2010
17

Working Paper

INSTITUTO DE POLÍTICAS Y BIENES PÚBLICOS (IPP)

COALITION FORMATION AND BARGAINING POWER: THEORY AND APPLICATION TO INTERNATIONAL NEGOTIATIONS ON PUBLIC GOODS

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How to quote or cite this document:

Caparrós, A. & Péreau, J. C. (2010). Coalition formation and bargaining power: theory and application to international negotiations on public goods. Instituto de Políticas y Bienes Públicos (IPP), CCHS-CSIC, Working paper, Number 17.
http://hdl.handle.net/10261/28914

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Coalition formation and bargaining power: Theory and application to international negotiations on public goods

November 24, 2009

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Coalition formation and bargaining power: Theory and application to international negotiations on public goods

Abstract: This paper studies the role of bargaining power in coalition formation when two groups of substantially different agents negotiate over a public good with positive or negative spillovers. Both types of agent are allowed to form coalitions before the negotiations start. The forming of coalitions does or does not increase bargaining power, depending on the type of public good and the impact on the agents not participating in the equilibrium agreements. After analyzing the general game we apply it to North-South negotiations. For a public good with positive spillovers, such as climate change abatement, southern countries increase their bargaining power by forming a coalition when a partial agreement induces larger indirect gains for northern countries not participating in the agreement than for non-participating southern countries. We obtain similar results, with the opposite sign, for the formation of a northern coalition.

JEL Classification: C78, Q54, F59.

Keywords: game theory, bargaining, coalition formation, climate change, international environmental agreements.

1 Introduction

This paper studies the role of bargaining power in coalition formation when two groups of substantially different agents negotiate over a public good with positive or negative spillovers (or a private good). Although the model developed below could be applied to negotiations between a group of buyers and a group of sellers over a private good, we will use the case of international negotiations over public goods to illustrate our model. The reasons for this choice are that negotiations over public goods (with positive or negative spillovers) are quite common in the international arena and that the formation of coalitions is also a common practice in international negotiations. Of the different examples that could be used to illustrate these negotiations, we have decided to focus on climate change negotiations, due to their relevance and to the fact that a large literature has applied game theoretic models to analyze these negotiations.

In 1992 virtually all the countries of the world signed and ratified the United Nations Framework Convention on Climate Change, the ultimate objective of which is to achieve the 'stabilization of greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic inference with the climate system'. Five years later, the Kyoto Protocol was signed, engaging countries included in Annex I (OECD countries and economies in transition) to reduce their overall emission by five per cent in 2012 compared to 1990 but leaving non-Annex I countries without abatement commitments. In other words, right from the start, the international community recognized that there were two types of fundamentally different countries: Annex I countries (developed countries that accepted a 'historical responsibility' in the current levels of atmospheric CO2) and non-Annex I countries (developing countries with a reduced 'historical responsibility' and an urgent need for development). Nevertheless, every year

non-Annex I countries represent a more relevant part of the total emissions with the result that the current negotiation rounds are focusing on the best way to convince these countries to accept binding abatement efforts. However, it is unlikely that non-Annex I countries (hereinafter, "southern countries") will accept these binding targets without some kind of transfer from Annex I countries ("northern countries"). This "transfer" could take the form of money (unlikely in large sums) or any other form of benefit (technology transfers or better conditions in other negotiations).

The previous discussion has shown that, if we are looking for negotiations over a public good with two substantially different types of agent, climate change negotiations are a good example. It remains to be seen if coalitions play a significant role in these negotiations. The answer is yes, as during all the negotiation rounds countries have organized themselves into coalitions, such as the Umbrella Group (US and similarly minded countries during the nineties), the European Union, the G77 and China (a large coalition of developing countries), the Least Developed Countries, the AOASIS (small island countries) and more recently the Rainforest Coalition (a coalition including almost all countries with rainforests, except Brazil).

The question to which we are looking for an answer is whether or not there is a natural tendency for this type of negotiation over global public goods to be carried out between a reduced number of coalitions and whether the reason for this possible tendency is based on efficiency gains or bargaining power gains (or both). Existing literature adds relatively little to this question. The bulk of the literature on International Environmental Agreements (IEA) focuses on the formation of a single coalition with more or less similar countries, chiefly using the concept of internal and external stability from non-cooperative game theory (Finus, 2001). In the initial papers, all countries were assumed to be identical

(Carraro and Siniscalco, 1993; Barret, 1994), although this assumption has been relaxed in recent years (McGinty, 2007). Another branch of the literature, more concerned with transfers and initiated by Chander and Tulkens (1997) uses cooperative game theory to determine optimal transfer schemes but without modeling negotiations explicitly and without analyzing the role of bargaining power. In general, this literature does not analyze the negotiation process itself and the concept of "coalition" used also differs from the one we are going to use. In the literature on IEAs a "coalition" is a group of countries that have decided to determine jointly their GHG abatement effort (this is usually done by assuming that they have merged and now maximize their welfare jointly). In our framework, a coalition is a group of countries that have decided to join forces in international negotiations over a public good. In other words, for us, "G77 and China" or the "Rainforest Coalition" are coalitions whereas they are not for most of the remaining literature on IEA. An exception can be found in Caparrós et al. (2004) who use the same concept of coalition as we do. The authors model international negotiations on climate change abatement efforts using a bargaining procedure à la Rubinstein but focusing only on the case of one northern coalition negotiating with one or two southern coalitions (see Carraro et al. (2005) or Harstad (2008) for a survey on bargaining theory and the use of this theory in the analysis of international negotiations). Furthermore, Caparrós et al. (2004) focus on asymmetries of information but not so much on the public good aspect of the problem.

Our focus on negotiations among coalitions of substantially different agents also distinguishes our paper from the now large literature that focuses on the formation of coalitions, such as Bloch (1996), Ray and Vohra (2001), Maskin (2003) or de Clippel and Serrano (2008). These papers take into account the interactions between coalitions when decid-

ing the coalition structure to be formed but they do not explicitly model the negotiation between coalitions.

In this paper we start by setting up a general framework to model negotiations between N different northern countries and S different southern countries over a public good with positive or negative spillovers. Both groups of countries can decide whether or not to form coalitions and, once this decision has been taken, they will engage in a negotiation à la Rubinstein to decide on the transfers offered by northern countries (northern coalitions) to southern countries (or coalitions). To avoid the problem of multiplicity of equilibria, we concentrate on a multilateral negotiation involving bilateral bargaining protocols. Our approach relies partly on Chipty and Snyder (1999), who analyze bilateral bargaining between an upstream firm and several downstream firms over a private good. We extend this framework to a public good with several "buyers" and "sellers", considering simultaneous Rubinstein negotiations. We then analyze the incentives that southern and northern countries have to form coalitions and differentiate the efficiency gains from the bargaining power gains. We show that whether or not the forming of coalitions increases bargaining power will depend on the type of public good and the impact on the countries not participating in the equilibrium agreements. For a public good with positive spillovers, such as climate change abatement, southern countries increase their bargaining power by forming a coalition if a partial agreement induces larger indirect gains for northern countries not participating in the agreement than for non-participating southern countries (we obtain similar results, but with the opposite sign, for the formation of a northern coalition).

