Discussion Paper No. 10-072

# Voting in International Environmental Agreements – Experimental Evidence from the Lab

Astrid Dannenberg

Zentrum für Europäische
Wirtschaftsforschung GmbH

Centre for European
Economic Research

Discussion Paper No. 10-072

# Voting in International Environmental Agreements – Experimental Evidence from the Lab

Astrid Dannenberg

## Non-technical summary

The management of global environmental resources, such as the global climate, requires cooperation between countries. In practice, countries willing to abate the emission of a pollutant that damages a shared environmental resource often cooperate in international environmental agreements (IEA). The essential feature of IEAs is that they must be self-enforcing because sovereign countries cannot be forced to sign an IEA. The theoretical literature on self-enforcing IEAs derives rather pessimistic predictions. If potential cooperative efficiency gains, and thereby free-riding incentives, are large, a self-enforcing IEA can attract only few signatories and marginally improve upon the non-cooperative outcome. Efficiency gains may be possible if an IEA does not require the collectively optimal abatement level from its signatories and thereby appeals to more participants.

The theoretical literature, however, has not paid so much attention to the question *how* signatories determine their pollution abatement level. Also, the experimental literature on coalition formation which is still at the beginning does not explicitly consider the negotiation process. Most experiments prompt the signatories to abate the optimal amount. The present paper tries to narrow this gap. It experimentally analyses the effects if signatories to an IEA apply different voting schemes to determine the terms of agreement. To this end, unanimity, qualified majority voting, and simple majority voting are compared with respect to the resulting pollution abatement level and social welfare. At first sight in line with theoretical predictions, the experiment shows that a change of the voting scheme implemented in an IEA does not significantly change social welfare. However, changing the majority required to determine the terms of an IEA alters the 'depth and breadth' of cooperation. 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.

## Das Wichtigste in Kürze

Der Schutz globaler Umweltressourcen erfordert länderübergreifende Kooperation. Diese wird in der Praxis oft in internationalen Umweltabkommen festgelegt. Das zentrale Element internationaler Umweltabkommen ist, dass sie den Ländern Anreize bieten müssen, die Abkommen zu unterzeichnen und einzuhalten, da kein souveräner Staat dazu gezwungen werden kann. Die spieltheoretische Literatur zu internationalen Umweltabkommen, die diese Abkommen als 'selbstdurchsetzend' bezeichnet, liefert pessimistische Prognosen: Sind die potenziellen Kooperationsgewinne und damit auch die Freifahreranreize hoch, haben nur wenige Länder einen Anreiz dem Kooperationsabkommen beizutreten. Effizienzgewinne sind in begrenztem Umfang möglich, wenn ein Abkommen statt dem kollektiv optimalen Umweltschutzniveau ein suboptimales Niveau von seinen Mitgliedern verlangt und damit mehr Unterzeichner gewinnen kann.

Die theoretischen Arbeiten haben jedoch der Frage, *wie* sich Länder auf ein bestimmtes Umweltschutzniveau einigen, wenig Aufmerksamkeit geschenkt. Auch die experimentelle Literatur im Bereich der Koalitionsbildung betrachtet oftmals nicht den Verhandlungsprozess sondern erzwingt das optimale Verhalten der Koalitionsmitglieder. Die vorliegende Arbeit versucht diese Lücke zu verkleinern. Sie betrachtet im Rahmen eines Laborexperimentes verschiedene Kooperationsabkommen, in denen Unterzeichner unterschiedliche Wahlsysteme anwenden, um das Umweltschutzniveau innerhalb des Abkommens festzulegen. Einstimmigkeit, qualifizierte Mehrheitsentscheidung und einfache Mehrheitsentscheidung werden im Hinblick auf Umweltschutzniveau und soziale Wohlfahrt verglichen. Auf den ersten Blick im Einklang mit den theoretischen Prognosen hat das zugrundeliegende Wahlsystem keinen signifikanten Einfluss auf die soziale Wohlfahrt. Die detaillierte Analyse zeigt jedoch, dass das Wahlsystem die 'Tiefe und Breite' des Kooperationsabkommens ändert. Während Einstimmigkeit zu relativ großen Koalitionen mit moderatem Umweltschutzniveau führt, erzeugen Mehrheitsentscheidungen kleine Koalitionen mit sehr hohem Umweltschutzniveau.

# Voting in International Environmental Agreements – Experimental Evidence from the Lab

Astrid Dannenberg

Centre for European Economic Research (ZEW), Mannheim, Germany

Email: dannenberg@zew.de

October 2010

**Abstract**

This paper experimentally analyzes the effects if signatories to an international environmental agreement (IEA) apply different voting schemes to determine the terms of the agreement. To this end, unanimity, qualified majority voting, and simple majority voting are compared with respect to the resulting pollution abatement level and social welfare. At first sight in line with theoretical predictions, the experiment shows that the change of the voting scheme implemented in an IEA does not significantly change social welfare. However, changing the majority required to determine the terms of an IEA alters the 'depth and breadth' of cooperation. 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.

**Keywords:** international environmental agreements, cooperation, voting

**JEL: C72, C92, D71, H41**

**Acknowledgement:** The author would like to thank the lecturers and participants at the 2010 FEEM-EAERE-VIU European Summer School in Resource and Environmental Economics in Venice for their very useful comments and suggestions. Financial support from the German Science Foundation is gratefully acknowledged.

## 1. Introduction

The management of global environmental resources, such as the global climate, requires cooperation between countries. In practice, countries willing to abate the emission of a pollutant that damages a shared environmental resource often cooperate in international environmental agreements (IEA). In the game theory literature, IEAs are usually modeled as an n-country dilemma game with multiple stages. In the first stage, all countries choose whether to be a signatory to an IEA or not. In the second stage, signatories determine their emission abatement levels with the objective of maximizing their collective payoff. In the third stage non-signatories choose their abatement levels independently with the goal of maximizing their individual payoff. If the underlying game involves dominant strategies, the final two stages could also be turned into a single stage because signatories cannot influence the behavior of the non-signatories by choosing a certain action. The essential feature of IEAs is that they must be self-enforcing because sovereign countries cannot be forced to sign an IEA. This feature is incorporated by the concept of internal and external stability. An IEA is internally stable if no signatory would like to leave the agreement unilaterally. It is externally stable, if no non-signatory would like to join the agreement unilaterally. The IEA literature (e.g. Barrett 1994, Hoel 1992, Carraro and Siniscalco 1993) that was inspired by theories of cartel formation (e.g. d'Aspremont et al. 1983) derives rather pessimistic predictions. If the difference in payoffs between the non-cooperative and full cooperative outcome is large, only few countries are predicted to form a self-enforcing IEA. The reason is that the free-rider incentives increase with the number of participants. Consequently internal stability is already violated for a small number of signatories. Hence, a self-enforcing IEA can only marginally improve upon the non-cooperative outcome. Finus and Maus (2008) suggest that an IEA can attract more participants by lowering the emission abatement required from the signatories. That is, an IEA that does not maximize the collective payoff by fully internalizing mutual benefits of the signatories but only partially internalizes benefits may be acceptable to more countries and thereby generate efficiency gains.

