in a subgame perfect equilibrium. For example, the grand coalition would stable if it allowed all agents to coordinate on the full internalization, while in all subcoalitions coordination failed and players contributed at the Nash level. This generally applies to all voting systems. However, the majority votes, the way they are implemented in this setting, are expected to produce higher internalization levels than unanimity because low minimum proposals are outvoted. Therefore, if majority voting leads to full internalization the coalition size in these treatments should approach $k = 3$.

3. Experimental Design

The experiment was designed to investigate the effects of different voting schemes on coalition formation and public good provision. All treatments involved a ten-person public good game. The payoff function for each player was given by $\pi_i = -q_i^2 + \gamma Q = -q_i^2 + \gamma \sum_{j=1}^{n} q_j$ with $\gamma = 10$, $n = 10$, $q_i \in [0,...,100]$ and was common knowledge.

The traditional voluntary contribution mechanism (*"VCM"*) served as a control treatment which only contained the contribution stage. Three coalition formation treatments involved three stages: they introduced a first membership stage in which subjects decided on participating in a coalition. Decisions to join or abstain from a coalition were made simultaneously and independently. In the second stage, after being told the number coalition members, all members negotiated of the minimum amount that each member should contribute to the public good (minimum stage). Negotiations took the form that all participants simultaneously and independently proposed a minimum amount between 0 and 100. In the treatment called *"COALmin"* the smallest proposed amount became the binding lower limit for the contributions of all coalition members. In the treatment *"COALqual_maj"* the proposed amount upon which three quarter of coalition members could agree by suggesting this or a higher provision level became binding minimum. In the treatment called *"COALsimple_maj"* the proposal upon which the simple majority of coalition members could agree by suggesting this or a higher amount became binding minimum. In all three coalition treatments, members were informed about all proposed minimum amounts (arranged in descending order). Non-members did not make any decision in this stage and were only informed about the coalition size. In the third stage, the contribution stage, members and non-members chose the amount of their contributions to the public good. While non-members could freely choose their contributions, members of the coalition were bound to provide at least the binding minimum.

Finally, three treatments were implemented in which *all* subjects took part in the negotiations about a minimum contribution. In these treatments, all players first simultaneously and independently proposed a minimum amount between 0 and 100. In the treatment called "*VCMmin*" the smallest proposed amount became the binding lower limit for the contributions of all players. In the treatment *"VCMqual_maj"* the proposed amount upon which three quarter of players could agree by suggesting this or a higher provision level became binding minimum. In the treatment called *"VCMsimple_maj"* the proposal upon which the simple majority of players could agree by suggesting this or a higher amount became binding minimum. In all three treatments, players were informed about all proposed minimum amounts (arranged in descending order). In the contribution stage, all players simultaneously and independently determined the amount of their contribution to the public good which had to be equal or greater than the binding minimum.[3]

Table 1 summarizes the key features of the experimental design and the number of participants in each session. The experiment was run in July and October 2009 at the MaxLab laboratory at the University of Magdeburg, Germany. In total, 700 students participated in the experiment, whereby 100 subjects took part in each treatment.

Twenty subjects took part in each session. Each subject was seated at linked computer terminals that were used to transmit all decision and payoff information (software Ztree, Fischbacher 2007). Once the individuals were seated and logged into the terminals, a set of instructions and a record sheet were handed out. Experimental instructions included several numerical examples and control questions in order to ensure that all subjects understood the game. The sessions each consisted of 12 rounds, the first two being practice. The subjects were instructed that the practice rounds would not affect earnings.

At the beginning of the experiment subjects were randomly assigned to groups of ten. The subjects were not aware of whom they were grouped with, but they did know that they remained within the same group of players throughout the rounds (partner matching). At the end of the experiment, one of the non-practice rounds was chosen at random as the round that would determine earnings. Sessions lasted between 60 and 90 minutes. On average, a subject earned €15.82 in the games. Additionally, all subjects received €1.00 as show-up fee.[4]

[3] The treatments *VCM*, *VCMmin*, and *COALmin* are also used in Dannenberg et al. (2010).
[4] Overall, 19 out of 700 subjects earned negative payoffs in the games. In these cases, payoffs were cut off at zero and the subjects only received the show-up fee.