The article is organized as follows. Section 2 outlines the general model, discussing the important distinction in our framework between an agreement structure and a coalition

structure. Section 3 and 4 show, respectively, the outcomes of the agreement structure selection process and the coalition structure selection process. Section 5 discusses the implications of our model for the analysis of climate negotiations. Section 6 concludes.

2 The model

2.1 Coalition structure and agreement structure

N $\{1, .., n\}$ is the set of northern countries and S $\{1, .., m\}$ the set of southern countries. The northern countries are the "buyers" of the emission reductions made by the southern countries (i.e. the northern countries are willing to negotiate over a transfer, in the form of money or other benefits, to the southern countries in exchange for their abatement efforts). A *coalition structure* of northern countries is a partition τ_N of N and a *coalition structure* of southern countries is a partition τ_S of S. Let Ω_N denote the set of all northern coalition structures and Ω_S the set of all southern coalition structures and let N_i denote an arbitrary northern coalition and S_j an arbitrary southern coalition. For each pair (τ_N, τ_S) an *agreement structure* $\phi(\tau_N, \tau_S)$ is a set of bilateral agreements. Let $\Phi(\tau_N, \tau_S)$ denote the set of all agreement structures for the pair (τ_N, τ_S). A partition function Ψ (Thrall and Lucas, 1963) assigns a worth $\Pi(N_i, S_j, \phi(\tau_N, \tau_S)) > 0$ to each agreement (N_i, S_j) between a northern coalition N_i and a southern coalition S_j in an agreement structure $\phi(\tau_N, \tau_S)$. The worth attributed to this particular bilateral agreement assumes that all the remaining players reach their optimal agreements. The distribution of this worth between N_i and S_j takes place following a bargaining process à la Rubinstein, leading to a worth of Π_{N_i} for the northern coalition and a worth of Π_{S_j} for the southern coalition. Northern and southern countries (coalitions) have different discount factors although all northern

(southern) countries share the same discount factor, with $1 > \delta_N, \delta_S > 0$. That is, we are assuming that northern countries (respectively southern countries) are relatively similar one to another but that northern and southern countries are fundamentally different. The game Γ has four stages: (i) stage 1, formation of the northern coalition structure τ_N^*, (ii) stage 2, formation of the southern coalition structure τ_S^*, (iii) stage 3, choice of the bilateral agreements to be negotiated between northern and southern coalitions (agreement structure), and (iv) stage 4, alternating-offers bargaining over the distribution of the worth generated by the bilateral agreements.

We make the following assumptions:

A1: *The coalition structure τ_N (respectively τ_S) is decided by the northern (southern) countries maximizing the aggregated worth for the northern (southern) countries.*

A2: *For each pair (τ_N, τ_S), the agreement structure $\phi(\tau_N, \tau_S)$ with the highest aggregated worth is selected out of $\Phi(\tau_N, \tau_S)$.*

A3: *The tie-breaking rule in A1 and A2 is random selection.*

A4: *The distribution of the surplus of each bilateral agreement is negotiated following Rubinstein's alternating-offer procedure, with the North proposing the first offer and under the belief that all the other optimal agreements are implemented.*

A5: *The southern coalitions can participate in only one bilateral agreement.*

A1 allows us to select the particular coalition structures that the North and the South will choose. More complex coalition formation procedures could also be considered (see e.g. Ray and Vohra (1999)); however, as we are interested in the agreements coming out from the different coalition structures we have decided to keep this part as simple as possible. A2 states that the agreement structure which maximizes the worth to be distributed is the one which will be selected. This is the same as stating that the North

will choose the agreement structure that maximizes the aggregate worth obtained by the North, since, as shown below in more detail, the bargaining procedure ultimately distributes the worth generated by a given agreement according to a distribution rule that is defined by the relative discount factors of the North and South. Therefore, the higher the aggregated worth of the agreement structure, the higher will be the aggregated worth which the North will obtain. A3 ensures that only one structure is selected when several structures yield the maximum worth for the decision maker. An alternative assumption with similar result would be, for example, to prefer a coalition structures with fewer coalitions (because the formation of a coalition has transaction costs). Assumption A4 states that the negotiation of the bilateral agreement will be carried out by alternating offers from the North and offers from the South until an agreement is reached (Rubinstein, 1982). In turn, this assumption implies a set of assumptions associated with this particular bargaining model that are well known (Rubinstein, 1982). A5 simplifies the analysis, especially in the section below where we will specify the partition function Ψ. These assumptions allow us to write the following proposition:

Proposition 1 *The game* Γ *has a unique subgame perfect equilibrium.*

Proof. The proof is by standard backward induction and we only sketch it. In stage 4 τ_N^*, τ_S^* and $\phi^*(\tau_N^*, \tau_S^*)$ have already been decided. $\Pi(N_i, S_j, \phi^*(\tau_N^*, \tau_S^*))$ gives the surplus to be shared between N_i and S_j in an arbitrary agreement that is part of $\phi^*(\tau_N^*, \tau_S^*)$. From A3 we know that the worth will be distributed according to the Rubinstein Bargaining Solution yielding a benefit Π_{N_i} for the North and a benefit Π_{S_j} for the South. Since this is a bilateral bargaining under complete information it is a well know result that the Subgame Perfect Equilibrium (SPE) of the Rubinstein procedure is unique. In

stage 3 we use the information obtained in stage 4 to calculate Π_{N_i} for each agreement structure $\phi(\tau_N^*, \tau_S^*)$ in $\Phi(\tau_N^*, \tau_S^*)$. From A2 the agreement structure $\phi^*(\tau_N^*, \tau_S^*)$ that maximizes $\sum_{i,j} \Pi(N_i, S_j, \phi(\tau_N^*, \tau_S^*))$ is selected, which is unique by A3. In stage 2 the southern coalitions know for each coalition structure τ_S the agreement structure that will be selected and the associated payments to the different southern coalitions involved in the subsequent agreements. They select the coalition structure τ_S^* that maximizes $\sum_j \Pi_{S_j}$. Similarly, the North selects in Stage 1 the coalition structure τ_N^* that maximizes $\sum_i \Pi_{N_i}$.

■

2.2 Example

We present now a simple example to illustrate game Γ. Assume there are 2 northern countries and 2 southern countries. Ω_N is $\{[N_1, N_2], [N_1 \cup N_2]\}$ and Ω_S is $\{[S_1, S_2], [S_1 \cup S_2]\}$, i.e. the northern countries and the southern countries can either act united or separated (countries in square brackets indicate a particular coalition structure, $\cup$ is used to show countries acting together as a coalition). To simplify assume that both type of countries have a common discount factor δ and that $\Delta \to 0$ (the interval between offers is infinitesimal).