Assuming either full or partial internalization of mutual benefits, the theoretical literature has not paid so much attention to the question *how* signatories determine their abatement level. Also, the experimental literature on IEA formation which is still at the beginning does not explicitly consider the negotiation process. Once the subjects have stated their willingness to be a signatory and implement an IEA, most experiments simply exact payoff-maximizing behavior of the signatories. Burger and Kolstad (2009) use majority voting to determine the joint action of a coalition. However, as the decision is binary, i.e. coalition members either contribute the collectively rational amount or the non-cooperative amount to the public good, the voting merely determines whether or not the coalition is actually formed. Similarly, Kosfeld et al. (2009) apply a unanimity rule to determine whether or not a coalition is formed. If a coalition is formed, members are required to contribute the collectively rational amount to the public good. McEvoy et al. (forthcoming) use a minimum participation threshold to determine whether an agreement is actually reached. The threshold is set at the theoretically stable coalition size. If an agreement is reached, all signatories automatically contribute the collectively rational amount to the public good. The latter two experiments also contain treatments in which signatories are not bound to comply with the terms of the agreement. Non-compliant signatories in these treatments face a sanction (in absolute or expected values) which is supposed to deter such behavior. However, none of the above mentioned experiments offer signatories the opportunity to negotiate and to agree on a (possibly suboptimal) effort level. In contrast, Dannenberg et al. (2010) consider an IEA where signatories can agree on the smallest common denominator. More precisely, after the decision to participate in an IEA, each signatory suggests a minimum abatement level. The smallest proposal is then binding minimum for all signatories. The signatories in this treatment negotiate an abatement level below the collectively optimal level. Thereby this ‘smallest common denominator treaty’ can attract more participants and generate efficiency gains compared to the treatments in which the internalization of mutual benefits is exogenously enforced.

The experiment is also related to a number of recent studies dealing with the theme of how institutions can improve efficiency in social dilemmas. The first branch of this literature studies the self-selection of individuals into groups with an exogenously given institution. These experiments demonstrate that individuals voting with their feet between different institutional frameworks can considerably increase efficiency in public goods provision (Gürerk et al. 2006, Rockenbach and Milinski 2006). The second branch considers fixed groups that self-select the institution that shall apply to their interaction. These studies show that endogenously imposed institutions work better than identical but exogenously imposed institutions (Tyran and Feld 2006, Sutter et al. 2010). However, neither of the two approaches captures the provision of transnational or global public goods. In these cases the group of countries concerned is fixed and due to countries' sovereignty they cannot be forced to accept institutional decisions of a majority or even to take part in the negotiations.

The present study experimentally analyzes the welfare effects if signatories to an IEA apply majority voting to determine the minimum abatement level. To this end, I consider qualified majority voting and simple majority voting, and compare the resulting abatement levels with those achieved by the smallest common denominator treaty (described above) where signatories apply a unanimity rule to determine their effort level. Furthermore, I compare these IEA treatments with a standard voluntary contribution mechanism and institutions in which participation in negotiations of a minimum provision level is exogenous. At first sight in line with theoretical predictions, the experiment shows that the change of the voting scheme implemented in an IEA does not significantly change social welfare. However, changing the majority required to determine the terms of an IEA alters the 'depth and breadth' of cooperation. Under the unanimity rule, coalitions are relatively large and implement moderate effort levels while the coalitions with majority votes implement very high effort levels but attract only few participants.

While the experimental game is designed to incorporate key real-world issues, such as the voluntary formation of an IEA and negotiations of the IEA terms, it is necessarily simplistic for the sake of control and tractability. In particular, the experimental subjects face exogenously specified voting schemes, whereas these institutions in real-world negotiations evolve endogenously. Furthermore, just like in most of the theoretical and experimental literature, signatories to an IEA are assumed (and forced) to comply with the IEA terms.[1] While the former assumption can be expected to hamper cooperation, as endogenous institutional choice has been shown to enhance cooperation, the latter is certainly an important precondition for cooperation. There are, however, arguments to justify this assumption. For example, customary international law may require full compliance by signatories and the enforcement of

[1] As mentioned before, some experimental studies (MyEvoy et al. forthcoming, Kosfeld et al. 2009) allow for non-compliance in the contribution stage. However, they enforce the implementation of sanctions; thus in a broader sense, they do assume compliance.

custom could be assumed to be solved outside the model in some kind of meta game (Barrett 2003).

The paper is structured as follows: Section 2 provides the theoretical background. The experimental design is laid out in section 3. Section 4 presents the results and section 5 concludes.

## 2. Theoretical background

The game underlying the experiment is standard in the IEA literature (e.g. Barrett 1994, Carraro and Siniscalco 1993). A world is considered with $i = 1,...,n$ identical countries which emit a pollutant that damages a global environmental resource. Each country's abatement costs are assumed to depend only on its own abatement level while benefits are assumed to depend on global abatement. For country $i$, the welfare function is set by

$$\pi_i = b\sum_{j=1}^{n} q_j - cq_i^2 / 2 \qquad (1)$$

where $q_i$ is $i$'s abatement with $q_i \in [0, q_i^{\max}]$, $b > 0$ denotes the constant marginal abatement benefits, and $c > 0$ represents the slope of each country's marginal abatement cost curve. The full cooperative abatement level which maximizes social welfare is given by

$$q_i{*} = bn / c$$

while the non-cooperative Nash equilibrium is given by

$$q_i^{NC} = b / c .$$

The Nash equilibrium involves dominant strategies such that each country's actions do not depend on the abatement levels chosen by the remaining countries. Throughout, interior solutions are assumed which require $q_i^{\max}$ to be sufficiently large.

*IEA modeling and voting rules*

The modeling of an IEA in this setting generally involves three stages: In the first stage, each country chooses to be a signatory or a non-signatory. Let $S$ be the set of signatories with $|S| = k$ and $1 \leq k \leq n$. In the second stage, signatories negotiate a minimum abatement level for all IEA members. Negotiations proceed in a way that all signatories anonymously vote on minimum abatement levels, starting from the level that fully internalizes the mutual benefits, $q_i^{\min} = bk/c$, and decreasing until the required majority of signatories agrees with a certain abatement level. This level, $q^{\min}$, is then the binding minimum abatement level for *all* signatories. In the third stage, the individual abatement is chosen. Non-signatories are free to choose any abatement level. Their payoff-maximizing decision does not depend on the IEA effort and is again given by $q_i^{NC} = b/c$, i.e. they completely free-ride. The choice of the abatement by the signatories depends on the negotiations inside the IEA. Three different voting rules are considered, namely unanimity, three quarter majority, and simple majority.

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

The individually welfare-maximizing abatement level at this last stage is given by $q_i = \max[q^{\min}, b/c]$. That is, signatories provide exactly the binding minimum as long as $q^{\min} \geq b/c$ is valid. This implies that it is weakly dominant to suggest a minimum abatement level of $q_i^{\min} = bk/c$. Suggesting a smaller level would potentially lower the binding minimum and thus negatively affect all payoffs. However, there are many other equilibria in weakly dominated strategies. In case of unanimity, any binding minimum $q^{\min} < bk/c$ is established as equilibrium if at least two players suggest that level while all other players suggest a larger minimum. Changing the voting rule only changes the number of equilibria in weakly dominated strategies. For example, if the simple majority is sufficient to implement the binding minimum abatement level inside the IEA, any binding minimum $q^{\min} < bk/c$ is established as equilibrium if at least $0.5k+1$ players suggest that level, while the remaining 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. participation in negotiations of a minimum abatement level is exogenous, generates the full cooperative outcome, $q_i{*} = bn/c$, in weakly dominant strategies.