4. Experimental Results

Decision on contribution levels

The results summary is crafted by pooling the data across all periods and reporting treatment differences in the first 5 periods and the last 5 periods. Table 2 provides mean contribution and payoff levels for each treatment and Figure 2 provides a graphical depiction of the data. The first panel presents the average contribution levels across treatments and the second reports the resulting average payoff levels. As can be seen from the table and figures, average contribution levels in the three coalition treatments – *COALmin*, *COALqual_maj*, and *COALsimple_maj* – slightly exceed those in the standard *VCM*. The VCM games with minimum stage – *VCMmin*, *VCMqual_maj*, and *VCMsimple_maj* – clearly increase average contributions compared to the standard *VCM*. These differences are confirmed by a series of Mann-Whitney tests with the average contribution by one group across all periods taken as the unit of observation: *VCM* gives lower contributions than *VCMmin*, *VCMqual_maj*, and *VCMsimple_maj* (10%, 10%, and 1% significance respectively). *VCM* also performs worse than *COALmin*, *COALqual_maj*, and *COALsimple_maj* (10%, 10%, and 1% significance). Table 2 and Figure 2 indicate furthermore that reducing the majority required to implement the minimum provision level of the public good leads to considerable increases of average contributions in the VCM games with minimum stage while the increases in the coalition treatments are only moderate. Using Mann-Whitney tests confirm that *VCMsimple_maj* performs better than *VCMqual_maj* (1% significance) and *VCMqual_maj* performs better than *VCMmin* (1% significance). In contrast, there are no significant differences between *COALmin* and *COALqual_maj* as well as between *COALqual_maj* and *COALsimple_maj*. *COALsimple_maj* performs somewhat better than *COALmin* (10% significance). Identical comparisons follow for the average payoff, i.e. the efficiency level of the respective institutions. A series of linear regression models confirm these findings (see Tables 3 and 4). We can therefore formulate the following result:

> *Result 1: All institutions under review perform better than the standard voluntary contribution mechanism (VCM). Reducing the majority required*

to implement a minimum provision level of the public good leads to high efficiency gains when negotiations involve all agents. Efficiency gains are substantially smaller when the majority decision only applies to members of a coalition.

Figure 3 shows the development of average contribution levels for all treatments over time. The contributions in *VCM* are decreasing over time, they are smaller in the last 5 periods than in the initial 5 periods (see also Table 2). This downward trend which has been observed in many other experimental settings primarily for linear public goods is also observable for the three coalition treatments. In fact, when concentrating on the last period, we do not find significant differences in average contributions between *VCM* and the three coalition treatments. The contributions in the VCM games with minimum stage, in contrast, follow an upward trend. This suggests that predictions from the theory hold: the coalition formation structure provides only small benefits compared to the voluntary contribution mechanism while negotiations of minimum provision levels including all agents provide considerable efficiency gains.

Decision on membership and coalition effort levels

In the following, we will have a closer look at the three coalition treatments. Figure 4 (left panel) shows the average contributions of coalition members compared to contributions of non-members across coalition treatments. As expected, contributions of non-members are clearly lower than those of members. However, the incentives for non-members to freeride seem to decrease with higher effort levels of the coalition. The right panel in Figure 4 shows the differences in the coalition size across coalition treatments. While in *COALmin* on average half of all agents form a coalition (5.07), the number of members is significantly lower in *COALqual_maj* (3.68) and *COALsimple_maj* (3.56) (Mann Whitney test, 5% and 1% significance respectively). This finding is confirmed by a probit regression of the decision to join the coalition as presented in Table 5. Players in *COALmin* are more likely to join than in *COALqual_maj* or *COALsimple_maj*. The regression furthermore shows that agents are more likely to join when they already have been a member in the previous period and they are less likely to join when the coalition in the previous period has agreed on a high minimum provision level of the public good. The coalition size in the previous period does not significantly affect the membership decision and being outvoted in the previous period does not significantly reduce the incentive to join the coalition in the next period. Figure 5 shows the average coalition size over time. While the coalition size in *COALmin* is relatively stable at around 5, the number of members in the coalition treatments with majority decision converges towards 3 over time.

