Coalition Formation in International Public Goods Provision with Heterogeneous Agents

Christine Gutekunst
Kaj Thomsson

Maastricht University
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Abstract

We analyze the impact of heterogeneity on the formation of coalitions for the provision of international public goods. Using a three stage setup that differentiates between the decision to join negotiations, the decision on the contribution amount, and the actual contribution, we can show that an increase in cost heterogeneity makes coalition formation more difficult. An increase in endowment heterogeneity, on the contrary, might make coalition formation easier, depending on the relation between costs and endowments. A country with large costs might be more willing to join an agreement if it has a higher endowment, that is, if endowment and costs are positively correlated. In that case, weighted voting in the sense of assigning a higher weight to large endowment countries makes the positive incentive effect for a large endowment country even stronger, that is, a large cost country is more likely to be in an agreement if endowment, political weight and abatement costs are positively correlated.

1 Introduction

Since the first global conference on environmental issues in Stockholm in 1972, questions of international environmental protection have received steadily growing attention. Specifically climate change abatement has been a relevant topic in international negotiations over the past decades. With the establishment of the United Nations Framework Convention on Climate Change in 1992, climate change questions have received a baseline framework under which negotiations on greenhouse gas abatement targets take place. As could be observed during negotiations on the Kyoto Protocol, however, the process of finding a commonly accepted standard of abatement has turned out to be fairly difficult. We analyze to which extent heterogeneity between countries contributes to difficulties in coping with international environmental issues such as climate change.

Climate change abatement can be seen as a pure public good (Stavins 2011). That is, no country can be excluded from benefiting from aggregate provisions, and the good, a stable climate system, does not deplete due to multiple countries benefiting from it. These two properties, non-excludeability and non-rivalry, lead to the most fundamental difficulty in the context of providing international public goods: while all countries benefit from higher aggregate provision, costs are carried only by those actually providing. Hence, countries have an incentive to free-ride on others' provisions. On the national level, a government might be capable of solving such free riding problems through coercion. At the international level, however, there exists no supra-national instance having such coercive power. That is, the sovereignty of nations makes coercion impossible. As Barrett (1990) points out, the formation of agreements thus poses the only way to limit inefficiencies resulting from free riding incentives on the international stage.

The formation of international agreements to cope with free riding incentives in public goods provision might be additionally complicated by heterogeneity between countries. Countries differ, for instance, with respect to abatement costs, endowment and political power. We analyze the impact these three dimensions of heterogeneity have on negotiation outcomes.

First, we consider the effect an increase in cost heterogeneity has on agreement formation. We can show that an increase in cost heterogeneity makes agreement formation more difficult. Second, we look at the impact of endowment heterogeneity on agreement formation. We first consider endowment heterogeneity as an isolated factor and subsequently analyze the way it interacts with cost heterogeneity. Endowment heterogeneity as an isolated factor leads countries with a large endowment to be more willing to participate in negotiations. The effect of an interaction between endowment heterogeneity and cost heterogeneity depends on whether high cost countries are associated with a high or a low endowment. That is, introducing endowment heterogeneity in addition to cost heterogeneity might make a large cost country more willing to participate if it leads to an increase in the large cost country's endowment.

Third, we consider heterogeneity of political power. As Stavins (2011) points out, difficulties with the formation of international agreements on abatement standards seem to be less induced by economical and technological feasibility questions, but rather appear to be due to political coordination problems. We therefore explicitly model political coordination, that is, we introduce a refined voting procedure into the analysis of negotiations on an agreement. We specifically model political heterogeneity through introducing different voting weights. We can show that the political process plays a crucial role in agreement formation. If a country with a large endowment has a larger political weight on the international stage, negotiation outcomes are shifted to its favor. Introducing different voting weights might thus lead a country with larger costs to be more likely to be in an agreement than under unweighted voting and through that make agreement formation easier.