*Participation decision*

The decision about the abatement level inside the IEA leads to specific incentives for countries to participate. We can denote the payoff to signatories given the number of participants $k$ by $\prod^{S}(k)$ and the payoffs to non-signatories by $\prod^{NS}(k)$. Using the terminology from the IEA literature, a coalition of size $k$ is externally stable if no non-signatory has an incentive to join unilaterally, i.e. if $\prod^{NS}(k) > \prod^{S}(k+1)$.[2] The IEA is internally stable if no signatory has an incentive to leave unilaterally, i.e. if $\prod^{S}(k) \geq \prod^{NS}(k-1)$.

The payoffs in the stage following the participation decision depend on whether the countries are able to fully internalize the mutual benefits of the IEA participants, i.e. whether they choose the weakly dominant strategy or not. The effect of partial internalization has been studied by Finus and Maus (2008). They define an internalization ratio $\alpha$ with $0 < \alpha \leq 1$. That is, the effort level for each signatory is $q_i^S(k,\alpha) = \alpha bk/c$. Using the concept of internal and external stability reveals that an

[2] It is assumed that a country joins the IEA if it is indifferent to being a signatory or non-signatory as this increases payoffs to all other countries.

IEA that is internally and externally stable satisfies $k \le \frac{2+\sqrt{3-2\alpha}}{\alpha}$ and $k+1 > \frac{2+\sqrt{3-2\alpha}}{\alpha}$.

For an IEA that fully internalizes mutual benefits ($\alpha = 1$), this implies that only 3 countries participate ($k = 3$). Figure 1 shows how the predicted number of participants depends on $\alpha$. The decreasing relation corresponds to a trade-off between the depth and the breadth of cooperation. For example, an IEA with $k = 6$ signatories could be stabilized for $\alpha = 0.5$ while only 3 countries form an IEA for $\alpha = 1$. The broad but shallow treaty can thereby generate efficiency gains. The example of $k = 6$ and $\alpha = 0.5$ illustrates this result: compared to the $k = 3$ solution if $\alpha = 1$, the same total abatement level results while the abatement efforts are being distributed across more countries. Due to the increasing marginal abatement costs, gains in total payoffs result.

Since the weakly dominant strategy in the stage following the participation decision involves full internalization of mutual benefits, the unique subgame perfect equilibrium in weakly dominant strategies implies $k = 3$. However, it is not clear that the signatories will choose the weakly dominant strategy at the minimum stage, which might result in less than full internalization. Consequently, any participation level could be in principal stabilized in a subgame perfect equilibrium in weakly dominated strategies. This generally applies to all voting systems.

## 3. Experimental Design

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

The traditional voluntary contribution mechanism (*"VCM"*) served as a control treatment which only contained a contribution stage where players chose their abatement level. The IEA treatments involved three stages. In the first stage subjects decided on participating in an IEA (participation stage). Decisions to join or abstain from an IEA were made simultaneously and independently. In the second stage, after being told the number of participants, all signatories negotiated the minimum amount that each member should abate (minimum stage). Negotiations took the form that all participants simultaneously and independently proposed a minimum abatement between 0 and 100. In the treatment called *"IEAmin"* the smallest proposed amount became the binding lower limit for the signatories' abatement. In the treatment *"IEAqual_maj"* the proposed amount on which three quarter of signatories could agree by suggesting this or a higher abatement level became binding minimum. In the treatment called *"IEAsimple_maj"* the proposal on which the simple majority of signatories could agree by suggesting this or a higher amount became binding minimum. In all three IEA treatments, signatories were informed about all proposed minimum amounts (arranged in descending order). Non-signatories did not make any decision at this stage and were only informed about the number of signatories. In the third stage, the contribution stage, signatories and non-signatories chose their abatement. While non-signatories could freely choose their abatement level, signatories 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 abatement level. 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 abatement 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 their abatement, 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 subjects 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

[3] The treatments *VCM*, *VCMmin*, and *IEAmin* are also used in Dannenberg et al. (2010).

participated in the experiment, of which 100 took part in each treatment (recruiting software Orsee, Greiner 2004).

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 (see appendix for experimental instructions). 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 randomly selected 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]

## 4. Experimental Results

*Decision on abatement levels*

To compare the various treatments, abatement and payoff levels are averaged over all players and rounds. Table 2 provides mean abatement and payoff levels for each treatment and Figure 2 provides a graphical depiction of the data. The first panel presents the average abatement levels and the second reports the resulting average payoff levels. Average abatement levels in the three IEA treatments – *IEAmin*, *IEAqual_maj*, and *IEAsimple_maj* – slightly exceed those in the standard *VCM*. The VCM games with minimum stage – *VCMmin*, *VCMqual_maj*, and *VCMsimple_maj* – clearly increase average abatement compared to the standard *VCM*. These differences are confirmed by a series of Mann-Whitney tests with the average abatement level of one group across all periods being taken as the unit of observation: *VCM* gives lower

[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.

abatement levels than *VCMmin*, *VCMqual_maj*, and *VCMsimple_maj* (10%, 10%, and 1% significance respectively). *VCM* also gives lower abatement levels than *IEAmin*, *IEAqual_maj*, and *IEAsimple_maj* (10%, 10%, and 1% significance). As illustrated in Table 2 and Figure 2, reducing the majority required to implement the minimum abatement level leads to considerable increases of average abatement in the VCM games with minimum stage while the increases in the IEA treatments are only minor. Using Mann-Whitney tests confirms that abatement in *VCMsimple_maj* is higher than in *VCMqual_maj* (1% significance) and abatement in *VCMqual_maj* is higher than in *VCMmin* (1% significance). In contrast, there are no significant differences between *IEAmin* and *IEAqual_maj* as well as between *IEAqual_maj* and *IEAsimple_maj*. *IEAsimple_maj* performs slightly better than *IEAmin* (10% significance). Identical comparisons follow for the average payoff level, i.e. the efficiency of the respective institutions.

*Result 1: All institutions under review perform better than the standard voluntary contribution mechanism (VCM). Reducing the majority required to implement a minimum abatement level leads to high efficiency gains when negotiations involve all agents. Efficiency gains are substantially smaller when the majority decision only applies to signatories to an IEA.*

Result 1 is confirmed by the linear regression models presented in Tables 3 and 4. Figure 3 shows the development of average abatement levels for all treatments over time. The contributions in *VCM* are decreasing over time (see also Table 2). This downward trend, which has been observed in many other public goods experiments, is also observable for the three IEA treatments. The contributions in the VCM games with minimum stage, in contrast, follow an upward trend. This suggests that predictions from the theory hold: irrespective of the voting scheme, the possibility to form an IEA provides only small benefits compared to the voluntary contribution mechanism while negotiations of minimum abatement levels, including all agents, provide considerable efficiency gains.

*Decision on participation and benefit internalization*

In the following, I will have a closer look at the three IEA treatments. Figure 4 (left panel) shows the average abatement of signatories compared to that of non-signatories. As expected, non-signatories' abatement levels are clearly lower than those of signatories. However, the incentives for non-signatories to free-ride seem to decrease with higher effort levels of the IEA. The right panel in Figure 4 shows the differences in the number of signatories across IEA treatments. While in *IEAmin* on average half of all players form an IEA (5.07), the number of signatories is significantly lower in *IEAqual_maj* (3.68) and *IEAsimple_maj* (3.56) (Mann Whitney test, 5% and 1% significance respectively). This is confirmed by a probit estimation model of the decision to join the IEA as presented in Table 5. Players in *IEAmin* are more likely to join than in *IEAqual_maj* or *IEAsimple_maj*. Moreover, the estimation model shows that players are more likely to join if they already have been a signatory in the previous round. They are less likely to join if the IEA in the previous round has agreed on a relatively high minimum abatement level. Figure 5 shows the average number of signatories over time. While this number in *IEAmin* is relatively stable at around 5, the number of signatories in the IEA treatments with majority decision converges towards 3 over time.