For the particular pair $(\tau_N, \tau_S) = ([N_1, N_2], [S_1, S_2])$, where both the North and the South act independently, Table 1 shows in the first column all the different agreement structures $\phi(\tau_N, \tau_S)$ and in the second column the worth associated with each bilateral agreement in the corresponding agreement structure. Therefore, $\Phi(\tau_N, \tau_S)$ is the set of all the agreement structures shown in column 1 (bilateral agreements are shown in parenthesis, i.e., (N_1, S_1) means a bilateral agreement between N_1 and S_1). There should be a similar table for all the possible pairs (τ_N, τ_S).

[Table 1]

The distribution of the worth shown in the second column takes place in Stage 4 following A4. Since we have assumed for this example that $\delta_N = \delta_S = \delta$ and $\Delta \to 0$, Rubinstein's procedure simplifies to the Nash Bargaining Solution and the worth is distributed equally between the northern coalition (column 3 in Table 1) and the southern coalition involved in the agreement (column 4 in Table 1). To further simplify the example, we assume that the worth obtained by a country that does not take part in any bilateral agreement is zero.

In Stage 3, and using A2, the agreement structure $\{(N_1, S_1), (N_2, S_2)\}$ is chosen since it has an aggregate worth of $\sum_{i,j} \Pi_{ij} = 140$. Repeating this process for all the coalition structure pairs in (Ω_N, Ω_S) yields the optimal agreement structure for each coalition structure pair. In our example, the additional coalition structure pairs in (Ω_N, Ω_S) to be considered are: $\{[N_1 \cup N_2], [S_1, S_2]\}$, where the North acts united and the South separated; $\{[N_1, N_2], [S_1 \cup S_2]\}$, where the North acts separated and the South united; and $\{[N_1 \cup N_2], [S_1 \cup S_2]\}$, where the North and the South act united.

Table 2 shows the result of this process (for the coalition structure pairs not considered in Table 1 we have selected arbitrary optimal agreement structures and arbitrary values). Column 1 in Table 2 shows the different coalition structures pairs available, column 2 the optimal agreement structures resulting from step 1, and columns 3 and 4 the aggregated worth for the North and the South, respectively.

[Table 2]

In Stage 2, and using A1, the South selects to go separated if the North goes separated (since $70 > 40$) and to go separated if the North goes united ($50 > 30$). Taking this information into account the North decides in Stage 1, and again using A1, to act

separated (since $70 > 50$). That is, in our example the coalition structure selected is $\{[N_1, N_2], [S_1, S_2]\}$, i.e., both the northern and the southern countries act independently and the resulting agreement structure is $\{(N_1, S_1), (N_2, S_2)\}$. The bilateral agreement (N_1, S_1) has a worth of 100 and this worth is distributed evenly between N_1 and S_1. The bilateral agreement (N_2, S_2) has a worth of 40 and would be distributed equally between N_2 and S_2.

3 Bargaining and agreement structure

The general setting in the previous section allows us to clarify how the negotiation process works. However, since it allows us to say relatively little, we now specify the partition function Ψ that assigns the worth $\Pi(N_i, S_j, \phi(\tau_N, \tau_S))$ as a function of the abatement and the transfers that result from each particular bilateral agreement. In order to do this, we start by defining the payoffs for the northern and southern coalitions.

The payoff of one northern coalition or country N_i (we generally refer to coalitions, but without excluding that a country acts as a singleton) is given by the function $V_i(Q, \overline{Q})$, where $Q = (q_1, ..., q_j, ...q_m)$ stands for the abatement performed by the southern coalitions and $\overline{Q} = (\bar{q}_1, ..., \bar{q}_i, ...\bar{q}_n)$ for the abatement made by the northern coalitions. All costs and benefits, except the transfer, are included in V_i. We further assume that the emission abatements made by the northern coalitions are an optimal reaction to the abatement of the South after the agreements discussed below have been signed. That is, we assume that northern countries act as Stackelberg leaders and decide their abatement levels according to the reaction function $\overline{q}_i = f_i(Q)$. Since this implies that $\overline{q}_i$ and $\overline{Q}$ are functions of southern abatement we can omit them in the payoff expressions. Hence:

$$U_{N_i} = V_i(Q) - \sum_{j=1}^{J_i} T_{ij} \tag{1}$$

Although this is not necessary to derive most of the results below, in order to facilitate the interpretation we assume that the value function takes the form $V_i(Q) = B_{N_i}(Q) - C_{N_i}(\overline{q}_i)$, where N_i benefits from the total emission reductions (B_{N_i}) but only bears the cost (C_{N_i}) of the abatement that it performs at home. Nevertheless, when a northern coalition signs an environmental agreement with some (at least one) southern coalition j, it also bears the cost of the transfer T_{ij} for each one of the J_i agreements it signs. The abatement q_j performed by a southern coalition j in exchange to the transfer granted by the North i, benefits i directly ($\frac{\partial B_{N_i}}{\partial q_j} \geq 0$) and reduces the abatement to be done by i at home (i.e. $\frac{\partial C_{N_i}}{\partial q_j} \leq 0$). However, other northern coalitions do not necessarily benefit from this abatement (it may benefit them but it may harm them in political terms, i.e., spillovers can be positive or negative).

Since by A5 a southern coalition S_j can only be involved in one bilateral agreement we have:

$$U_{S_j} = v_j(Q) + T_{ij} \tag{2}$$

Again, all costs and benefits except the transfer are included in v_j and we assume that $v_j(Q) = B_{S_j}(Q) - C_{S_j}(q_j)$. We assume $\frac{\partial B_{S_j}}{\partial q_j} \geq 0$ and $\frac{\partial C_{S_j}}{\partial q_j} \geq 0$. We further assume that for each possible bilateral agreement there is at least one level of abatement q_j for which $V_i(Q) + v_j(Q) > 0$.

3.1 Bilateral bargaining (Stage 4)

As indicated in A4, the transfer is determined by the Rubinstein Bargaining Solution (hereinafter, RBS) and is negotiated at stage 4. At this stage, the two parts of each bilateral agreement are already known and so is the abatement effort that the South must perform if the agreement is reached. Denoting the abatement made by all the southern coalitions not involved in the bilateral agreement by Q^*_{-j}, an agreement between N_i and S_j yields:

$$U^a_{N_i} = V_i(q_j, Q^*_{-j}) - T_{ij} - \sum_{l \neq j} T^*_{il} \quad (3)$$

$$U^a_{S_j} = v_j(q_j, Q^*_{-j}) + T_{ij} \quad (4)$$

A disagreement means that S_j will implement its non cooperative abatement q^{nc}_j. Nevertheless, the optimal agreement(s) obtained with the other southern coalition(s) Q^*_{-j} will continue to hold. That is, in every negotiation the northern coalition and the southern coalition believe that their failure to reach an agreement would not affect the other optimal agreements, which are negotiated simultaneously. Hence:

$$U^d_{N_i} = V_i(q^{nc}_j, Q^*_{-j}) - \sum_{l \neq j} T^*_{il} \quad (5)$$

$$U^d_{S_j} = v_j(q^{nc}_j, Q^*_{-j}) \quad (6)$$

where $q^{nc}_j = \arg\max_x v_j(x, Q^*_{-j})$, i.e. coalition S_j would choose the abatement level that maximizes its own payoff, assuming that all the other countries reach their optimal

agreements. We define the net payoff functions (R) from an agreement at period τ as:

$$\begin{aligned} R_i(T_{ij},\tau) &= \delta_N^\tau \left(U_i^a - U_i^d\right) = \delta_N^\tau \left(V_i(Q^*) - V_i(q_j^{nc}, Q_{-j}^*) - T_{ij}\right) \\ R_j(T_{ij},\tau) &= \delta_S^\tau \left(U_j^a - U_j^d\right) = \delta_S^\tau \left(v_j(Q^*) - v_j(q_j^{nc}, Q_{-j}^*) + T_{ij}\right) \end{aligned}$$