> *Result 2: The incentives to join the coalition are significantly smaller when the coalition decides by majority vote than by unanimity. Moreover a high binding minimum provision level of the public good reduces the incentives to join the coalition in the next round.*

We will now look at what level of public good provision the coalitions can agree upon. A sensible measure to assess the provision level in the coalition is the internalization ratio, i.e. the ratio of chosen provision effort of the coalition compared with the efficient level, $\sum_{i=S} q_i /(k^2\gamma/2)$. On average the ratio is given by 83% for *COALmin*, 132% for *COALqual_maj*, and 167% for *COALsimple_maj* as illustrated in Figure 6. Interestingly, while members in *COALmin* do not fully internalize their mutual benefits, members in the two coalition treatments with majority decision overinternalize mutual benefits, i.e. they internalize in part also benefits of non-members. The internalization ratio depends on the size of the coalition. Figure 7 shows that in all three treatments the ratio based on the coalition's provision level are decreasing in the coalition size k. We can furthermore compare the actual internalization ratios with the internalization ratio needed to stabilize a given coalition size as derived in section 2 (black line in Figure 7, see also Figure 1). The internalization ratios in *COALmin* closely follow these stabilization levels so that each coalition size on average is stable. In the coalition treatments with majority decision, the internalization ratios always exceed the stabilization levels; they converge 100% with increasing coalition size (see Figure 7). Thus, no coalition size is stable.

> *Result 3: Majority voting changes the type of the coalition: While unanimity leads to relatively large coalitions with moderate effort levels, majority votes produce small coalitions with very high effort levels.*

Decision on minimum levels

The decision on the binding minimum level is particularly important since agents' provision levels of the public good are (as predicted) highly sensitive to the required minimum. In fact, 80% of contribution decisions in the VCM treatments with minimum stage and also 80% of coalition members' decisions on contributions in the coalition treatments are exactly at the minimum level. It is therefore evident that those players whose suggestions form the binding minimum have a large impact on the total provision level of the public good.

A distinct prediction from the theory described above is that agents in both the VCM treatments with minimum stage and the coalition treatments have a weakly dominant strategy to suggest the minimum which fully internalizes mutual benefits. We have already seen that this full internalization depends on the voting rule and whether negotiations involve all players or a subset of players. We therefore finally address the question how agents choose their minimum suggestions. Table 6 presents the results of a linear regression of the efficiency levels of individual minimum proposals. For the VCM treatments with minimum stage a variable "eff_qimin" is defined which reflects how far a player's suggestion internalizes mutual benefits. For the coalition treatments, the variable "eff_qimin_coal" reflects how far coalition members' suggestions internalize mutual benefits of the coalition. In both the VCM treatments with minimum stage and the coalition treatments the efficiency is higher for subjects who already have submitted larger proposals in the previous period. In the VCM treatments with minimum stage the efficiency of the individual minimum proposals increases over time. Thus, subjects learn from experience to propose minimum levels that increase efficiency. In the coalition treatments the efficiency decreases with larger coalitions. The introduction of majority voting does not significantly affect the efficiency of minimum suggestions compared to unanimity. Hence, majority voting does not change individual minimum suggestions but merely the outcome of the negotiations.

Result 4: Independently of whether negotiations involve all or only a subset of players the voting rule does not affect the individual minimum proposals but merely the outcome of the negotiations.

5. Conclusions

One major obstacle for the international community to find an effective and meaningful way to address climate change may be the high number of bargaining parties, particularly when they have to decide unanimously on the abatement target and burden sharing. Even if a subgroup of countries bargains, the unanimity rule may render negotiations tedious. An intuitive solution to this problem is the implementation of a majority voting system. That is, countries can decide whether or not to join a coalition. If and only if a country becomes a member, it is bound to accept the decision of the majority of coalition members. This may lead to more efficient negotiations and higher effort levels of the coalition, but at the same time, reduce the number of countries willing to join the coalition because each member runs the risk of being outvoted.