> *Result 2: The incentives to join an IEA are significantly smaller if the IEA decides by majority vote than by unanimity. Moreover a high minimum abatement level reduces the incentives to join an IEA in the next round.*

The next point of interest is the level of abatement the signatories can agree upon. A sensible measure to assess the abatement level in the IEA is the internalization ratio, i.e. the ratio of the chosen abatement level compared with the payoff-maximizing level, $\sum_{i=S} q_i /(bk^2/c)$. On average the ratio is 83% for *IEAmin*, 132% for *IEAqual_maj*, and 167% for *IEAsimple_maj* as illustrated in Figure 6. Interestingly, while signatories in *IEAmin* do not fully internalize their mutual benefits, signatories in the two IEA treatments with majority decision 'overinternalize' mutual benefits, i.e. they internalize in part also benefits of non-signatories. The internalization ratio depends on the number of signatories. Figure 7 shows that in all three treatments the internalization ratios based on actual abatement levels are decreasing in $k$. The actual internalization ratios can be compared with the internalization ratio needed to stabilize a given coalition size as derived in section 2 (see Figures 1 and 7). The internalization ratios in *IEAmin* closely follow these stabilization levels. In contrast, in the IEA treatments with majority decision, the internalization ratios always exceed the stabilization levels; they approach 100% with increasing number of signatories (see Figure 7).

*Result 3: Majority voting changes the type of an IEA: while unanimity leads to 'broad but rather shallow' agreements, majority votes produce 'narrow but very deep' agreements.*

*Decision on minimum abatement proposals*

The decision on the binding minimum level is particularly important since the agents' abatement levels 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 signatories' decisions on contributions in the IEA 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 abatement.

As distinct prediction from the theory described above is that agents in both the VCM treatments with minimum stage and the IEA treatments have a weakly dominant strategy to suggest the minimum which fully internalizes mutual benefits. We have already seen that the internalization depends on the voting rule and whether negotiations involve all players or a subset of players. I finally address the question whether agents adjust their minimum proposals to the prevailing voting rule. It might be, for example, that subjects anticipate the risk of being outvoted and therefore adjust their minimum proposals downwardly. Table 6 presents the results of a linear regression of the internalization levels of individual minimum proposals. For the VCM treatments with minimum stage a variable "int_qimin" is defined which reflects how far a player's suggestion internalizes mutual benefits. For the IEA treatments, the variable "int_qimin_IEA" reflects how far signatories' suggestions internalize mutual benefits of the IEA participants. In both the VCM treatments with minimum stage and the IEA treatments, the internalization level is higher for subjects who already have submitted larger proposals in the previous round. In the VCM treatments with minimum stage, the internalization of the individual minimum proposals increases over time. Thus, subjects learn from experience to propose minimum levels that increase efficiency. In the IEA treatments the internalization decreases with larger coalitions. Interestingly, the introduction of majority voting does not significantly affect the internalization level of minimum suggestions. Thus, compared to unanimity majority voting does not change individual minimum suggestions but merely the outcome of the negotiations.

> *Result 4: Irrespective of whether negotiations involve all players 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

In this paper I experimentally analyze the welfare effects if signatories to an IEA apply majority voting to determine the terms of the agreement. To this end, I consider qualified majority voting and simple majority voting, and compare the resulting pollution abatement levels with those achieved by the smallest common denominator treaty in which signatories apply a unanimity rule to determine their effort level. At first sight in line with theoretical predictions, the experiment shows that a change of the voting scheme implemented in an IEA does not significantly change social welfare. However, changing the majority required to determine the terms of an IEA alters the depth and breadth of cooperation. 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.

The institutions which exogenously bring together *all* players to negotiate a minimum public good provision level perform much better than the insider-outsider structure created by an IEA. In this case, 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 implemented in this setting – necessarily increase the binding minimum abatement 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 reduce 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. if they have the same payoff function.

This is different if 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 increase 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. Finally, 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 (e.g. Fehr and Schmidt 1999).

The experimental results have implications for public policy. First, the results confirm that the terms of institutionalizing the requirements from an IEA are crucial for the capacity to attract signatories. Countries should be aware of the trade-off between the depth and breadth of cooperation. The most recent United Nations Climate Change Conference in Copenhagen in December 2009 may serve as an example. As part of the resulting agreement, the Copenhagen Accord, some countries offer ranges of emissions reduction targets with the more stringent targets being conditional on other countries' actions. For example, the European Union pledged an unconditional 20% reduction by 2020 compared to 1990 and a 30% reduction contingent on comparable emissions reductions by other developed countries.[5] The meaning of 'comparable' emissions reductions is not obvious. However, given the fact that the economic

[5] See http://unfccc.int/home/items/5264.php (accessed in August 2010).

consequences of the Accord pledges vary significantly between countries,[6] comparability of efforts might imply more stringent targets for certain countries. While making offers conditional on others' efforts seems to be a good strategy to implement a kind of minimum contribution for a number of countries, insisting on too ambitious targets is likely to deter some countries from joining the coalition. Therefore, inducing these countries to accept moderate reduction targets may be a more promising way than ambitious but unilateral efforts. Such unilateral efforts may merely crowd out other countries' contributions and therefore subsidize free-riders as observed in the experiment.

The second implication is more general. The theoretical IEA literature mostly assumes that countries only care about their self-interest.[7] The experimental coalition formation studies provide some insight to the consequences arising from real (and possibly other-regarding) preferences. Similar to the standard public goods games they show that people in the lab do not always act in line with the theory, but all the same, they are still far away from the social optimum. Though Kosfeld et al. (2009) show that the grand coalition is particularly compelling for small groups (n=4), larger groups in other experiments (n=10) rarely implemented the grand coalition. Relative to the difference between the full cooperative and the non-cooperative outcome, the average achieved efficiency gain often ranges between 20% and 50% and decreases with periods of repeated play. On average, the subjects in the present analysis achieved an efficiency gain of 29-39% which decreased to 17-24% in the final round. It remains an open question which approach, the theoretical or the experimental approach, is more suitable to capture the 'preferences' of countries. However, both approaches indicate that under certain circumstances, first-best solutions are not available. In this respect, the experimental results so far tend to support the view that small changes in the design of a particular IEA might not be enough but more radical changes might be needed (see e.g. Barrett 2002, 2008 for climate treaties).

As already pointed out in the introduction, the experimental coalition formation literature is in need of further development and therefore the picture is still

[6] For an assessment with domestically achievement of targets only see McKibbin et al. 2010; for an assessment with limited use of an international carbon market see http://ec.europa.eu/environment/climat/pdf/26-05-2010working_doc2.pdf (accessed in August 2010).
[7] Exceptions are for instance Lange and Vogt (2003) and Lange (2006).

incomplete. Promising areas for further research include asymmetric actors, endogenous institution design, and non-compliance.

**References**


Barrett, S. (1994), Self-Enforcing International Environmental Agreements, *Oxford Economic Papers* 46, 878-94.

Barrett, S. (2002), Towards a Better Climate Treaty, *World Economics* 3 (2), 35-45.