Our work builds on the economic literature on self-enforcing international environmental agreements (IEAs), the general public goods literature and the literature on union formation. The economic literature on self-enforcing international environmental agreements started in the 1990s with the seminal contributions by Carraro and Siniscalco (1993) and Barrett (1994). Since, scholars in the field have looked at numerous ways of how to enhance participation and contributions incentives. However, most of this work has been dealing with homogeneous agents. Barrett (1997) is one of the first to consider heterogeneity. He looks at how benefits from cooperation

can be divided between countries in a coalition and mostly uses simulations to derive results. Botteon and Carraro (2001) and Mc Ginty (2006) extend his framework to a larger number of countries, but also have to use simulations to derive results. Kolstad (2010) is one of the first to present a tractable model of agreement formation under heterogeneity. However, he limits heterogeneity to size and marginal damage and considers only two different types of countries.

Further, the recent literature on public provision of public goods is relevant to our work. Public provision here refers to the formation of agreements to provide public goods. A recent paper which considers the formation of such agreements is Kosfeld et al. (2009). Kosfeld et al. consider heterogeneity with respect to preferences. However, they do not analyze endowment or cost heterogeneity and assume a fairly simplified political process. A recent contribution in the literature on union formation which influenced our work, is Alesina et al. (2005). Alesina et al. consider a setting with heterogeneity and a fairly general political approach, but they do not allow for spillovers between coalition members and non-members.

We combine these different strands of literature and add to them by incorporating a more general approach to heterogeneity and a more refined political process. We present an N-country game theoretic model of agreement formation, allowing for heterogeneity over costs, endowment and political power.

2 The Model

There exist $N \geq 2$ countries which we, in slight abuse of notation, label $i = 1, ..., N$. A country i's preferences with respect to the provision of a public good are given by the following Cobb-Douglas function:

$$U_i = ln(\frac{w_i - (1 + c_i)g_i}{n_i}) + a_i ln(\sum_{j=1}^{N} g_j),$$

where w_i is endowment, c_i are costs, a_i is valuation, n_i is the number of citizens, and g_i is a country's contribution. The first term of the expression denotes the utility received from private consumption, that is, from the part of the endowment that is not invested in the public good. The second part of the expression is the utility

received from the aggregate amount provided, weighted by the respective country's valuation for the good. A country's utility decreases in own provision but increases in aggregate provision.

In order to analyze how an agreement for the provision of such a public good might form, we introduce a three stage setup. In the first stage, countries decide simultaneously and independently whether they wish to enter negotiations over their contribution to a public good. If at least three countries enter, they become participants of negotiations which subsequently take place in the second stage. Participants vote on a common fraction $t \in [0, 1]$ of endowment they wish to contribute[1]. In our baseline model decisions are made by majority rule. Countries vote in favor if they are indifferent between forming an agreement or not. Participants of negotiations cannot leave during the second stage and non-participants cannot enter. If an agreement forms the participants of negotiations turn into members of the agreement.

In the third stage countries contribute depending on whether an agreement formed and, if so, depending on whether they are members of that agreement. If none or only one country decided to enter negotiations all countries provide their privately optimal provision amounts. If at least two countries enter negotiations, an agreement forms in stage two and its members provide according to the fraction t they agreed on, while non-members provide zero. Zero provision of non-members is an assumption which seems to be well reflected in reality. That members provide according to their agreed upon amounts follows because choices made in the second stage are part of subgame perfect strategies.

This three stage setup matches the agreement formation process outlined in most of the literature on international environmental agreements (Wagner 2001) and international public goods provision (Kosfeld et al. 2009). However, we introduce an explicit voting procedure and thereby add more detail to the political process described in the second stage. This helps us to analyze our main underlying question,

[1] An alternative approach could be to allow for different fractions of endowment being contributed by different countries. However, we will follow Barrett (1992) who suggests that a uniform percentage reduction of abatement can be seen as a focal point in climate negotiations. We thus limit our analysis to agreements on a common fraction t of endowment.

the impact of heterogeneity on agreement formation, contributions and welfare.

