Climate Economics at the NCCR Climate

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Research Paper
2007/03

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This paper examines the effects of political pressure groups (lobbies) on the size and stability of international climate agreements. We consider two types of lobbies, industry and environmentalists. We show the potential effects of lobbying using the STAbility of COalitions (STACO) model. We find that although lobby contributions may help to stimulate international cooperation, the resulting stable agreement does little to tackle climate change. We observe that, contrary to intuition, a member of a stable agreement can collect industry contributions.

JEL-Classification: C72, D72, D78, H41, Q25, Q28

Keywords: interest groups, coalition theory, international environmental agreements.

1. Introduction

Game theoretical studies on the formation and stability of international environmental agreements (IEAs) have pointed out that strong free-rider incentives exist and that these prevent agreements from being effective (e.g. Hoel 1992, Carraro and Siniscalco 1993, Barrett 1994, 1997, Jeppesen and Andersen 1998). A common characteristic of these studies is that the participants in international negotiations are treated as monolithic and benevolent governments that truly represent the common interests of their nation. Furthermore, it is assumed that governments only care about the aggregated welfare level of their respective country. Thus, in this view, welfare maximization is the main force that drives environmental policy decisions. However, recent events in the international policy arena have illustrated the fact that national political actors (e.g. lobby groups and voters) are able to affect environmental policy-making, both at the national and the international level.[1]

Even though the game theoretical analysis of IEAs has yielded many important insights, it ignores the fact that governments often have interests not in line with those of their constituency. Moreover, it does not consider that the electoral process and the lobby groups may influence what these governments would do at the international negotiation tables. In particular, lobby groups (e.g. business associations and environmental NGOs) may be able to affect the behavior of politicians by providing information, by financing election campaigns, or by bringing environmental concerns to the forefront of the minds of the voters (Grossman and Helpman 2001). These political factors play an important role when the national representatives meet at the international level to decide, for instance, whether or not they will participate in an IEA.

[1] In 2002, the Competitive Enterprise Institute (CEI), a conservative lobby group in the USA, intended to discredit the USA's Environmental Protection Agency report on global warming. Moreover, in 2003, the CEI sued other government climate research bodies that produced evidence for global warming (The Observer, 2003). In 2005, Scientific Alliance, a British lobby group linked to Exxon Mobile, published a report challenging current views about potential effects of climate change (The Guardian, 2005).

Most of the studies on the influence of interest groups on policy-making focus on the role of producer groups in the determination of trade policies. In this area, the political contributions approach of Grossman and Helpman (1994, 1995 and 1996) is a standard model. Grossman and Helpman study the effect of lobby contributions on trade policies. They consider self-interested policy-makers who seek to maximize the sum of lobby contributions and the welfare of the median voter in order to increase their chances to be reelected. The political contributions approach has further been applied to study environmental policy-making (e.g. Fredriksson 1997, Aidt 1998, Conconi 2003, Fredriksson *et al.* 2005, Fredriksson *et al.* 2007). Fredriksson (1997) shows that there is a relation between the strength of lobby activities and the deviation from an optimal pollution tax. Aidt (1998) explains that lobby groups, through the competitive political process, are important to internalize production externalities. Conconi (2003) shows that the impact of lobby groups on environmental policy depends on the trade policy regime and the size of the transboundary environmental spillovers. Finally, Fredriksson *et al.* (2005) empirically show, for OECD countries, that there is an effect of lobby actions on policy-making and that it is more likely to occur in countries with sufficiently high levels of political competition. In very recent empirical work Fredriksson *et al*. (2007) show that the ratification of the Kyoto Protocol has been facilitated by environmental lobbying in particular in countries with a lower integrity of government.

A theoretical analysis that combines the influence of interest groups (e.g. using the political contributions approach) and stability of IEAs is largely missing. Only Haffoudhi (2005) has studied the impact of lobby groups on the size and stability of IEAs for homogeneous countries. She finds that a global agreement would be sustained by means of industry lobby contributions. The aim of this paper is to develop a model in which a government's decision about IEA participation and abatement policies are influenced by lobby groups. In our model, lobby groups organize a collective action to influence government decisions. We model this by means of contributions that reflect the willingness to pay of a lobby to change the government’s policies in its favor.