In this paper, I experimentally analyze whether these effects occur and if so, which effect dominates. To this end, I consider three different voting systems, namely unanimity, qualified majority and simple majority and compare the resulting provision levels of the public good with those achieved by a standard voluntary contribution mechanism and voting systems that apply to *all* players. The experiment shows that compared to the standard voluntary contribution mechanism only minor efficiency gains occur from the formation of coalitions thereby supporting the rather pessimistic conclusions from the theory. While the coalitions under unanimity are relatively large with moderate effort levels, majority voting leads to small coalitions with very high effort levels. Hence, there is a trade-off between the number of players agreeing to the institution and the degree to which they internalize benefits and provide the public good. The institutions which exogenously bring together *all* players to negotiate a minimum public good provision level perform much better. Here, the reduction of the majority required to determine the minimum provision level leads to substantial efficiency gains.

Why do the majority votes provide efficiency gains when all players are involved in negotiations but not when only a subgroup of countries negotiates? The qualified majority rule and the simple majority rule as they are implemented in this setting necessarily increase the binding minimum contribution level (or do not change it) compared to unanimity. Therefore, as long as *all* players have to comply with the minimum contribution and the minimum is equal or less than the socially optimal level, majority decisions increase the benefits of the group and *each* player (or do not change them). The reason for this is that most players exactly contribute the minimum provision level and do not go beyond. Therefore, the majority votes effectively remedy the sensitivity of the unanimity rule with respect to low minimum proposals. The experiment shows that this property is relevant even if agents are symmetric, i.e. have the same payoff function.

This is different when only a subgroup of countries negotiates. First, raising the binding minimum contribution level for coalition members increases the members' payoffs only until mutual benefits are fully internalized. After this point an increasing minimum level may raise the group payoff but reduces the member payoff. Since the unanimity rule already generates an internalization ratio of over 80%, the scope for efficiency gains inside the coalition due to majority votes is small. Second, higher internalization ratios reduce the incentives to join the coalition, in particular when they are above 100% as observed in this experiment. Therefore, efficiency gains through higher internalization ratios are negated by smaller coalitions. Third, the inequality manifested by the coalition structure between members and non-members combined with the members' risk of being outvoted may additionally reduce incentives to join the coalition when agents have some kind of fairness preferences (see e.g. Fehr and Schmidt, 1999 or Kosfeld et al., 2009).

The experimental results have implications for public policy. Forming clubs or coalitions to provide public goods provide only minor benefits compared to voluntary contributions from everybody. The introduction of majority voting is not advisable as it reduces the willingness to join the coalition. The terms of institutionalizing the provision requirements from coalition or club members are crucial for the capacity to attract members: under majority voting only altruistic subjects who are willing to partly internalize the freeriders' benefits join the coalition. If agents are only bound to the smallest common denominator, more players are willing to accept the coalition. Countries should be aware of this trade-off between coalition effort and coalition size when making their proposals for international climate policy. For example, as part of the Copenhagen Accord the EU committed to an independent economy wide emissions reduction target of 20% by 2020 compared to 1990. The EU is furthermore willing to increase its target to 30% provided that other developed countries commit themselves to comparable emissions reductions. Other countries such as Japan and Australia also make their contributions dependent on an international agreement in which the developed economies commit to ambitious targets.[5] While making offers conditional on others' efforts seems to be a good strategy to implement a minimum contribution for a coalition of countries, the insistence on very ambitious targets is likely to deter some countries from joining the coalition. For example, the United States pledged a 4% reduction and Canada pledged a 3% increase of emissions compared to 1990.[6] It seems to be out of reach to convince these countries to increase their reduction targets up to a range of 20% to 30%. Therefore, inducing these countries to accept moderate reductions targets may be a more promising way than ambitious but unilateral efforts. Such unilateral efforts may merely crowd out other countries' contributions as it has been observed in the experiment and therefore subsidize freeriders. After all, it appears worthwhile to explore institutional settings in which *all* agents participate in making minimum proposals.

[5] http://unfccc.int/home/items/5264.php accessed in March 2010.

[6] These targets correspond to the pledge of a 17% reduction compared to 2005 which was announced during the Copenhagen summit by both countries.