3 Homogeneous countries

We start by considering the case of homogeneous countries, that is, we assume all countries to have equal costs, endowment, valuation and number of citizens. In that case all countries have the same optimal private provision contributions in an equilibrium without coalition, denoted by

$$g_i = \frac{aw}{(N+a)(1+c)}.$$

The sum of private provisions in such a private provision equilibrium is then $G_P = Ng_i$. If a coalition forms, it provides $G_C = St^*w$ where S is the number of members of the coalition and

$$t^* = \frac{a}{(1+a)(1+c)}.$$

This follows because all voting participants have the same optimal t, so there is no disagreement and the agreed upon t trivially equals all countries' optimal t. We now look at when a coalition is stable. That is, at when a member country of a coalition would have an incentive to not participate or a country not being in the coalition would prefer to participate. A country's utility from being in a coalition is

$$U_C = ln(\frac{w}{n} - \frac{a}{1+a}\frac{w}{n}) + aln(\frac{Saw}{(1+a)(1+c)}),$$

while being outside of a coalition yields utility

$$U_O = ln(\frac{w}{n}) + aln(\frac{Saw}{(1+a)(1+c)}).$$

We now look at the equilibrium coalition size. We find a unique number of countries for which a coalition is stable.

Proposition 1. *If all countries are homogeneous, there exists a unique number of countries that can form a stable agreement in equilibrium, defined by S^* as the smallest integer such that*

$$S^* \geq S = \frac{(1+a)^{\frac{1}{a}}}{(1+a)^{\frac{1}{a}} - 1} \qquad for \quad a \geq 4.$$

Proof. The proposition follows from considering internal and external stability. Comparing the utility a country in a coalition with S members receives to the utility a country being outside of an $S-1$ coalition receives, yields

$$\ln(1-\frac{a}{1+a})+aln(Sw)\geq a\ln((S-1)w). \tag{1}$$

Comparing the utility a country outside of a coalition with S members receives to that which a country participating in a coalition of $S+1$ receives, yields

$$\ln(1-\frac{a}{1+a})+a\ln((S+1)w)\leq a\ln(Sw). \tag{2}$$

For both inequalities the sign flips at some S, such that a coalition is internally stable for $S\leq\bar{S}$ and externally stable for $S\geq\underline{S}$. As $\bar{S}=\underline{S}$, there exists a unique coalition size. □

The expression defining the unique coalition size is independent of costs and endowment. The number of countries involved in a stable coalition thus depends only on the valuation of the respective public good. The higher the good is valued the more countries form a coalition in equilibrium. A special case of this is the formation of a grand coalition, that is, a coalition including all countries. A grand coalition forms if the number of countries is lower than the upper bound for internal stability, $N\leq\bar{S}$. In that case all countries prefer participating in a coalition over not doing so and a coalition with $S=N$ forms.

Corollary 1. *If $N\leq\bar{S}$ a grand coalition with $S=N$ forms.*

4 Cost heterogeneity

We now introduce heterogeneity over costs. Countries might differ with respect to their costs of abatement. That is, while one country might be able to reach some abatement amount fairly easily given the production technology it uses, the same abatement might cause much higher costs for another country. These differences are important to take into consideration as they largely influence countries' willingness to engage in abatement.

If cost heterogeneity is taken into account, privately optimal provisions take the form

$$g_i = \frac{w}{1+c_i} - \frac{1}{N+a}\sum_{i=1}^{N}\frac{w}{1+c_i} \quad \text{and} \quad G_P = \sum_{i=1}^{N} g_i.$$

We then turn to an analysis of the coalitions which can form in equilibrium. We continue to assume that provisions are zero for all non-members. As preferences are single-peaked, the participants in the voting process can be ordered according to their optimal t. Larger costs induce the fraction of endowment a country wishes to contribute to decrease. We order countries from highest costs to lowest costs, that is, from lowest t_i^* to highest t_i^*, given by

$$t_i = \frac{a}{(1+a)(1+c_i)}.$$

The distribution of c is uniform. We limit our analysis to contiguous coalitions. That is, we only consider coalitions formed by countries with adjacent cost levels. This approach follows a result in Alesina et al. (2005).