Our analysis has four distinguishing characteristics. First, as in Grossman and Helpman (1994), we assume that lobbies try to influence government’s policy decisions and we abstract from the election process. We represent lobbies’ influence as prospective contributions that enter into the government’s political revenue function and are made conditional on a change of government’s policy decisions. Secondly, different from Grossman and Helpman (1994), we do not model lobbying as a menu auction where exogenously given lobby groups offer contribution schedules to policy-makers. We assume, instead, following Felli and Merlo (2005), that a government chooses the lobby from which it will receive contributions. Thirdly, different from Haffoudhi (2005), we consider heterogeneous world regions and use an empirical model to compute results. Finally, following Hillman and Ursprung (1992, 1994), we compare two model variants where governments consider the contributions from supergreen and green environmentalist lobby groups. Supergreens are concerned about global environmental damages, whereas greens are only concerned about the environmental impacts that affect their own region.

This paper is the first to study the effect of lobbying on the size and stability of IEAs with an empirically meaningful model. It extends previous work in two directions. First, we extend the literature on IEAs to include political pressure (modeled by means of prospective lobby contributions) on governments’ decisions when signing an agreement. Second, we demonstrate the potential impacts of lobbying with the help of the STAbility of COalitions (STACO) model introduced by Dellink *et al.* (2004). STACO combines an empirical climate change module comprising 12 world regions with a game theoretical module to investigate the stability of coalitions of any subset of regions. This allows us, with appropriate modifications, to study the impact of the pressure from lobby groups on the stability of climate coalitions and the resulting environmental and economic effects. We test for stability using the concept of internal and external stability (d'Aspremont *et al.*, 1983). A coalition is said to be stable if no member region wants to leave the coalition (internal stability) and no other region wants to accede to the coalition (external stability).

The results from our analysis show that, first, lobby contributions may help to establish an international climate agreement (ICA) that would not emerge in the absence of lobbying. However, the stable agreement provides little additional greenhouse gas abatement and achieves only a small fraction of the potential welfare gains. Secondly, we find that it is not straightforward to assume that regions participating in an ICA will always be influenced by an environmentalist lobby. We show that a member of a stable agreement may well collect industry contributions and thus abate less than in the absence of lobbying.

The structure of the paper is as follows, the next section presents our analytical framework. Section 3 describes the empirical calibration of the payoff function including the lobby contribution schemes. Section 4 presents and analyzes the main results. Finally, section 5 summarizes and concludes.

2. Analytical framework

We set up a model of coalition formation with lobby contributions. In the model, the government in each region $i \in N$ seeks to maximize its own political revenue considering the pressure from lobby groups. We model lobby pressure as prospective contributions that reflect the willingness to pay of a lobby to influence the government's policy decisions in their favor. Contributions, thus, represent the monetary value assigned to all lobbying activities that influence the government's decisions.[2] The political revenue function has two components. First, it is a function of the regional net benefits of climate policy. This may include the net

[2] Some authors argue that contributions may be interpreted as bribes in order to influence government policies (see Schulze and Ursprung, 2001).

benefits of participating in an ICA. Second, political revenue depends on the contributions from lobby groups. We assume that only two groups of citizens can overcome the problems involved with organizing a lobby (e.g. organizational costs and free-riding) described by Olson (1965) and actually form effective lobby groups. Hence, following a common assumption in the literature (see Grossman and Helpman 1996, Aidt 1998 and Conconi 2003), we assume exogenously given lobby groups. In particular, we assume that an environmentalist (E_i) and an industry lobby (I_i) are active in region i. Lobby groups are indexed by $h_i \in \{E_i, I_i\}$. Furthermore, we consider two types of environmentalists, supergreens (S) and greens (G), thus $E_i \in \{S_i, G_i\}$.