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Table 1. *Summary of experimental design*

Treatment	Stages	Coalition structure	n	γ	No. of subjects
VCM	contribution	no	10	10	100
VCMmin	minimum contribution	no	10	10	100
VCMqual_maj	minimum contribution	no	10	10	100
VCMsimple_maj	minimum contribution	no	10	10	100
COALmin	membership minimum contribution	yes	10	10	100
COALqual_maj	membership minimum contribution	yes	10	10	100
COALsimple_maj	membership minimum contribution	yes	10	10	100

Table 2. *Summary statistics for all treatments*

Treatment	Total			First 5 periods			Last 5 periods		
	q	π	k	q	π	k	q	π	k
VCM	12.3	905.2		15.7	1098.4		8.9	711.9	
VCMmin	22.1	1418.6		16.8	1187.9		27.5	1649.2	
VCMqual_maj	41.4	2296.0		38.3	2221.6		44.4	2370.5	
VCMsimple_maj	48.5	2447.3		48.2	2436.8		48.8	2457.8	
COALmin	14.8	1060.1	5.1	16.32	1160.1	5.3	13.4	960.1	4.8
COALqual_maj	15.7	1107.0	3.7	17.8	1200.6	3.9	13.6	1013.5	3.5
COALsimple_maj	18.9	1235.8	3.6	22.8	1430.4	4	15.1	1041.1	3.1

Notes: q = average contributions, π = average payoffs, k = average coalition size

Table 3. *Linear regression of public good contributions for all treatments*

VARIABLES	Per 1-10 qi	Per 1-10 qi	Per 6-10 qi	Per 10 qi
bmin	9.833***	9.833***	18.62***	23.98***
	(0.627)	(0.627)	(0.819)	(1.978)
bqm	29.07***	29.07***	35.58***	31.33***
	(0.627)	(0.627)	(0.819)	(1.978)
bm	36.21***	36.21***	39.95***	40.25***
	(0.627)	(0.627)	(0.819)	(1.978)
cmin	2.551***	2.551***	4.520***	5.320***
	(0.627)	(0.627)	(0.819)	(1.978)
cqm	3.360***	3.360***	4.698***	3.970**
	(0.627)	(0.627)	(0.819)	(1.978)
cm	6.644***	6.644***	6.194***	1.450
	(0.627)	(0.627)	(0.819)	(1.978)
per6_10		-0.625*		
		(0.335)		
Constant	12.30***	12.61***	8.858***	9.070***
	(0.444)	(0.474)	(0.579)	(1.399)
Observations	7000	7000	3500	700
R-squared	0.469	0.470	0.573	0.543

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 4. *Linear regression of payoff levels for all treatments*

VARIABLES	Per 1-10 pay	Per 1-10 pay	Per 6-10 pay	Per 10 pay
bmin	513.4***	513.4***	937.3***	1173***
	(35.76)	(35.72)	(48.38)	(111.6)
bqm	1391***	1391***	1659***	1521***
	(35.76)	(35.72)	(48.38)	(111.6)
bm	1542***	1542***	1746***	1831***
	(35.76)	(35.72)	(48.38)	(111.6)
cmin	154.9***	154.9***	248.2***	262.3**
	(35.76)	(35.72)	(48.38)	(111.6)
cqm	201.9***	201.9***	301.6***	307.0***
	(35.76)	(35.72)	(48.38)	(111.6)
cm	330.6***	330.6***	329.2***	165.3
	(35.76)	(35.72)	(48.38)	(111.6)
per6_10		-75.96***		
		(19.09)		
Constant	905.2***	943.2***	711.9***	662.4***
	(25.29)	(27.00)	(34.21)	(78.91)
Observations	7000	7000	3500	700
R-squared	0.341	0.342	0.427	0.432

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 5. *Probit regression of decision to join the coalition for all coalition treatments*