As the policy space is linear and countries' preferences are single-peaked, the median voter theorem holds. If a coalition forms, it thus provides $G_C = t_M Sw$ where t_M, the fraction of endowment the median country would like to provide, can be expressed by

$$t_M = \frac{a}{(1+a)(1+c_M)}.$$

In the case of an even number of countries joining negotiations, t_M is an average of the two countries around the median position.

The country with the highest costs in a conjectured coalition is then the least likely to be willing to be a member of that coalition. That follows from two different aspects: a private consumption effect and a political effect. The political effect describes the change in the median t if a country does not participate. If a country with a $t > t_M$ were to not participate the new median t, denoted by $\tilde{t_M}$, would be lower than t_M with that country participating. Thus, the fraction contributed by the coalition would be lower. If, however, a country with $t < t_M$ does not participate, then $\tilde{t_M} > t_M$. That is, the fraction contributed by the coalition is larger. The private consumption effect describes the decrease in private consumption which

occurs due to being in the coalition. The larger a country's costs in comparison to median costs, the larger its decrease in private consumption due to contributing. Thus, the country with the highest costs incurs the largest change in utility when leaving the coalition.

We now analyze how an increase in heterogeneity affects the outcome in terms of coalition formation and contributions. New technological developments might bring about changes in the costs of abatement. These changes might either affect all countries or a subgroup, that is, they might induce a shift of the overall cost structure or change the degree of heterogeneity. We are specifically interested in cost changes that hold only for some countries and thus change the degree of cost heterogeneity without shifting the distribution. We call such a change in costs a median-preserving increase of heterogeneity.

A median preserving increase of heterogeneity might occur either as a pull on both sides of the distribution or as a pull on one side while keeping the other fixed. In the first scenario, costs increase for high cost countries while they decrease for low cost countries. In the second scenario, either costs of low cost countries decrease while nothing changes for high cost countries, or costs for high cost countries increase while nothing changes for low cost countries.

An equal increase in heterogeneity on both sides of the median leads to two effects: The decrease in private consumption due to providing becomes larger, and the political effect is stronger, that is, t_M increases more if a large cost country does not participate. Both effects induce a coalition to be less likely to form. An increase of heterogeneity on the low-cost side induces only the political effect to be stronger. An increase on the high cost side only leads to a larger decrease in private consumption.

Proposition 2. *A median preserving increase in the degree of cost heterogeneity makes it harder to reach an agreement.*

Proof. Consider internal and external stability:

$$\begin{aligned} \ln(1-\frac{1+c_i}{1+c_M}\frac{a}{1+a})+ \quad & a\ln(\tfrac{a}{(1+c_M)(1+a)})+ \quad a\ln(Sw) \quad \geq \\ & a\ln(\tfrac{a}{(1+\tilde{c_M})(1+a))}+ \quad a\ln((S-1)w) \end{aligned} \tag{3}$$

and

$$\begin{aligned} & a\ln(\tfrac{a}{(1+c_M)(1+a)}+ \quad a\ln(Sw) \quad \geq \\ \ln(1-\frac{1+c_i}{1+\tilde{c_M^z}}\frac{a}{1+a})+ \quad & a\ln(\tfrac{a}{(1+\tilde{c_M^z})(1+a)}+ \quad a\ln((S+1)w) \end{aligned} \tag{4}$$

If heterogeneity on the low cost side increases, the distance between countries with respect to costs increases. That induces the political effect to be stronger. The difference between t_M when the country with the highest costs in a conjectured coalition participates and $\tilde{t_M}$ when it does not, increases. That makes it more profitable for the country to not participate.