Barrett, S. (2003), *Environment and Statecraft: The Strategy of Environmental Treaty-making*, Oxford University Press, Oxford.

Barrett, S. (2008), *A Portfolio System of Climate Treaties*, Discussion Paper 08-13, Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School.

Burger, N. and C.D. Kolstad (2009), *Voluntary Public Goods Provision, Coalition Formation, and Uncertainty*, NBER Working Paper Series 15543.

Carraro, C. and D. Siniscalco (1993), Strategies for the International Protection of the Environment, *Journal of Public Economics* 52 (3).

Dannenberg, A., A. Lange, and B. Sturm (2010), *On the Formation of Coalitions to Provide Public Goods - Experimental Evidence from the Lab*, NBER Working Paper Series 15967.

D'Aspremont, C., J.J. Gabszeweiz, and J.A. Weymark (1983), On the stability of collusive price leadership. *Canadian Journal of Economics* 16, 17-25.

Fehr, E. and K. Schmidt (1999), A theory of fairness, competition, and cooperation. *Quarterly Journal of Economics*, 114, 817-868.

Finus, M. and S. Maus (2008) Modesty May Pay, *Journal of Public Economic Theory* 10, 801-826.

Fischbacher, U. (2007), Z-Tree: Zurich Toolbox for Ready-made Economic Experiments, *Experimental Economics*. 10 (2), 171-178.

Greiner, B. (2004), An Online Recruitment System for Economic Experiments, in: Kurt Kremer, Volker Macho (Eds.): Forschung und wissenschaftliches Rechnen 2003. GWDG Bericht 63, Göttingen : Ges. für Wiss. Datenverarbeitung, 79-93.

Gürerk, O., B. Irlenbusch, and B. Rockenbach (2006), The Competitive Advantage of Sanctioning, *Science* 312, 108-110.

Hoel, M. (1992), International Environmental Conventions: The Case of Uniform Reductions of Emissions, *Environmental and Resource Economics* 2, 41-59.

Kosfeld, M., A. Okada, and A. Riedl (2009), Institution Formation in Public Goods Games, *American Economic Review*, 99 (4), 1335–1355.

Lange, A. (2006), The Impact of Equity-preferences on the Stability of International Environmental Agreements, *Environmental and Resource Economics* 34, 247-267.

Lange, A. and C. Vogt (2003), Cooperation in International Environmental Negotiations due to a Preference for Equity, *Journal of Public Economics* 87, 2049-2067.

McEvoy, D.M., J.J. Murphy, J.M. Spraggon, and J.K. Stranlund (forthcoming), The Problem of Maintaining Compliance within Stable Coalitions: Experimental Evidence, *Oxford Economic Papers*.

McKibbin, W.J., A. Morris, and P.J. Wilcoxen (2010), *Comparing Climate Commitments: A Model-Based Analysis of the Copenhagen Accord*, Discussion Paper 10-35, Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School.

Rockenbach, B. and M. Milinski (2006), The Efficient Interaction of Indirect Reciprocity and Costly Punishment, *Nature* 444 (7), 718-723.

Sutter, M., S. Haigner, and M.G. Kocher (2010), Choosing the stick or the carrot? – Endogenous institutional choice in social dilemma situations. *Review of Economic Studies* 77, 1540-1566.

Tyran, J.-R. and L.P. Feld (2006), Achieving compliance when legal sanctions are nondeterrent, *Scandinavian Journal of Economics* 108, 135-156.

**Table 1.** *Summary of experimental design*

| Treatment | Stages | IEA | $n$ | $b$ | $c$ | No. of subjects |
|---|---|---|---|---|---|---|
| VCM | contribution | no | 10 | 10 | 2 | 100 |
| VCMmin | minimum contribution | no | 10 | 10 | 2 | 100 |
| VCMqual_maj | minimum contribution | no | 10 | 10 | 2 | 100 |
| VCMsimple_maj | minimum contribution | no | 10 | 10 | 2 | 100 |
| IEAmin | participation minimum contribution | yes | 10 | 10 | 2 | 100 |
| IEAqual_maj | participation minimum contribution | yes | 10 | 10 | 2 | 100 |
| IEAsimple_maj | participation minimum contribution | yes | 10 | 10 | 2 | 100 |

**Table 2.** *Summary statistics for all treatments*

| Treatment | Total | | | First 5 rounds | | | Last 5 rounds | | |
|---|---|---|---|---|---|---|---|---|---|
| | $q$ | $\pi$ | $k$ | $q$ | $\pi$ | $k$ | $q$ | $\pi$ | $k$ |
| 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 | |
| IEAmin | 14.8 | 1060.1 | 5.1 | 16.32 | 1160.1 | 5.3 | 13.4 | 960.1 | 4.8 |
| IEAqual_maj | 15.7 | 1107.0 | 3.7 | 17.8 | 1200.6 | 3.9 | 13.6 | 1013.5 | 3.5 |
| IEAsimple_maj | 18.9 | 1235.8 | 3.6 | 22.8 | 1430.4 | 4 | 15.1 | 1041.1 | 3.1 |

Notes: $q$ = average contributions, $\pi$ = average payoffs, $k$ = average number of signatories

**Table 3.** *Linear regression of abatement levels for all treatments*

| VARIABLES | Round 1-10<br>qi | Round 1-10<br>qi | Round 6-10<br>qi |
|---|---|---|---|
| VCMmin | 9.833*** | 9.833*** | 18.62*** |
| | (3.249) | (3.250) | (4.468) |
| VCMqm | 29.07*** | 29.07*** | 35.58*** |
| | (1.968) | (1.968) | (1.546) |
| VCMsm | 36.21*** | 36.21*** | 39.95*** |
| | (1.251) | (1.251) | (1.017) |
| IEAmin | 2.551** | 2.551** | 4.520*** |
| | (1.007) | (1.007) | (1.364) |
| IEAqm | 3.360** | 3.360** | 4.698*** |
| | (1.678) | (1.678) | (1.459) |
| IEAsm | 6.644*** | 6.644*** | 6.194*** |
| | (1.655) | (1.655) | (1.261) |
| round6_10 | | -0.625 | |
| | | (1.081) | |
| Constant | 12.30*** | 12.61*** | 8.858*** |
| | (0.613) | (0.841) | (0.591) |
| Observations | 7000 | 7000 | 3500 |
| Number of groups | 700 | 700 | 700 |
| Wald chi2 | 3517.17*** | 3621.96*** | 5121.66*** |

Notes: Random effects estimation clustered at group level, standard errors in parentheses,
significance *** p<0.01, ** p<0.05, * p<0.1.
Definition of variables:
qi = subject's abatement,
VCMmin = 1 if subject plays in the *VCMmin* treatment, 0 otherwise,
VCMqm = 1 if subject plays in the *VCMqual_maj* treatment, 0 otherwise,
VCMsm = 1 if subject plays in the *VCMsimple_maj* treatment, 0 otherwise,
IEAmin = 1 if subject plays in the *IEAmin* treatment, 0 otherwise,
IEAqm = 1 if subject plays in the *IEAqual_maj* treatment, 0 otherwise,
IEAsm = 1 if subject plays in the *IEAsimple_maj* treatment, 0 otherwise,
round6_10 = 1 for the last five rounds, 0 for the first five rounds.