VARIABLES	Per 1-10 ci	Per 1-10 ci
ci_lag	1.255***	1.268***
	(0.0572)	(0.0590)
k_lag	0.00442	0.00545
	(0.0172)	(0.0172)
cqm	-0.152**	-0.144**
	(0.0684)	(0.0691)
cm	-0.213***	-0.198***
	(0.0717)	(0.0736)
eff_mincoal_lag	-0.0941***	-0.0938***
	(0.0286)	(0.0285)
outvoted_lag		-0.111
		(0.123)
Constant	-0.612***	-0.624***
	(0.0976)	(0.0985)
Observations	2650	2650
Pseudo R-squared	0.185	0.185

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 6. *Linear regression of efficiency levels of individual minimum proposals*

VARIABLES	VCM treatments with minimum stage eff_qimin	Coalition treatments eff_qimincoal
qi_min_lag	0.0117***	0.0252***
	(0.000307)	(0.00173)
q_min_lag	-0.00130***	-0.00284
	(0.000502)	(0.00285)
per6_10	0.0275**	0.00447
	(0.0123)	(0.0615)
k		-0.153***
		(0.0183)
cqm		0.0860
		(0.0770)
cm		0.0588
		(0.0891)
bqm	0.0110	
	(0.0185)	
bm	0.00552	
	(0.0212)	
Constant	0.421***	1.355***
	(0.0184)	(0.137)
Observations	2700	763
R-squared	0.358	0.283

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Figure 1. *Internalization factor α needed to stabilize a given coalition size*