If heterogeneity on the high cost side increases, the difference between the median player and the player with the largest costs increases. Thus, $\frac{1+c_i}{1+c_M}$ increases, which leads the utility received from private consumption to decrease more due to contributing. This makes a country more likely not to participate. In the case of a two-sided heterogeneity increase both effects work together. □

This proposition says that the existence of an equilibrium in which a coalition forms depends on the degree of heterogeneity between countries. If heterogeneity is sufficiently large, coalition formation becomes impossible.

5 Endowment heterogeneity

Differences in size and endowment of countries are probably two of the most visible forms of heterogeneity on the international stage. Size refers to the number of citizens n_i in a country, endowment to its overall wealth w_i, and richness of a country refers to its per-capita income $\frac{w_i}{n_i}$. Heterogeneity along the two dimensions endowment and size leads to four extreme combinations, a rich big country, a rich small country, a poor big country and a poor small country. A rich big country and a rich small country have a higher per-capita endowment than a poor big country and a poor small country.

In our model, willingness to participate in an agreement depends mostly in aggregate endowment. A rich big country is also likely to have a high aggregate endowment, while a poor small country has a low aggregate endowment. A rich small country

and a poor big country most likely are somewhere between these two extremes in terms of aggregate endowment. It is not necessarily clear though whether aggregate endowment is larger for a rich small country or a poor big country.

We assume aggregate endowment to be equidistantly distributed across countries. A country with a larger aggregate endowment is more likely to be in an agreement. This can be seen by rewriting inequalities (1) and (2) to

$$\ln(1-\frac{a}{1+a})+a\ln(\sum_{j\in S}w_j)\geq a\ln(\sum_{j\in S-1}w_j) \tag{5}$$

and

$$a\ln(\sum_{j\in S}w_j)\geq \ln(1-\frac{a}{1+a})+a\ln(\sum_{j\in S+1}w_j). \tag{6}$$

For a country with a large aggregate endowment the utility difference between being member of a coalition and not being member is larger, that is, being in a coalition is more profitable.

We now analyze the effects which result from combining endowment and cost heterogeneity. In order to do so, we rewrite inequalities (3) and (4) to

$$\begin{aligned}\ln(1-\frac{1+c_i}{1+c_M}\frac{a}{1+a})+ \quad a\ln(\tfrac{a}{(1+c_M)(1+a)}+ \quad aln(\sum_{j\in S}w_j) \quad \geq \\ a\ln(\tfrac{a}{(1+\tilde{c_M})(1+a)})+ \quad a\ln(\sum_{j\in S-1}w_j)\end{aligned} \tag{7}$$

and

$$\begin{aligned}a\ln(\tfrac{a}{(1+c_M)(1+a)}+ \quad a\ln(\sum_{j\in S}w_j) \quad \geq \\ \ln(1-\frac{1+c_i}{1+\tilde{c_M}}\frac{a}{1+a})+ \quad a\ln(\tfrac{a}{(1+\tilde{c_M})(1+a)}+ \quad a\ln(\sum_{j\in S+1}w_j)\end{aligned} \tag{8}$$

The insight that a country with a higher endowment is more likely to be in a coalition continues to hold. The effect of additional endowment heterogeneity on coalition formation under cost heterogeneity depends on whether costs are higher for high or low endowment countries. Either one of the two approaches has arguments on

its side. On the one hand, a larger endowment enables a country to invest more in the development of cleaner technologies. As this can substantially lower the costs of abatement, one could argue that large-endowment countries have lower costs of abatement. On the other hand, large endowment countries might already be at a higher abatement level which makes additional abatement more expensive, while low endowment countries might still have enough low-cost emission reduction to engage in. Additionally, a large endowment country has a larger aggregate contribution to make in case it is in a coalition. Thus, one can argue similarly that higher endowment countries on average have higher costs while low endowment countries have lower costs. We thus allow for two different scenarios: First, we consider endowment as being ordered in the same direction as cost heterogeneity. This is the case if marginal costs are assumed to be increasing. Second, we consider endowment to be ordered opposite to cost heterogeneity, which is the case if marginal costs are decreasing.