Let $T_{ij}^{(i)}$ be the offer or the counteroffer made by i over the transfer T_{ij} received by j. Rubinstein's bargaining procedure mentioned above is as follows: N_i makes an offer of a transfer $T_{ij}^{(i)}$ to S_j. If S_j accepts then the bargaining is over. If S_j declines the offer, S_j proposes a counteroffer $T_{ij}^{(j)}$. The alternating-offers procedure continues until an agreement is reached. The RBS that we are looking for is the unique SPE given by the following two conditions: $R_i(T_{ij}^{(j)}, 0) = R_i(T_{ij}^{(i)}, 1)$ and $R_j(T_{ij}^{(i)}, 0) = R_j(T_{ij}^{(j)}, 1)$. This yields:

$$\begin{aligned} V_i(Q^*) - V_i(q_j^{nc}, Q_{-j}^*) - T_{ij}^{(j)} &= \delta_N \left[V_i(Q^*) - V_i(q_j^{nc}, Q_{-j}^*) - T_{ij}^{(i)}\right] \\ v_j(Q^*) - v_j(q_j^{nc}, Q_{-j}^*) + T_{ij}^{(i)} &= \delta_S \left[v_j(Q^*) - v_j(q_j^{nc}, Q_{-j}^*) + T_{ij}^{(j)}\right] \end{aligned}$$

The first equation asserts that N_i is indifferent in terms of expected payoffs as regards accepting S_j's offer $T_{ij}^{(j)}$ in the current period or rejecting it and making in the following period the counteroffer $T_{ij}^{(i)}$ that will be accepted by S_j. The second equation reflects the same indifference for S_j. Since we assume (A4) that N_i makes the first offer, the equilibrium transfer is

$$T_{ij}^* = \frac{\delta_S(1-\delta_N)}{1-\delta_N\delta_S}\left[V_i(Q^*) - V_i(q_j^{nc}, Q_{-j}^*)\right] - \frac{(1-\delta_S)}{(1-\delta_N\delta_S)}\left[v_j(Q^*) - v_j(q_j^{nc}, Q_{-j}^*)\right] \qquad (7)$$

The transfer T_{ij}^* paid by N_i to S_j depends positively on the marginal contribution of S_j

to the surplus obtained by N_i (first term in brackets) and negatively on the marginal contribution to the payoff of S_j (second term in brackets). That is, the more N_i gets out of the agreement the more willing it is to pay and the more the S_j benefits from the agreement the less willing is N_i to pay. The resulting payoffs for N_i and S_j are:

$$\begin{aligned} U_{N_i} &= V_i(Q^*) - T^*_{ij} - \sum_{l \neq j} T^*_{il} = V_i(Q^*) - \sum_j T^*_{ij} \\ U_{S_j} &= v_j(Q^*) + T^*_{ij} \end{aligned}$$

3.2 Agreement structure and abatement (Stage 3)

At this stage both coalition structures (τ^*_N, τ^*_S) have been formed. The agreement structure set $\Phi(\tau^*_N, \tau^*_S)$ includes all the possible combinations of bilateral agreements between these two coalition structures. Both players involved know that they will distribute the worth on stage 4 according to the RBS. Thus, they are interested in maximizing the worth of the bilateral agreement by choosing the level of abatement $\hat{q}_j$ that maximizes the surplus. Hence for each possible bilateral agreement within $\Phi(\tau^*_N, \tau^*_S)$ we have that

$$\hat{q}_j = \arg\max_x \left[V_i(x, Q^*_{-j}) + v_j(x, Q^*_{-j}) \right] \tag{8}$$

This gives the abatement effort that would be performed for each possible bilateral agreement. The worth of each one of these agreements is given by

$$\Pi_{ij}(\hat{q}_j, Q^*_{-j}) = \Pi_{ij}(N_i, S_j, \phi(\tau^*_N, \tau^*_S)) = V_i(\hat{q}_j, Q^*_{-j}) + v_j(\hat{q}_j, Q^*_{-j}) \tag{9}$$

This allows us to write the partition function Ψ that assigns the worth $\Pi(N_i, S_j, \phi(\tau_N, \tau_S))$ to each particular bilateral agreement as a function of the abatement made by the dif-

ferent coalitions in the agreement structure. Using this information and applying A2 the agreement structure $\phi^*(\tau_N^*, \tau_S^*)$ selected from $\Phi(\tau_N^*, \tau_S^*)$ includes the agreements which yield the highest aggregate bilateral payoff $\sum \Pi_{ij}$, $(i \in \tau_N^*, j \in \tau_S^*)$ for a given coalition structure pair (τ_N^*, τ_S^*). We denote q_j^* the optimal abatement corresponding to each bilateral agreement in $\phi^*(\tau_N^*, \tau_S^*)$.

4 Coalition formation and bargaining power

4.1 Formation of a southern coalition (Stage 2)

We now analyze the implications of the formation of a southern coalition τ_S at Stage 2. In particular, and without loss of generality, we analyze the case in which two southern countries S_j and S_l face the question of whether or not to form a coalition S_{j^c}. Equations (1)-(8) have to be calculated for the two countries acting separately and for the coalition. To facilitate the discussion we introduce the superscript (sc) to refer to the values calculated in equations (1)-(8) for the southern coalition. The only issue worth mentioning is that since the coalition formation is decided in Stage 2 and bargaining only starts in Stage 4 the impasse point for the coalition S_{j^c} differs from that of the separated countries S_j and S_l.