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

| VARIABLES | Round 1-10 pay | Round 1-10 pay | Round 6-10 pay |
|---|---|---|---|
| VCMmin | 513.4*** | 513.4*** | 937.3*** |
| | (164.9) | (164.9) | (216.6) |
| VCMqm | 1391*** | 1391*** | 1659*** |
| | (70.63) | (70.63) | (66.43) |
| VCMsm | 1542*** | 1542*** | 1746*** |
| | (56.39) | (56.40) | (55.53) |
| IEAmin | 154.9*** | 154.9*** | 248.2*** |
| | (58.64) | (58.64) | (81.78) |
| IEAqm | 201.9** | 201.9** | 301.6*** |
| | (93.51) | (93.52) | (89.55) |
| IEAsm | 330.6*** | 330.6*** | 329.2*** |
| | (75.75) | (75.76) | (65.83) |
| round6_10 | | -75.96 | |
| | | (50.01) | |
| Constant | 905.2*** | 943.2*** | 711.9*** |
| | (42.46) | (49.67) | (42.10) |
| Observations | 7000 | 7000 | 3500 |
| Number of groups | 700 | 700 | 700 |
| Wald chi2 | 7789.81*** | 7817.35*** | 7855.15*** |

Notes: Random effects estimation clustered at group level, standard errors in parentheses,
significance *** p<0.01, ** p<0.05, * p<0.1.
Definition of variables:
pay = subject's payoff level,
VCMmin = 1 if subject plays in the *VCMmin* treatment, 0 otherwise,
VCMqm = 1 if subject plays in the *VCMqual_maj* treatment, 0 otherwise,
VCMsm = 1 if subject plays in the *VCMsimple_maj* treatment, 0 otherwise,
IEAmin = 1 if subject plays in the *IEAmin* treatment, 0 otherwise,
IEAqm = 1 if subject plays in the *IEAqual_maj* treatment, 0 otherwise,
IEAsm = 1 if subject plays in the *IEAsimple_maj* treatment, 0 otherwise,
round6_10 = 1 for the last five rounds, 0 for the first five rounds.

**Table 5.** *Probit estimation of participation decision for all IEA treatments*

| VARIABLES | Round 1-10<br>ci | Round 1-10<br>ci |
|---|---|---|
| ci_lag | 1.255*** | 1.268*** |
| | (0.0572) | (0.0590) |
| k_lag | 0.00442 | 0.00545 |
| | (0.0172) | (0.0172) |
| IEAqm | -0.152** | -0.144** |
| | (0.0684) | (0.0691) |
| IEAsm | -0.213*** | -0.198*** |
| | (0.0717) | (0.0736) |
| int_min_IEA_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 |

Notes: Standard errors in parentheses,
significance *** p<0.01, ** p<0.05, * p<0.1.
Definition of variables:
ci = 1 if subject participates in IEA, 0 otherwise,
ci_lag = 1 if subject participated in the previous round, 0 otherwise,
k_lag = coalition size in the previous round,
IEAqm = 1 if subject plays in the *IEAqual_maj* treatment, 0 otherwise,
IEAsm = 1 if subject plays in the *IEAsimple_maj* treatment, 0 otherwise,
int_min_IEA_lag = previous round internalization ratio based on the binding minimum,
outvoted_lag = 1 if subject's minimum proposal in previous round was below the binding minimum, 0 otherwise.

**Table 6.** *Linear regression of internalization ratios of individual minimum proposals*

| VARIABLES | VCM with minimum int_qimin | IEA with minimum int_qimin_IEA |
|---|---|---|
| qi_min_lag | 0.0117*** | 0.0206*** |
| | (0.000628) | (0.00264) |
| q_min_lag | -0.00130* | -0.00195 |
| | (0.000759) | (0.00288) |
| round6_10 | 0.0275*** | 0.00490 |
| | (0.00998) | (0.0521) |
| k | | -0.135*** |
| | | (0.0230) |
| IEAqm | | 0.0820 |
| | | (0.0944) |
| IEAsm | | 0.0356 |
| | | (0.0937) |
| VCMqm | 0.0110 | |
| | (0.0228) | |
| VCMsm | 0.00552 | |
| | (0.0286) | |
| Constant | 0.421*** | 1.425*** |
| | (0.0310) | (0.176) |
| Observations | 2700 | 763 |
| Number of groups | 300 | 186 |
| Wald chi2 | 48,883.76*** | 134.83*** |

Notes: Random effects estimation clustered at group level, standard errors in parentheses,
significance *** p<0.01, ** p<0.05, * p<0.1.
Definition of variables:
int_qimin = internalization ratio of subject's minimum proposal in VCM treatments
int_qimin_IEA = internalization ratio of subject's minimum proposal in IEA treatments
qi_min_lag = subject's minimum proposal in the previous round,
q_min_lag = binding minimum in the previous round,
k = coalition size,
round6_10 = 1 for the last five rounds, 0 for the first five rounds,
VCMqm = 1 if subject plays in the *VCMqual_maj* treatment, 0 otherwise,
VCMsm = 1 if subject plays in the *VCMsimple_maj* treatment, 0 otherwise,
IEAqm = 1 if subject plays in the *IEAqual_maj* treatment, 0 otherwise,
IEAsm = 1 if subject plays in the *IEAsimple_maj* treatment, 0 otherwise.