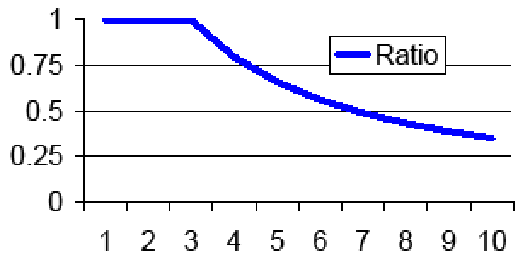

Figure 2. *Average contribution and payoff levels for the different treatments*

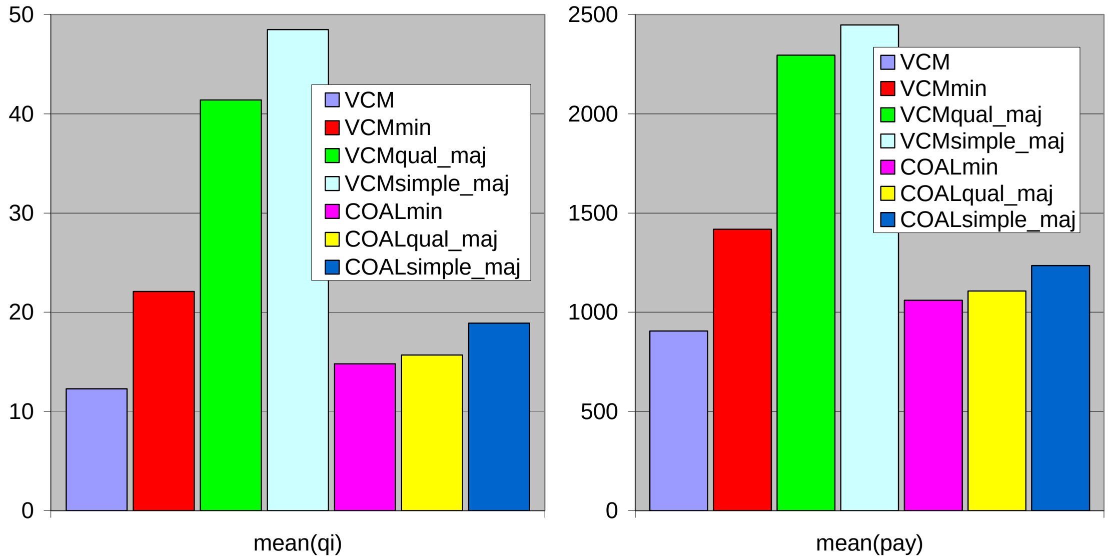

Figure 3. *Average contribution levels for the different treatments over time*

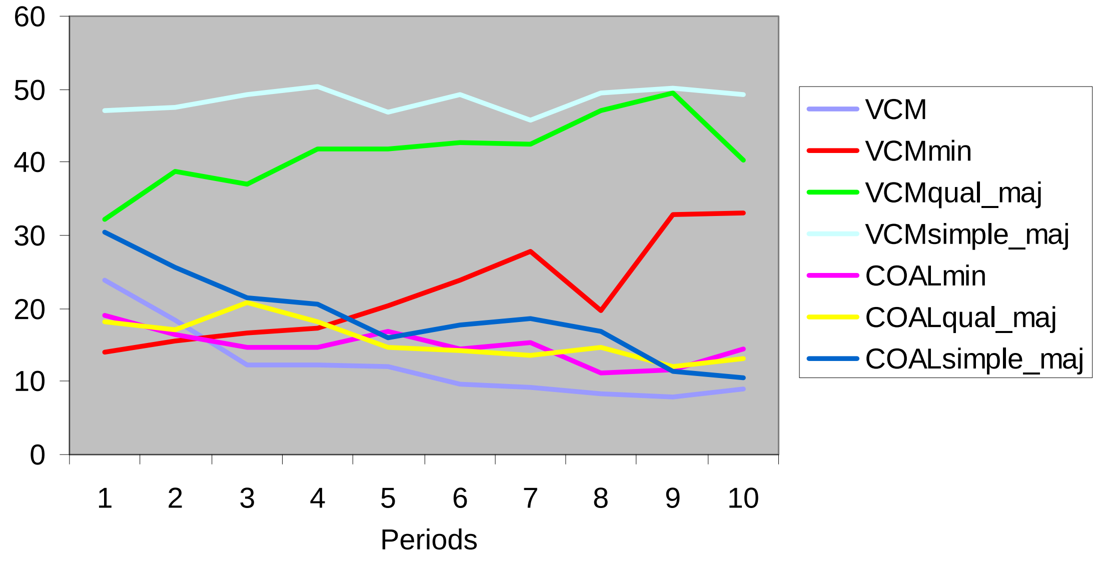

Figure 4. *Average contribution levels among coalition members and freeriders and average coalition size across coalition treatments*