Proposition 3. *An increase in the degree of endowment heterogeneity makes coalition formation less difficult if marginal costs are increasing. It makes coalition formation more difficult if marginal costs are decreasing.*

Proof. The proof follows directly from equations (7) and (8). Increasing marginal costs lead to higher average costs for a large endowment country. Decreasing marginal costs lead to lower average costs. If a country with high average costs has a high endowment it is more likely to participate, while it is even less likely to participate than it would be under income homogeneity if it has a low endowment. □

6 Political Power

Political power is not distributed equally across countries. Some countries might have a higher weight on the international stage while others might have a lower weight. Such heterogeneity over political weights might make agreement formation more or less difficult, depending on the distribution of weights.

We consider two different settings. In the first setting countries with high costs have a larger weight and in the second setting countries with low costs have a larger weight.

If weight is larger for countries with high cost, $t_{M_{weighted}} < t_M$. That is, $t_{M_{weighted}}$ is closer to a high cost country's optimal t than t_M. This induces a high cost country which participates in a coalition to be better off in the case with weighted voting than in the case without. If a country with high costs opt against participating, on the other hand, it causes the median to change more if it decides against participating. Thus, it would be worse off not participating than what it is in the unweighted voting case. Thus, a large cost country is more likely to be in a coalition than under unweighted voting.

If weight is larger for countries with small costs, $t_{M_{weighted}} > t_M$. That makes a large cost country worse off in case it participates under weighted voting than what it would be under unweighted voting. If it does not participate, on the other hand, it would be better off than under unweighted voting. It induces a lower change in the median t through not participating, that is, not participating causes the coalition provisions to fall less than under unweighted voting.

Proposition 4. *Weighted voting makes coalition formation easier if countries with high costs have greater political power, while it makes coalition formation more difficult if countries with low costs have greater political weight.*

Proof. We first consider the case where weight is larger for countries with large costs and then the case where weight is larger for countries with small costs.

1. Weight is larger for countries with large costs: Assume there exists some coalition S. It holds that $t_{M_{weighted}} < t_M$. For countries with a $t^* \geq t_{M_{weighted}}$ not participating would yield a lower utility than participating. Thus, these countries are more likely to be members of a coalition than to be non-members. We can therefore focus on countries with $t^* < t_{M_{weighted}}$. As $t_{M_{weighted}} < t_M$, $t_{M_{weighted}}$ is closer to these countries' optimal t than t_M. Thus, a high cost country which participates in a coalition is better off in the case with weighted voting than in the case without. At the same time, the political effect is stronger if a high weight country does not participate, that is, it causes the median to change more if it decides against participating. A country with a larger weight is thus worse off not participating than in the unweighted voting case, while it is better off participating than in the unweighted voting case. Therefore, a large cost country is more likely to be in a coalition than under unweighted voting.

2. Weight is larger for countries with small costs: Assume there exists some coalition S. It holds that $t_{M_{weighted}} > t_M$. As above, for countries with a $t^* \geq t_{M_{weighted}}$ not

participating would yield a lower utility than participating. Thus, these countries are more likely to be members of a coalition than to be non-members. We can therefore again focus on countries with $t^* < t_{M_{weighted}}$. As $t_{M_{weighted}} > t_M$, $t_{M_{weighted}}$ is further away from these countries' optimal t. That makes a large cost country worse off in case it participates under weighted voting than what it would be under unweighted voting. If it does not participate, on the other hand, it would be better off than under unweighted voting because it induces a lower increase in the median t through not participating. □

We now look at an extreme case, where one country in a coalition is able to dictate the t which will be provided. In such a case the weight of all other countries in a coalition is zero and they have no influence at all on the provision outcome. Consider a high cost country being the dictator. This country has a relatively low t^* compared to the other countries, which leads to a relatively large incentive for countries to participate. We can thus make the following statement with respect to coalition size and provisions.