The political revenue function of government i, π_i, reflects the benefits and costs of greenhouse gas abatement and the prospective contributions, L_{h_i}, from lobby group h_i supporting the government's policy. We assume that either industry or environmentalists, but not both, support a chosen policy. More specifically, a government that implements an abatement level q_i receives contributions from the environmentalists if q_i is higher and industry contributions if q_i is lower than a certain benchmark level of abatement. Details of the specification are explained in section 3.3 below. The political revenue function is

$$\pi_i(q_i) = B_i(q) - C_i(q_i) + \rho_i \cdot L_{h_i}(q_i), \tag{1}$$

where B_i are the total discounted benefits from global abatement $q = \sum_{i \in N} q_i$, and C_i are the total discounted abatement costs from regional abatement q_i. We assume that B_i is concave, i.e. $\partial B_i / \partial q_i > 0$ and $\partial^2 B_i / \partial q_i^2 \leq 0$, C_i is strictly convex, i.e. $\partial C_i / \partial q_i > 0$ and $\partial^2 C_i / \partial q_i^2 > 0$, and that $q_i \in [0, e_i^{BAU}]$ where e_i^{BAU} is the emission level in the Business-as-usual scenario with no abatement. The parameter $\rho_i \geq 0$ captures the relative weight of contributions compared to net benefits from abatement. For simplicity we assume that $\rho_i = \rho_j = \rho$ for all $i, j \in N$.[3] Finally, $L_{h_i} \geq 0$, represents the total discounted contributions from a regional lobby and we assume that for the environmentalist lobby $\partial L_{E_i} / \partial q_i > 0$, $\partial^2 L_{E_i} / \partial q_i^2 \leq 0$, and for the industry lobby $\partial L_{I_i} / \partial q_i < 0$, $\partial^2 L_{I_I} / \partial q_i^2 < 0$.

We model the formation of ICAs as a two-stage game of cartel formation. At the first stage, regions decide on membership. At the second stage, regions choose their abatement strategies. At the first stage, we assume that regions can choose between two membership strategies: to sign or not to sign an ICA. Those who sign an ICA become signatories, i.e. members of a coalition $K \subseteq N$. If no region or only a single region signs the ICA, then K is not effective and the singleton coalition structure emerges. If $K = N$, the grand coalition emerges. In our empirical setting, with 12 heterogeneous players (regions), the game renders $2^{12} - 12 = 4084$ different coalition structures.

A non-signatory government chooses an abatement level that maximizes its political revenue given by expression [1]. Signatory governments commit in the agreement to account for the benefits of abatement that accrue to all coalition members. Thereby, the positive externalities of abatement are internalized among coalition members. Hence, a signatory government $i \in K$ maximizes

$$\sum_{j \in K} B_j(q) - C_i(q_i) + \rho \cdot L_{h_i}(q_i). \qquad [2]$$

We do not follow the standard assumption in coalition formation games that the coalition behaves like a single player and plays non-cooperatively against non-signatories and we do

[3] As explained before a “contribution” do not represent actual payments, but are rather a device to capture the value of very different sorts of activities. Because of lack of reliable empirical data on these activities we assume that lobbies have equal influence on governments across regions.

not assume joint profit maximization.[4] Each government maximizes its political revenue subject to the obligation from the agreement if it is signed. The Nash equilibrium of the resulting abatement game gives a unique abatement vector.