The formation of a southern coalition at Stage 2 is profitable under the condition that a southern coalition j^c is able to get a higher payoff than two southern countries separately:

$$U_{S_{j^c}} > U_{S_j} + U_{S_l} \tag{10}$$

Let us assume, again without loss of generality, that the northern country i signs an agreement with the southern coalition j^c while the northern country k (respectively p)

signs an agreement with the southern country j (respectively l) when they are separate. Thus, condition (10) yields:

$$v_{j^c}(Q^{sc^*}) + T^{sc^*}_{i,j^c} > v_j(Q^*) + T^*_{kj} + v_l(Q^*) + T^*_{pl} \tag{11}$$

with $T^{sc^*}_{i,j^c}, T^*_{kj}$ and T^*_{pl} given by the equivalent to equation (7). Adding and subtracting $Dv_j(q^{nc}_j, q^{nc}_l, Q^*_{-j-l})$, $Dv_l(q^{nc}_j, q^{nc}_l, Q^*_{-j-l})$, $V_k(q^{nc}_j, q^{nc}_l, Q^*_{-j-l})$ and $V_p(q^{nc}_j, q^{nc}_l, Q^*_{-j-l})$ we can manipulate this expression to obtain a form in which the motives for the formation of a coalition can be distinguished. To this end, we define:

$$\begin{aligned} SE &= \left[v_{j^c}(Q^{sc^*}) + Dv_{j^c}(q^{nc}_{j^c}, Q^{sc^*}_{-j^c})\right] \qquad (12)\\ &\quad - \left[v_l(Q^*) + Dv_l(q^{nc}_j, q^{nc}_l, Q^*_{-j-l})\right] - \left[v_j(Q^*) + Dv_j(q^{nc}_j, q^{nc}_l, Q^*_{-j-l})\right] \\ NE &= \left[V_i(Q^{sc^*}) - V_i(q^{nc}_{j^c}, Q^{sc^*}_{-j^c})\right] \qquad (13)\\ &\quad - \left[V_p(Q^*) - V_p(q^{nc}_j, q^{nc}_l, Q^*_{-j-l})\right] - \left[V_k(Q^*) - V_k(q^{nc}_j, q^{nc}_l, Q^*_{-j-l})\right] \\ SBP &= D\left[v_l(q^{nc}_l, Q^*_{-l}) - v_l(q^{nc}_j, q^{nc}_l, Q^*_{-j-l})\right] \qquad (14)\\ &\quad + D\left[v_j(q^{nc}_j, Q^*_{-j}) - v_j(q^{nc}_j, q^{nc}_l, Q^*_{-j-l})\right] \\ NBP &= \left[V_p(q^{nc}_l, Q^*_{-l}) - V_p(q^{nc}_j, q^{nc}_l, Q^*_{-j-l})\right] \qquad (15)\\ &\quad + \left[V_k(q^{nc}_j, Q^*_{-j}) - V_k(q^{nc}_j, q^{nc}_l, Q^*_{-j-l})\right] \\ D &= \frac{1-\delta_S}{\delta_S(1-\delta_N)} \qquad (16) \end{aligned}$$

SE (respectively NE) compares the direct gains obtained by the different southern (northern, respectively) countries involved in the agreements by going from the status quo situation (Nash equilibrium) to the end situation where all the optimal agreements are in place. Direct net gains can come from fixed-costs savings but also from the different

amounts of abatement to which the southern countries rationally expect they are going to commit themselves while acting united instead of separated. Acting together may also provide the opportunity to share abatement technologies (between the southern countries) and this may reduce marginal abatement costs. We call these benefits "efficiency gains" as most of them fall into this category. However, in many international negotiations the direct net gains can also be political, if it is perceived that negotiating together with other southern countries is more convenient.

SE represents the "southern efficiency", that is, the gain which the southern countries can expect when they act together (first square bracket) minus what they can expect acting separately (second and third square bracket). Note that to compare the two situations the southern countries add what they would obtain in the event of an agreement and their net benefit in the event of a disagreement, since their expected payoff is a function of both eventualities. NE represents the "northern efficiency", the gain which the northern countries would obtain from an agreement with the coalition minus the gain they would obtain when dealing with two separated southern countries. For NE, only the net benefit for the northern countries from the agreement is relevant (i.e. the three square brackets show the difference before and after the different agreements). The reason is that the southern countries, when deciding whether or not to form a coalition, are only interested in the part of the benefit for the North that is relevant to them, i.e. the part that explains the transfer they can expect to obtain.

The first square bracket in (14) shows the indirect gain that an agreement between the southern country j and the northern country k induces for the southern country l as long as l sign no agreement (the second square bracket shows the indirect gain for j of an agreement between l and p). The first square bracket in (15) shows the indirect gain

which the agreement between j and k induces for the northern country p if it does not sign any agreement (the second square bracket shows the indirect gain for k of an agreement between l and p). We refer to SBP and NBP as "bargaining power" terms. These gains are irrelevant in equilibrium (where all countries sign their optimal agreements) but, as we show below, they determine whether or not forming a coalition increases bargaining power. As in standard one to one bargaining situations, the agreement that never takes place in equilibrium, the impasse point, defines the bargaining power of the different agents. That is, NE and SE capture the differences in the gains obtained in equilibrium between acting as a coalition and acting separately. However, the out-of-equilibrium information captured in $(NBP - SBP)$ is also relevant for deciding whether or not to form a coalition. Furthermore, what defines $(NBP - SBP)$ are the indirect gains obtained in this out-of-equilibrium situation by the countries not taking part in the partial agreements (while NE and SE focus on the direct gains obtained by the countries taking part in the agreements).

Finally, D collects the discount terms and has the following properties: (i) for a given δ_S, the larger δ_N the larger D, (ii) for a given δ_N, the larger δ_S the smaller D, (iii) if $\delta_N = \delta_S$ the larger the discount rate the smaller D, and (iv) $D > 0$. In other words, a decrease in D implies more patient countries or a more patient South compared to the North. In most economic analysis discount factors are assumed to be smaller for southern countries than for northern countries (or discount rates larger). Nevertheless, the terms included in D are not necessarily related to financial discount rates but incorporate all "political" reasons that may explain why one country is more impatient than another to reach an agreement. In international negotiations over climate change internal political pressure may be stronger in northern countries implying that they are more impatient

to reach an agreement, and this would yield $\delta_N < \delta_S$. We can now write the following proposition:

Proposition 2 *Southern countries have an incentive to form a coalition if* $SE + NE + (NBP - SBP) > 0$.

Proof. Rewrite (11) using equations (12) to (16). ■

Focusing only on the bargaining power terms we can write:

Corollary 3 *Assume that forming a southern coalition has no efficiency gains (i.e.* $SE = NE = 0$*). The formation of a southern coalition is solely determined by the bargaining power terms and:*

(i) If the public good has positive spillovers for the North and negative spillovers for the South, southern countries have an incentive to form a coalition.

(ii) If the public good has negative spillovers for the North and positive spillovers for the South, southern countries have no incentive to form a coalition.

(iii) If the public good has positive spillovers for both North and South, southern countries have an incentive to form a coalition if $NBP > SBP$.

(iv) If the public good has negative spillovers for both North and South, southern countries have an incentive to form a coalition if $NBP < SBP$.

(v) the bargaining power terms are zero for private goods.