Corollary 2. *If there is a high cost dictator in a coalition, the number of members of the coalition weakly increases, while t weakly decreases compared to a setting with equal voting weights.*

We now take a closer look at the factors that induce heterogeneity over political weights. We argue that political weight might be seen as linked to endowment, saying that a country with a larger endowment often has a larger political weight. While potentially neglecting some aspects that might cause differences in political weights, such as for instance historical relevance, this approach reflects much of the political heterogeneity observed on the international stage.

Furthermore, a country's cost structure might be seen as linked to endowment. That is, one could either see marginal costs as decreasing in endowment or as increasing. Increasing marginal costs would lead to higher average costs of a country with a larger endowment, because such a country has to provide a larger aggregate amount if it participates in a coalition. Following the same line of reasoning, decreasing marginal costs would lead to lower average costs of a country with a large endowment. We argue that increasing marginal costs can be seen as the more intuitive assumption. Based on that we can make the following statement.

Corollary 3. *If political power is positively correlated with endowment and high endowment countries have higher average costs, coalition formation is less difficult under weighted voting than under unweighted voting.*

7 Conclusion

We have shown that if countries are homogeneous, there exists a unique number of countries that can form a stable agreement in equilibrium. If we allow for cost heterogeneity, agreement formation becomes more difficult. We have seen that the country with the highest costs is the least likely to be willing to be a member of a coalition and we have argued that this follows from a private consumption effect and a political effect. The existence of an equilibrium in which a coalition forms thus depends on the degree of heterogeneity between countries. If heterogeneity is sufficiently large, coalition formation may become impossible.

Further, we looked at the impact of endowment heterogeneity on agreement formation. We first considered pure endowment heterogeneity and then analyzed the way it interacts with cost heterogeneity. Endowment heterogeneity leads countries with a large endowment to be more willing to participate in negotiations. The effect of an interaction between endowment heterogeneity and cost heterogeneity depends on whether high cost countries are associated with a high or a low endowment. We have shown that introducing endowment heterogeneity in addition to cost heterogeneity might make a large cost country more willing to participate if it leads to an increase in the large cost country's endowment.

Subsequently, we considered heterogeneity of political power. We modeled political coordination through introducing an explicit voting procedure into the analysis of negotiations, where political heterogeneity was introduced through different voting weights. We were able to show that the political process plays a crucial role in agreement formation. If a country with a large endowment has a larger political weight on the international stage, negotiation outcomes are shifted to its favor. Introducing different voting weights might thus lead a country with larger costs to be more likely to be in an agreement than under unweighted voting. Thus, if political power is positively correlated with costs, coalition formation is less difficult under

weighted voting than under unweighted voting.

We have thus seen that cost heterogeneity has a direct negative effect on agreement formation. Heterogeneity over costs causes countries to differ with respect to the amount they are willing to contribute to a public good. Such differences in willingness to contribute lead agreement formation to be fairly difficult, especially if differences are substantial. Endowment heterogeneity, on the other hand, has a more indirect effect. It does not change countries direct willingness to contribute, but has an indirect effect which is based on the externalities caused by a country. A larger country causes larger positive externalities for other countries if it provides. If it does not provide, however, aggregate amount provided decreases more than if a smaller country decided against joining.

In that sense, a larger country can be seen as more decisive for the outcome of negotiations. That idea can be reflected through weighted voting. We showed that, if there is a high cost dictator in a coalition, the number of members of the coalition weakly increases. One could, for instance, argue that such a high cost dictator situation resembles the negotiations around the Montreal Protocol, where the U.S. was the single most decisive country in banning ozone depleting substances. On the contrary, negotiations around climate change abatement are more multilateral, that is, the group of decisive countries is substantially larger. As countries within that decisive group are heterogeneous with respect to abatement costs, agreement formation is more difficult. Changes in the general political setting on the international stage, combined with differences in the underlying cost structure of abatement, might thus constitute a possible reason for difficulties in the formation of an agreement on climate change abatement.

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