**Figure 1.** *Internalization factor* $\alpha$ *needed to stabilize a given coalition size*

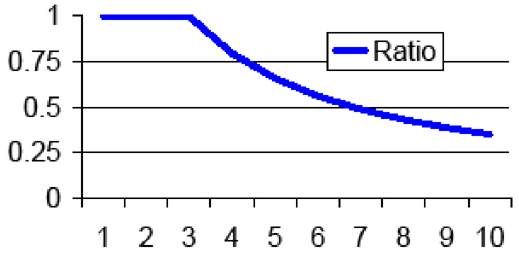



**Figure 2.** *Average abatement and payoff levels for all treatments*

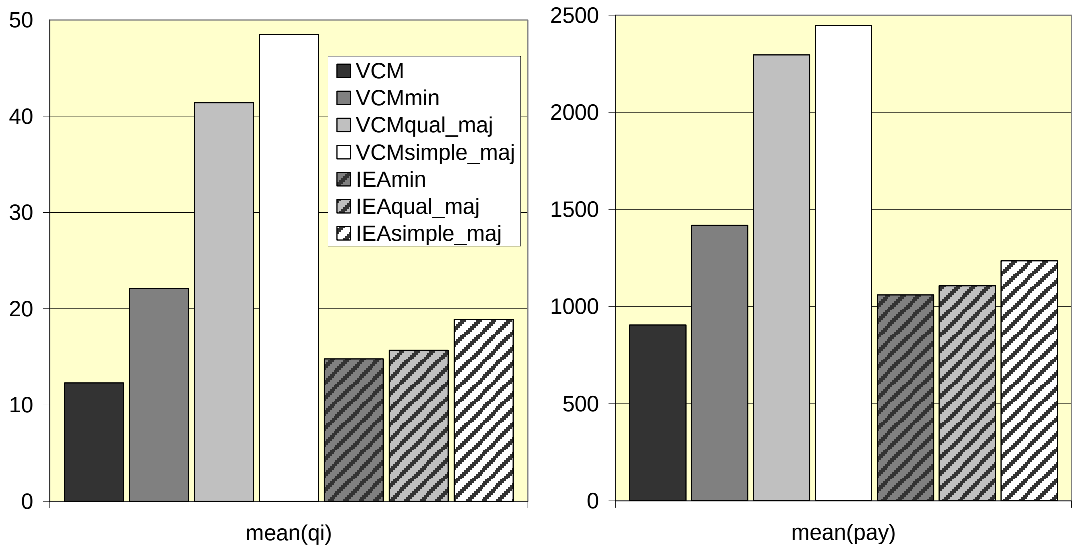


**Figure 3.** *Average abatement levels for all treatments over time*

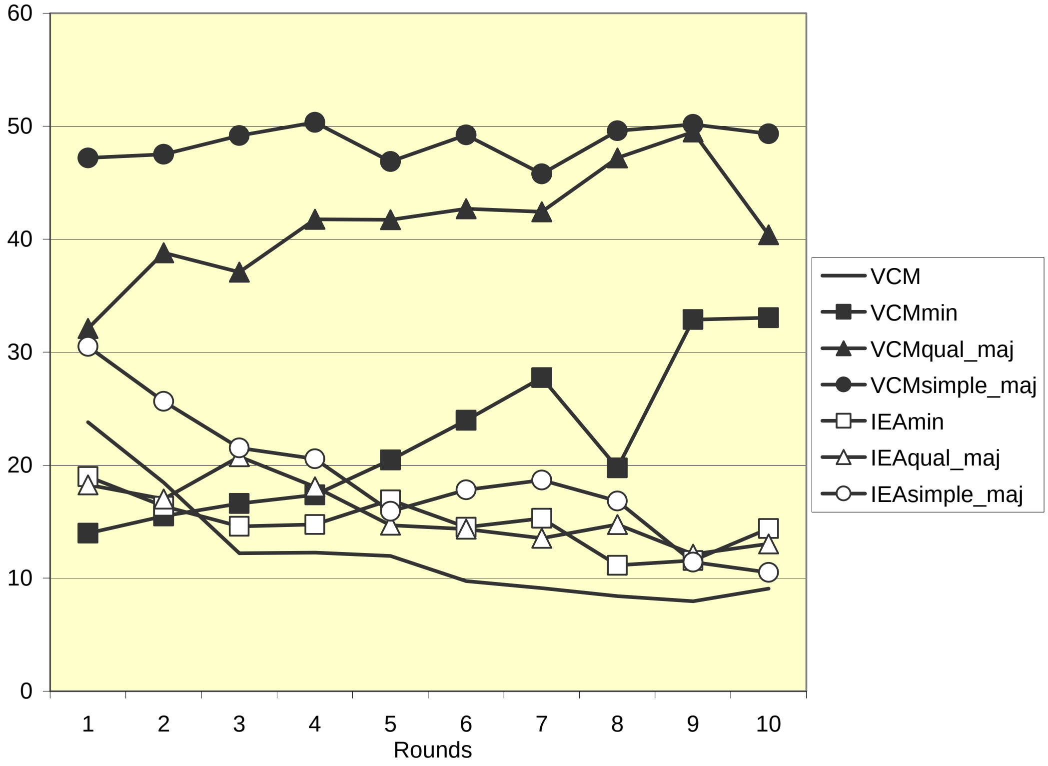



**Figure 4.** *Average abatement levels among signatories and non-signatories and average coalition size across IEA treatments*

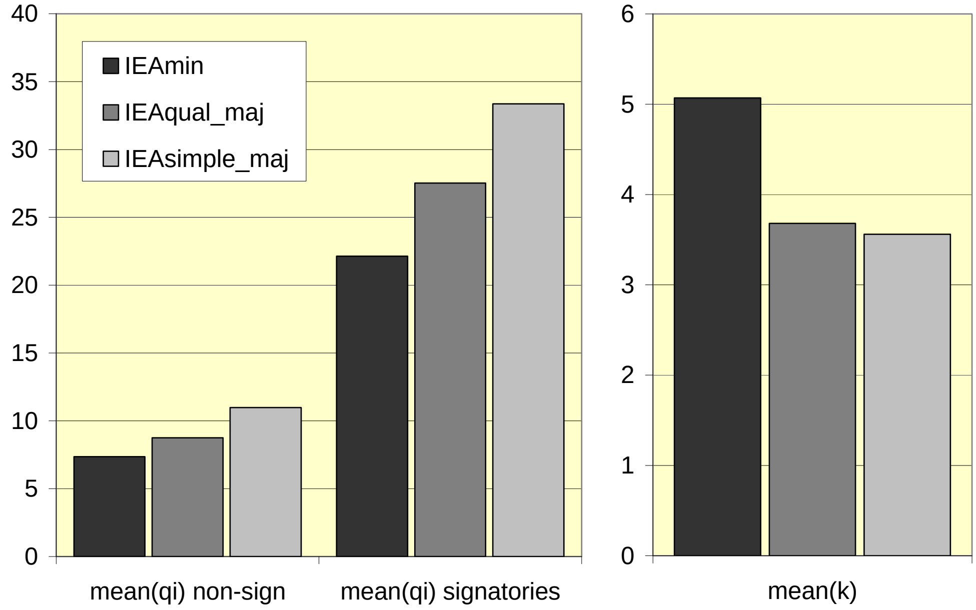


**Figure 5.** *Average coalition size across all IEA treatments over time*

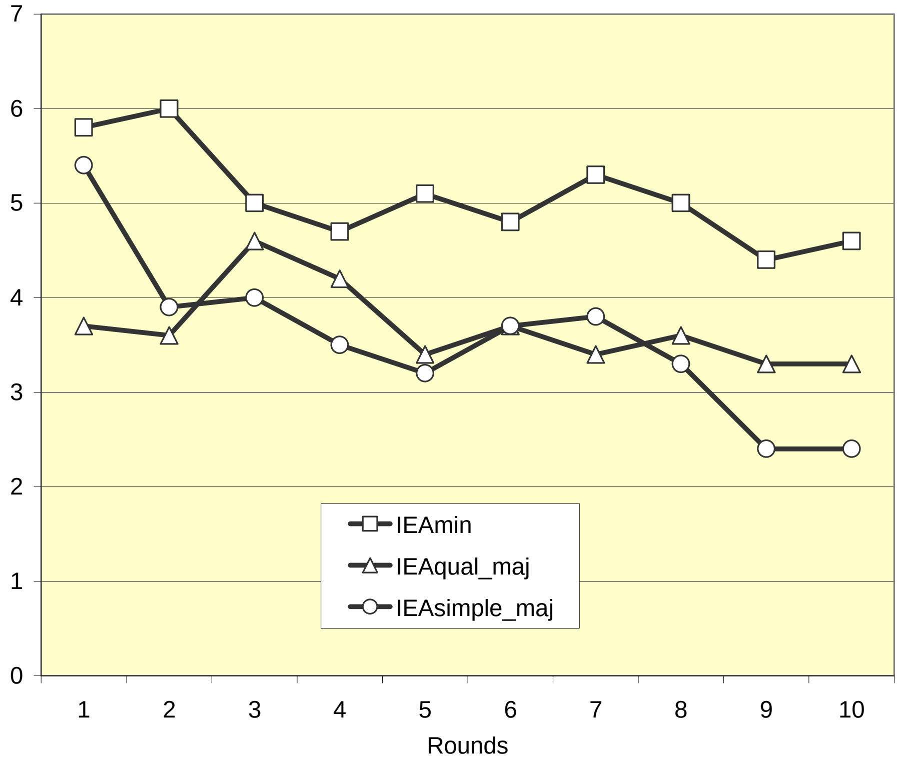



**Figure 6.** *Average internalization ratios across IEA treatments (fraction of benefits that is internalized) and average coalition size*