Proof. If we are dealing with a public good with positive spillovers for the North, the increase in abatement provided by j comes to no cost to p (because the agreement has

been signed between j and k), i.e., $V_p(q_l^{nc}, Q_{-l}^*) > V_p(q_j^{nc}, q_l^{nc}, Q_{-j-l}^*)$. Since the same holds for the second square bracket in (15) we have that $NBP \geq 0$. More precisely, $NBP > 0$ if $p \neq k$ and the spillovers are strictly positive and $NBP = 0$ if $p = k$. Following similar reasoning, and recalling that $D > 0$, we can show that for public goods with negative spillovers for the North we have $NBP \leq 0$, and that $SBP \geq 0$ if we are dealing with a public good with positive spillovers for the South, i.e. $v_j(q_j^{nc}, Q_{-j}^*) > v_j(q_j^{nc}, q_l^{nc}, Q_{-j-l}^*)$, and $SBP \leq 0$ for a public good with negative spillovers for the South. NBP and SBP are zero for private goods since they collect only indirect benefits obtained by those not taking part in the agreements. Combining this information with Proposition (3) yields the corollary. ■

That is, even in the eventuality that $SE = NE = 0$ (i.e., that all the countries involved in the agreements obtain the same benefit by passing from the status quo situation to the final situation with all the optimal agreements in place), the southern countries may have incentives to form a coalition, depending on the relative values of the bargaining terms NBP and SBP. In the most relevant case to our discussion on climate change negotiations, we are dealing with a public good with positive spillovers. Thus, if $NBP > SBP$ southern countries have an incentive to form a coalition. In other words, southern countries have an incentive to form a coalition in climate change negotiations, if, while acting separately, a partial agreement induces a larger indirect gain for northern countries that do not participate than for southern countries that are not part of the agreement (taking into account in the latter case the impact of D).

4.2 Formation of a northern coalition (Stage 1)

This sub-section analyzes the implications of the formation of a northern coalition τ_N at Stage 1. As before, without loss of generality, we focus on the case in which two northern countries N_i and N_k decide whether or not to form a coalition N_{i^c}; introducing the superscript (bc) to refer to the values calculated using equations (1)-(8) for the northern coalition.

To consider the formation of a northern coalition, we assume that when they are separated N_i signs an agreement with J_i southern coalitions (indexed by z) and N_k signs an agreement with J_k southern coalitions (indexed by y). The sets J_i and J_k are disjoint such that $J_i \cap J_k = \emptyset$. Finally, we consider that the northern coalition N_{i^c} signs an agreement with J_{i^c} southern coalitions (indexed by w), although we do not impose the condition $J_{i^c} = J_i + J_k$. In all cases the southern coalitions involved are given by the optimal southern coalition structure τ_S^* formed in Stage 2 as a reaction to the northern coalition structure τ_N. The formation of a northern coalition will be profitable if:

$$U_{N_{i^c}} > U_{N_i} + U_{N_k} \tag{17}$$

$$V_{i^c}(Q^{bc^*}) - \sum_{w=1}^{J_{i^c}} T_{i^c w}^{bc^*} > V_i(Q^*) - \sum_{z=1}^{J_i} T_{iz}^* + V_k(Q^*) - \sum_{y=1}^{J_k} T_{ky}^* \tag{18}$$

with $T_{i^c w}^{bc^*}, T_{iz}^*$ and T_{ky}^* given by the equivalent to equation (7). By adding and subtracting $\sum_{z=1}^{J_i} v_z(q_z^{nc}, q_y^{nc}, Q_{-z-y}^*)$, $\sum_{y=1}^{J_k} v_y(q_z^{nc}, q_y^{nc}, Q_{-z-y}^*)$, $D^{-1}\sum_{z=1}^{J_i} V_i(q_z^{nc}, q_y^{nc}, Q_{-z-y}^*)$ and

$D^{-1}\sum_{y=1}^{J_k} V_k(q_z^{nc}, q_y^{nc}, Q_{-z-y}^*)$ we define:

$$\begin{aligned}
\overline{SE} &= \sum_{w=1}^{J_{i^c}} v\left[{}_w(Q^{bc^*}) - v_w(q_w^{nc}, Q_{-w}^{bc^*})\right] \qquad (19)\\
&\quad - \sum_{z=1}^{J_i}\left[v_z(Q^*) - v_z(q_z^{nc}, q_y^{nc}, Q_{-z-y}^*)\right] - \sum_{y=1}^{J_k}\left[v_y(Q^*) - v_y(q_z^{nc}, q_y^{nc}, Q_{-z-y}^*)\right]\\
\overline{NE} &= \left(1 + D^{-1} - D^{-1}J_{i^c}\right)V_{i^c}(Q^{bc^*}) + D^{-1}\sum_{w=1}^{J_{i^c}} V_{i^c}(q_w^{nc}, Q_{-w}^{bc^*}) \qquad (20)\\
&\quad - \left[\left(1 + D^{-1} - D^{-1}J_i\right)V_i(Q^*) + D^{-1}\sum_{z=1}^{J_i} V_i(q_z^{nc}, q_y^{nc}, Q_{-z-y}^*)\right]\\
&\quad - \left[\left(1 + D^{-1} - D^{-1}J_k\right)V_k(Q^*) + D^{-1}\sum_{y=1}^{J_k} V_k(q_z^{nc}, q_y^{nc}, Q_{-z-y}^*)\right]\\
\overline{SBP} &= \sum_{z=1}^{J_i}\left(v_z(q_z^{nc}, Q_{-z}^*) - v_z(q_z^{nc}, q_y^{nc}, Q_{-z-y}^*)\right) \qquad (21)\\
&\quad + \sum_{y=1}^{J_k}\left(v_y(q_y^{nc}, Q_{-y}^*) - v_y(q_z^{nc}, q_y^{nc}, Q_{-z-y}^*)\right)\\
\overline{NBP} &= D^{-1}\left[\sum_{z=1}^{J_i}\left(V_i(q_z^{nc}, Q_{-z}^*) - V_i(q_z^{nc}, q_y^{nc}, Q_{-z-y}^*)\right)\right] \qquad (22)\\
&\quad + D^{-1}\left[\sum_{y=1}^{J_k}\left(V_k(q_y^{nc}, Q_{-y}^*) - V_k(q_z^{nc}, q_y^{nc}, Q_{-z-y}^*)\right)\right]
\end{aligned}$$

The fact that each northern country can sign multiple agreements (unlike the southern coalitions) explains the differences with the definitions of SE, NE, NBP and SBP in the preceding section. If $J_i = J_k = J_{i^c} = 1$ (each northern coalition signs an agreement with only one coalition) the definitions are almost identical or at least symmetrical: (i) D appears in $\overline{NE}$ and $\overline{NBP}$ and not in $\overline{SE}$ and $\overline{SBP}$ (ii) $\overline{SE}$ focuses on incremental benefits as does NE and (iii) $\overline{NE}$ adds up agreement and disagreement outcomes as does SE. Interpretations are therefore symmetrical. We can now write:

Proposition 4 *Northern countries have an incentive to form a coalition if* $\overline{NE} + \overline{SE} + \left(\overline{SBP} - \overline{NBP}\right) > 0$

Proof. Rewrite (18) using equations (19) to (22). ■

In the presence of a public good with positive spillovers, we have $\overline{NBP} \geq 0$ and $\overline{SBP} \geq 0$. Thus, we obtain a similar result to that obtained for the formation of a southern coalition but with the opposite signs for $\overline{NBP}$ and $\overline{SBP}$. The interpretation of $\overline{NBP}$ and $\overline{SBP}$ is similar to that of NBP and SBP although now the expressions have to take into account the fact that northern coalitions can sign agreements with different coalitions whereas our assumption is that southern coalitions can only sign one agreement. Focusing again on the eventuality that $\overline{SE} = \overline{NE} = 0$, the incentive for the northern countries to form a coalition depends on the relative values of the bargaining terms $\overline{NBP}$ and $\overline{SBP}$. For public goods with positive spillovers, northern countries have an incentive to form a coalition if $\overline{SBP} > \overline{NBP}$ (i.e., if a partial agreement induces a larger indirect gain in southern countries or coalitions that do not participate than in northern countries that are not part of the partial agreement).