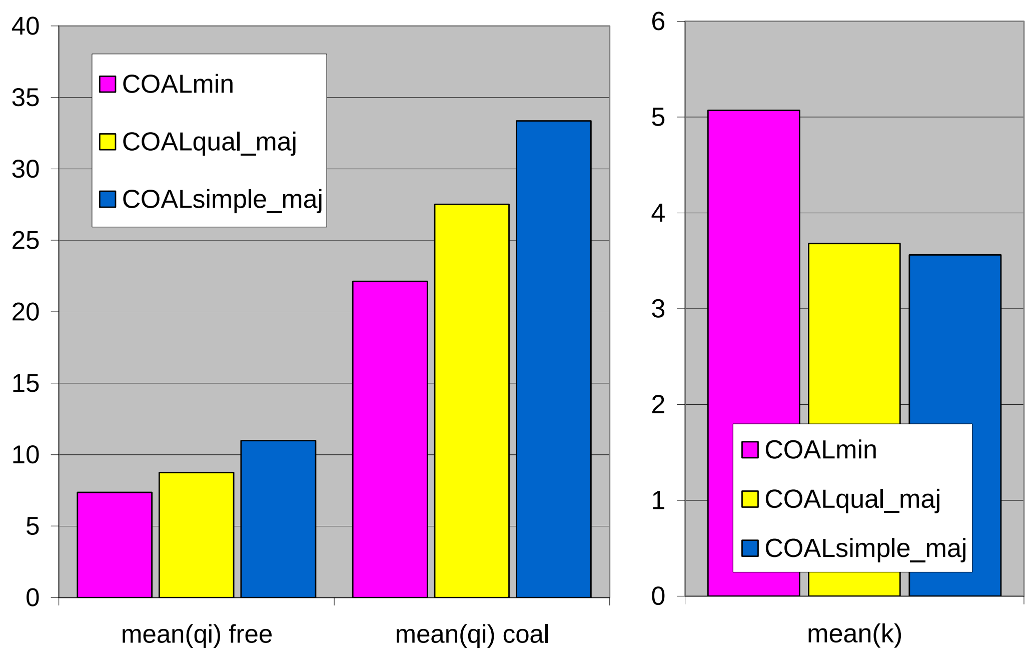

Figure 5. *Average coalition size across all coalition treatments over time*

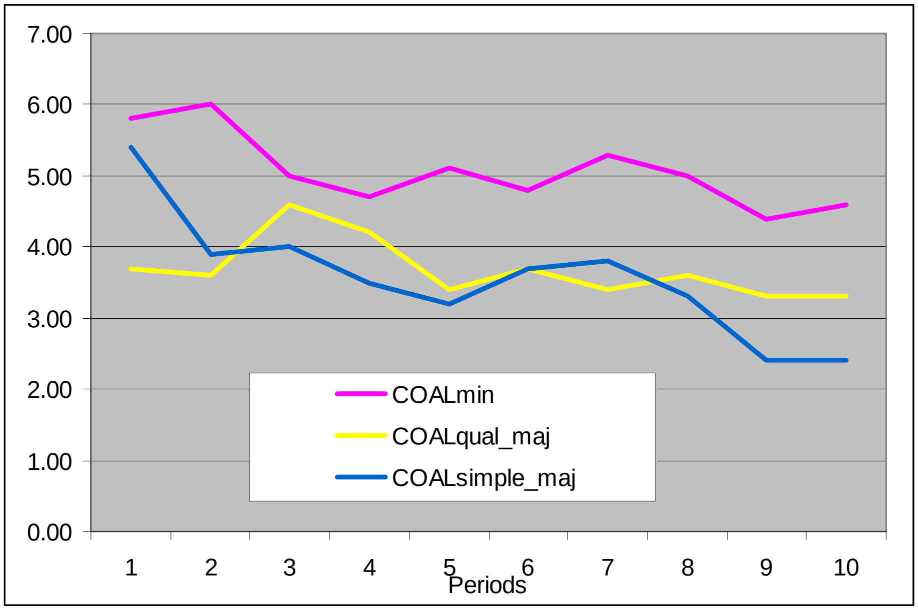

Figure 6. *Average internalization ratios across coalition treatments: fraction of benefits that are internalized in coalition and average coalition size*

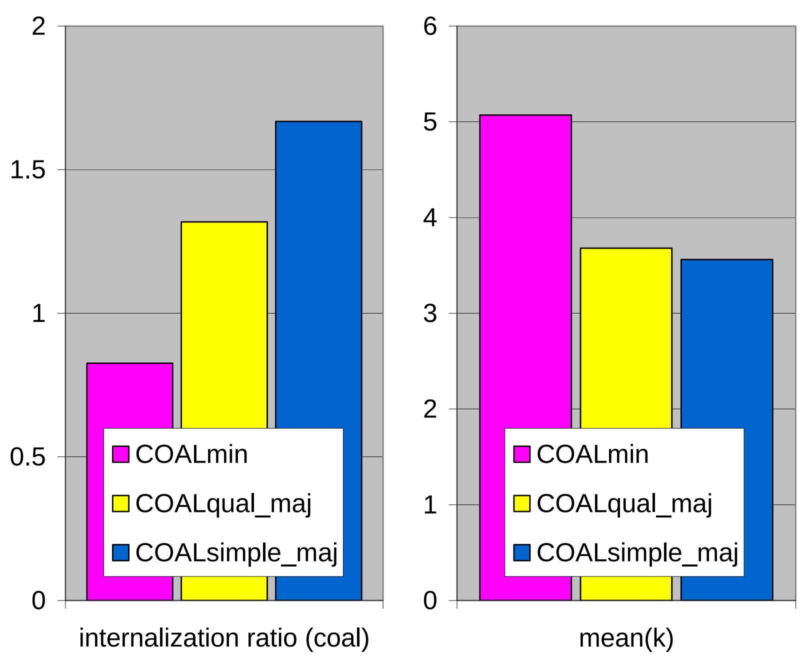

Figure 7. *Average internalization ratios conditional on coalition size across the coalition treatments: fraction of benefits that are internalized in coalition; the black line shows the internalization ratios theoretically required to achieve the respective coalition size*