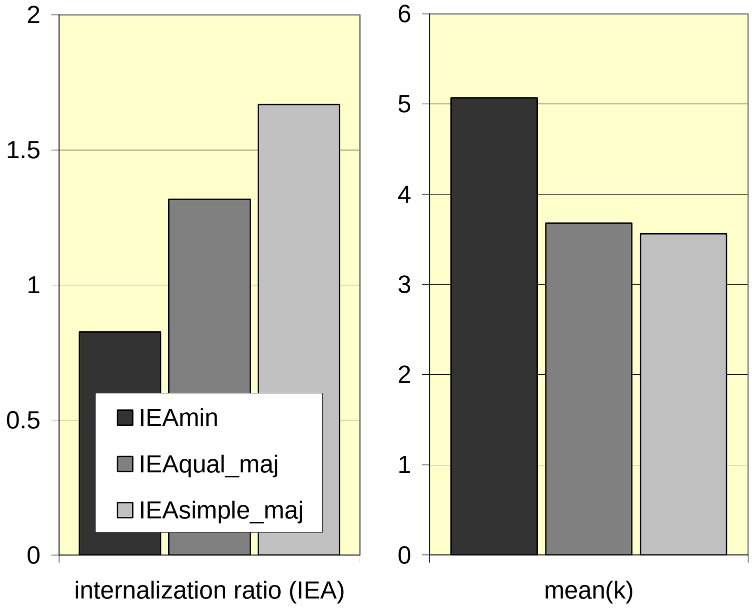
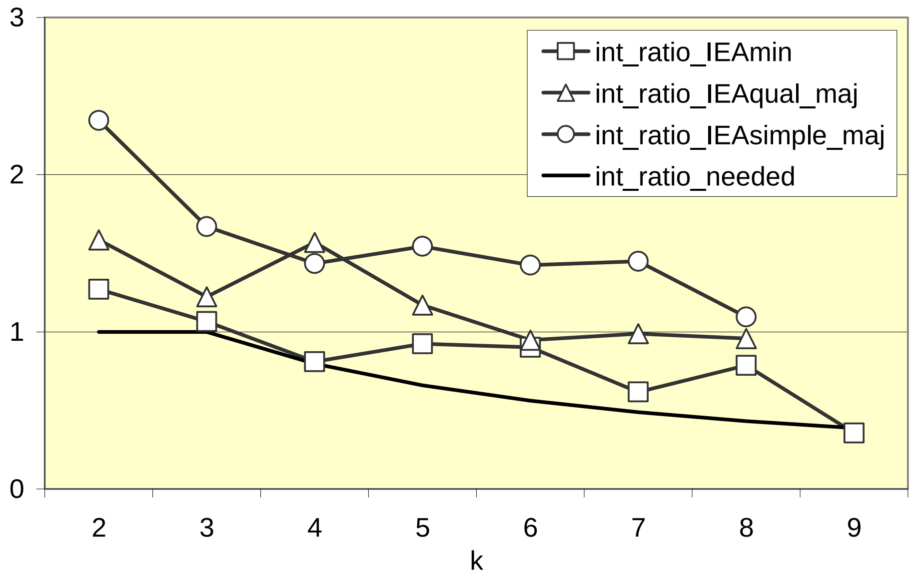



**Figure 7.** *Average internalization ratios conditional on coalition size across the IEA treatments (the line "int_ratio_needed" shows the internalization ratios theoretically needed to achieve the respective coalition size)*



int_ratio_IEAmin
int_ratio_IEAqual_maj
int_ratio_IEAsimple_maj
int_ratio_needed
3
2
1
0
2
3
4
5
6
7
8
9
k

## Appendix

Experimental instructions for the *IEAmin* treatment

## Instructions

Welcome to the Magdeburg Experimental Laboratory MAXLAB!

Please read these instructions carefully and should you have any questions please signal us by opening the door or a show of hands. In the laboratory experiment you are taking part in, you can win money depending on your decisions and the decisions of your fellow players. Your payout from the experiment will be calculated in LabDollars (LD). The conversion rate between € and LD is **1:100**, i.e. 100 LD are €1. All your decisions made the experiment will remain **anonymous**. Only the experimenter will know your identity, but your data will be treated confidentially.

### Rules of the game

Now you will learn more about the rules of the game you will be participating in. Altogether **10 players** take part in the game, so besides you there are 9 more players. Every participant faces the same decision making problem. Your task in the game, and also your fellow players' task, is to decide how many points (between 0 and 100) you would like to contribute to a **joint project**. Your **payout** will be calculated as follows:

| |
|---|
| Your payout = –(your contribution to the project)$^2$ + 10·(sum of all contributions of all players to the project) |

Example: If all other players have contributed an amount of 90 points to the project and you contribute an amount of 10 points, then your payout will be:

$-(10)^2 + 10\cdot(10+90) = 900$ LD

If, however, all other players contribute a total amount of 50 points and you do not contribute anything, your payout will be:

$-(0)^2 + 10\cdot(0+50) = 500$ LD

To simplify the calculation of your payout, you will find an excel-file called **"Simulator"** on your screen. You can enter your contribution and the **average** contribution of all other players and so quickly determine your payout.

There are **two stages** in this game. In **stage 1** you can decide whether you want to become a member of a coalition, i.e. if you want to join a coalition or not. Should you decide that you want to join a coalition you additionally can decide which amount should be the **minimum amount** each member of the coalition should contribute to the project. Also all other members of the coalition can state their desired minimum amount. The members will be informed about the proposals for the minimum amount of all members. If you are member of a coalition, **stage 2** will be to decide for yourself which amount you want to contribute. In this decision the **smallest** minimum amount of all members will form your **lower** limit of contribution. If you have decided not to join a coalition, **stage 2** for you will be to state your contribution to the project without any limitation.

The game consists of **10 separate rounds** in each of which you will play the same two-stage game. The nine other players you will interact with will be the same in every round. If the experiment is complete you will receive the **payout of one of the rounds** in € (according to the conversion rate stated above). The round to be paid out will be determined **randomly**. This means you should behave in **each** round as if it were the round relevant for payout. In the beginning, **two trial rounds** will be played which are **not relevant for payout**. Independent of the course of the game you will receive €1 for your participation.

**Control questions**

If you have read the instructions and do not have any questions, please answer the following control questions (hint: use the simulator).

1. Please assume your contribution to the project is 10 points and the average contribution of all the other players is 15 points. How much LD will be your payout of this round?

   My payout is: ________

2. Please assume the average contribution of all other players is 5 points, which of the following amounts will result in the highest payout for you?

   O 5 points  O 10 points  O 20 points  O 30 points

3. Please assume you want to maximise your payout, does it make sense to not contribute at all (meaning zero points) to the project?

   O yes  O no

4. Please assume you and three other players have joined a coalition and all members have stated the following minimum contribution: 4, 88, 22, 56. In which range does your contribution to the project have to be?

   More than or equal ____ and less than or equal _____.

5. Is it possible that a member of a coalition has to contribute more than he proposed as his minimum contribution?

   O yes  O no

6. Please assume all players chose the same amount, which of the following contributions results in the highest payout for all players (please check the according box)?

   O 10 points  O 30 points  O 50 points  O 70 points  O 100 points

If you have answered all questions, please signal us. We will then check your answers. The game begins when all participants in the experiment have successfully completed the test.

Good luck in the experiment! The MaXLab-Team