5 Discussion

The model presented above is very general but to facilitate its interpretation we will focus during the discussion on a much simpler framework with only two northern and two southern coalitions. Let the northern countries/coalitions be the US and the EU and the southern countries/coalitions China on the one side and the remaining developing countries forming the G77 on the other. Are northern (southern) countries/coalitions going to act united or separately during international negotiations over, for example, climate change? Before answering this question, let us see to what extent our assumptions are reasonable for describing these negotiations.

The main limitation is that we have assumed that only bilateral agreements are pos-

sible, meaning that the only way to reach a global agreement would be a deal between a coalesced North and a coalesced South. Fortunately, this is not as far away from reality as it could appear at first glance since the North (EU-US) and the South (G77-China) would probably need to reach a common position before they negotiate between themselves if a final global agreement is to be reached. If the US proposes a different deal to that of the EU, then a final global agreement is unlikely. In other words, our bilateral agreement framework does not preclude a global agreement; it only imposes a precise structure for the negotiations in order to reach this agreement. This brings us to the second strong assumption of our framework, the sequential coalition structure formation: first the North, then the South. As pointed out above, this is reasonable if the North acts as a Stackelberg leader, a plausible assumption for a negotiation in which the North "grants" a transfer to the South in exchange for an abatement effort which ultimately benefits the South more than the North (as climate change is expected to harm more southern countries). Furthermore, the EU has approved its strategy until 2020 by committing to a 30% reduction in its 1990 emissions if other industrialized countries join the effort or 20% if they do not[1]. Since this has been done before the negotiations for the post-Kyoto agreement have really started and the EU has good chances to meet its Kyoto targets, the commitment of the EU is a priori and credible (almost defining a Stackelberg strategy).

Then, are the countries/coalitions going to act united or separately? First they will check whether the agreement they can expect by joining forces is better or worse than the agreement they can expect by acting separately. This is captured in the term SE, NE, $\overline{SE}$ and $\overline{NE}$ and is hardly surprising.

[1]Brussels European Council 8/9 March 2007.7224/1/07Rev1. Brussels, 2 May 2007.

SE captures the direct benefit the G77 and China (j^c) expect to obtain by negotiating jointly in comparison with the sum of the benefits that China (j) and the G77 (l) expect to obtain from their respective independent bilateral agreements. Note that not only an improvement in the expected agreement favors the merger but that an improvement in the non-agreement situation ($v_{j^c}(q^{nc}_{j^c}, Q^{sc^*}_{-j^c}) - v_j(q^{nc}_j, q^{nc}_l, Q^*_{-j-l}) - v_l(q^{nc}_j, q^{nc}_l, Q^*_{-j-l}) > 0$) also favors the merger. NE compares the benefit, in terms of abatement, that the North would obtain in an agreement with the coalesced G77 and China with the benefits the North would obtain from negotiating with China and the G77 acting independently. Unlike in SE, each square bracket in NE captures only the increase in benefits obtained by passing from the non-agreement status quo to the agreement situation. The reason is that the South can only expect to extract (some part of) the additional rent that the North obtains from an agreement.

We are now going to analyze the most interesting terms since they are not focused on the obvious fact that coalitions will compare the benefits they can expect to obtain by merging. The first square bracket in SBP measures the additional benefits obtained by the G77 (l) when China (j) signs a bilateral agreement and therefore moves from its non-cooperative emission level (q^{nc}_j) to its optimal emission level (the interpretation of the second square bracket is similar). In fact, SBP compares out-of-equilibrium situations since both terms in the first square bracket assume that the G77 (l) stays in its non-cooperative emission level (q^{nc}_l) and in our framework an agreement will always be reached if the surplus to be shared is positive (as in the part of SE above focused on non-agreement situations, the term D has to be taken into account). The interpretation of NBP is similar.

Accepting that a climate change agreement has positive spillovers for southern and

northern countries (because all of them benefit from the reductions performed by others) Corollary 3(iii) tells us that if NBP is larger than SBP then China and the G77 will have an additional reason to act together, not related to the different agreements that would actually be signed while acting together or separately. Should we expect NBP to be larger than SBP? Probably not. The major beneficiaries of GHG abatement efforts are the countries of the South since they are expected to be the most damaged by climate change. Therefore, the G77 would benefit from a partial agreement involving only China and an agreement signed only by the G77 would probably benefit China (i.e. SBP will be positive and presumably large). On the other hand, the EU or the US would benefit relatively little from a partial agreement involving only the other northern country/coalition. Furthermore, a partial agreement may even harm one of them in political terms, as the Bush administration in the US probably suffered when the EU and the remaining Annex I countries continued with the Kyoto Protocol (i.e. NBP if positive is probably small, or even negative).

And what about the EU and the US? Do they have an incentive based on bargaining power to unite in climate negotiations? Proposition 6 gives us the terms which the EU and the US have to consider while deciding whether or not to merge. Assume, for the sake of the argument, that each northern coalition signs only one agreement ($J_i = J_k = J_{i^c} = 1$). As stated above, with this assumption, equations (19) to (22) are almost identical to (12) to (15). The main difference is the impact of D, the term that collects the discount factors. But if $\delta_S = \delta_N \to 1$ we have $D \to 1$ meaning that this difference also vanishes. In this case, $\overline{NBP} \simeq NBP$ and $\overline{SBP} \simeq SBP$. Owing to the fact that these terms enter with the opposite sign in Proposition 2 to that in Proposition 6, the same arguments used to support the lack of incentives for the merging of China and the G77 can be used to

show that the EU and the US do indeed have an incentive to coalesce for bargaining power reasons (more generally, this argument shows that if bargaining power favors a merger for one of the sides of the negotiations the general tendency will go in the opposite direction for the other side).

Have we seen this behavior in past climate change negotiations? On the road to Kyoto and Marrakech, not really. G77 and China negotiated together for the major part of the negotiation process whereas the EU and the US held opposing positions on most issues. However, the Kyoto Protocol and the Marrakech Accords include no obligations for the southern countries, meaning that we can hardly talk of a North-South agreement, in our sense. Nevertheless, current climate change negotiations are more in line with the predictions of the bargaining power part of our argument. On the northern side, the G8 members agreed in July 2009 upon a common abatement target for 2050 (80% reduction of GHG emissions compared to 1990 levels and a 2^oC increase in temperature target) and proposed a 50% global abatement target that would imply abatement efforts for southern countries[2] (G8 countries also accepted that they would need to contribute financially). The opposition of China and India prevented an agreement within the G17 on this proposal. That is, the North is forming a common position and offering the South a deal, which has been rejected. Further negotiations (further offers and counter-offers) will take place during the Conference of the Parties in Copenhagen in December 2009.

[2] "There has been an important convergence in G8 positions, which has provided a strong impulse to the upcoming negotiations to reach an ambitious and effective global agreement in Copenhagen. [...] the G8 countries have committed to reduce their greenhouse gas emissions by 80% or more by 2050 with reference to 1990 or more recent years. [...] The G8 countries confirmed their willingness to contribute their fair share of the financing [...] to ensure the necessary actions to combat climate change also in developing countries." G8 Fact Sheet – Climate Change (www.g8italia2009.it, downloaded 09/09/09)

6 Conclusion

This paper has studied the role of bargaining power in coalition formation when two groups of substantially different agents negotiate over a public good with positive or negative spillovers (or over a private good). We have applied this framework to international negotiations over global public goods such as climate change mitigation since the basic features of our model fit these negotiations well. The main question that we have analyzed is whether or not these negotiations over global public goods have a natural tendency to be carried out between a reduced number of coalitions and whether the reason for this possible tendency is based on efficiency gains or bargaining power gains (or both). We have shown that what drives whether or not bargaining power gains induce the formation of coalitions are the gains obtained by those not involved in the possible partial agreements (which are, in our framework, out-of-equilibrium agreements). Furthermore, if bargaining power favors one of the sides of the negotiations acting in a united way, the general tendency will go in the opposite direction for the other side.

We have left possible extensions of this paper for future research. One alternative would be to assume the sequential bargaining of the different agreements instead of simultaneous bargaining. This would probably just change the expressions obtained without changing the fundamental message. Nevertheless, analyzing the type of bargaining protocol preferred by the North or the South, respectively, remains an open question. Another alternative would be to allow southern countries to reach partial agreements with different northern countries, since this could change some of our conclusions. Finally, and as already pointed out, the coalition formation protocol which we have assumed in stages 1 and 2 could be replaced by a more complex procedure. This would probably not change the results obtained in our Propositions and Corollaries but it would allow the

stability of the different coalitions to be analyzed in a more adequate manner.

References

1. Barrett, S. (1994). Self Enforcing International Environmental Agreements, *Oxford Economic Papers* 46: 878-894.

2. Bloch, F. (1996). Sequential Formation of Coalitions in Games with Externalities and Fixed Payoff Division, *Games and Economic Behavior* 14: 90-123.

3. Caparrós A., Péreau, J.-C. and Tazdaït, T. (2004), North-South Climate Change Negotiations: a Sequential Game with Asymmetric Information, *Public Choice* 121 (3-4): 455-480.

4. Carraro, C. and Siniscalco, D. (1993). Strategies for the International Protection of the Environment. *Journal of Public Economics* 2: 309-328.

5. Carraro, C., Marchiori, C. and Sgobbia, A. (2005). *Advances in Negotiation Theory: Bargaining, Coalitions and Fairness.* FEEM Working Paper No. 66.05. Milan.

6. Chander, P. and Tulkens, H. (1997). The Core of an Economy With Multilateral Environmental Externalities. *International Journal of Game Theory* 26: 379-401.

7. Chipty, T and Snyder, C.M. (1999). The Role of Firm Size in Bilateral Bargaining: A Study of the Cable Television Industry, *Review of Economics and Statistics* 81(2): 326-340.

8. de Clippel, G. and Serrano, R. (2008). *Bargaining, Coalitions and Externalities: A Comment on Maskin.* Unpublished Manuscript, Department of Economics, Brown University.

9. Finus, M. (2001). *Game Theory and International Environmental Cooperation.* Edward Elgar: Cheltenham.

10. McGinty, M. (2007). International environmental agreements among asymmetric nations, *Oxford Economic Papers* 59: 45–62.

11. Harstad, B. (2008). How to Negotiate and Update Climate Agreements. *Discussion Paper 2008-19. Harvard Project on International Climate Agreements.* Cambridge.

12. Maskin, E. (2003). *Bargaining, Coalitions and Externalities*, Presidential Address to the Econometric Society, Institute for Advanced Study, Princeton.

13. Ray, D., and Vohra, R. (1999). A Theory of Endogenous Coalition Structures. *Games and Economic Behavior* 26: 286-336.

14. Ray, D., and Vohra, R. (2001). Coalitional Power and Public Goods. *Journal of Political Economy* 109(6): 1355-1384.

15. Rubinstein, A. (1982). Perfect Equilibrium in a Bargaining Model, *Econometrica* 50: 97-109.

16. Thrall, R. M. and Lucas, W.F., (1963). n-Person Games in Partition Function Form. *Naval Research Logistics Quarterly* 10: 281–298.

$\phi(\tau_N, \tau_S)$	$\Pi(N_i, S_j, \phi(.))$	$\Pi_{N_i}(N_i, S_j, \phi(.))$	$\Pi_{S_j}(N_i, S_j, \phi(.))$
$\{(N_1, S_1), (N_1, S_2)\}$	$\{120, 10\}$	$\{60, 5\}$	$\{60, 5\}$
$\{(N_1, S_1), (N_2, S_2)\}$	$\{100, 40\}$	$\{50, 20\}$	$\{50, 20\}$
$\{(N_2, S_1), (N_1, S_2)\}$	$\{60, 40\}$	$\{30, 20\}$	$\{30, 20\}$
$\{(N_2, S_1), (N_2, S_2)\}$	$\{10, 20\}$	$\{5, 10\}$	$\{5, 10\}$
$\{(N_1, S_1)\}$	$\{10\}$	$\{5\}$	$\{5\}$
$\{(N_2, S_1)\}$	$\{10\}$	$\{5\}$	$\{5\}$
$\{(N_1, S_2)\}$	$\{10\}$	$\{5\}$	$\{5\}$
$\{(N_2, S_2)\}$	$\{10\}$	$\{5\}$	$\{5\}$

Table 1. Agreement structure worth for the coalition structure pair

$$(\tau_N, \tau_S) = ([N_1, N_2], [S_1, S_2]).$$

(τ_N, τ_S)	$\phi^*(\tau_N, \tau_S)$	$\sum_i \Pi_{N_i}$	$\sum_j \Pi_{S_j}$
$\{[N_1, N_2], [S_1, S_2]\}$	$\{(N_1, S_1), (N_2, S_2)\}$	70	70
$\{[N_1 \cup N_2], [S_1, S_2]\}$	$\{([N_1 \cup N_2], S_1), ([N_1 \cup N_2], S_2)\}$	50	50
$\{[N_1, N_2], [S_1 \cup S_2]\}$	$\{(N_1, [S_1 \cup S_2]), (N_1, [S_1 \cup S_2])\}$	40	40
$\{[N_1 \cup N_2], [S_1 \cup S_2]\}$	$\{([N_1 \cup N_2], [S_1 \cup S_2])\}$	30	30

Table 2. Aggregated worth of the optimal agreement structures

for different coalition structure pairs

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