We consider the situation without lobby contributions as our base case. Setting $L_{h_i} = 0$ in [1] we obtain the first order condition, for the base case, of a government as a singleton:

$$\partial B_i(q)/\partial q_i = \partial C_i(q_i)/\partial q_i \ . \qquad [3]$$

Setting $L_{h_i} = 0$ in [2] we obtain the first order condition of a coalition member in the base case

$$\sum_{j \in K} \partial B_j(q) \Big/ \partial q_i = \partial C_i(q_i)/\partial q_i \ . \qquad [4]$$

From [1] we obtain the first order condition for a singleton with lobby contributions

$$\partial B_i(q)/\partial q_i + \rho \partial L_{h_i}(q_i)/\partial q_i = \partial C_i(q_i)/\partial q_i \ . \qquad [5]$$

From [2] we obtain the first order condition for a coalition member

$$\sum_{j \in K} \left[\partial B_j(q)/\partial q_i \right] + \rho \partial L_{h_i}(q_i)/\partial q_i = \partial C_i(q_i)/\partial q_i \ . \qquad [6]$$

Comparing [5] and [6] with [3] and [4] we observe that lobby contributions enter as an extra term on the marginal benefits side (left-hand side of these expressions). Hence, as long as $\partial L_{h_i}(q_i)/\partial q_i \neq 0$ the abatement levels of singletons and coalition members will be different from the corresponding levels in the base case. Furthermore, expression [4] is the condition of an efficient provision of abatement for coalition K (Samuelson condition).[5] Hence, comparing

[4] As assumed by Barrett (1994), Chander and Tulkens (1995) and Dellink *et al*. (2006) among others.

[5] Global efficiency is obtained if K = N.

[4] and [6] we observe that lobby contributions distort efficiency of coalitional abatement. Marginal contributions ($\partial L_{h_i}(q_i)/\partial q_i$) make coalition members to move away from the efficient level of abatement. This is further discussed below once we have introduced our specification of lobby contributions.

3. Calibration of the model

In this section we describe the main features of the calibration of the empirical module of the STAbility of COalitions (STACO) model – see Dellink *et al.* (2004) and Finus *et al*. (2006) for a detailed description of the calibration. STACO has been used to examine effects of exclusive membership (Finus *et al*. 2005), permit trading (Altamirano-Cabrera and Finus, 2006) and surplus sharing (Weikard *et al*. 2006) on the stability of ICAs. STACO calculates payoffs (in terms of net benefits) for each region and each coalition structure. These payoffs are used to check for stability. The regions considered are USA, Japan, European Union (EU-15), other OECD countries (O-OECD), Eastern European countries (EE), former Soviet Union (FSU), energy exporting countries (EEX), China, India, dynamic Asian economies (DAE), Brazil and "rest of the world" (ROW).[6] STACO considers a time horizon of 100 years starting in 2010, focuses on abatement of CO_2 emissions, and uses a uniform 2% discount rate for the calculation of the net present value of the net benefits of abatement. We adopt the same specification. In section 4.2 we present a sensitivity analysis varying the discount rate. Finally, we assume stationary abatement strategies, i.e. a constant abatement level over the time horizon of our model.

[6] EU-15 comprises the 15 countries of the European Union as of 1995. O-OECD includes among others Canada, Australia and New Zealand. EE includes, among others, Hungary, Poland, and Czech Republic. EEX includes, among others, the Middle East Countries, Mexico, Venezuela and Indonesia. DAE comprises South Korea, Philippines, Thailand and Singapore. ROW includes South Africa, Morocco and many countries in Latin America and Asia. For details, see Babiker *et al*. (2001).

3.1. The benefit function

The STACO calibration of the benefit function is based on a linear approximation of the damage cost function of the DICE model (Nordhaus 1994). We assume that the benefits of global abatement are derived from reduced environmental damages from CO_2 emissions and that each region receives a share of the global benefits. The resulting (discounted) regional benefit function, $B_i(q)$, is expressed as

$$B_i(q) = \mu_i \cdot \delta_B \cdot q \qquad [7]$$

where μ_i is region i's share of the benefits ($\sum_{i \in N} \mu_i = 1$) from global abatement $q = \sum_{i \in N} q_i$ and δ_B is a parameter that captures the discounting of benefits of abatement and the stock effects of CO_2 emissions. The parameter δ_B represents the global marginal benefits in STACO.[7] From [7] follows that the regional marginal benefits are constant and equal to $\mu_i \delta_B$. The regional parameters for the benefit function are listed in Appendix A, Table A.1. With constant marginal benefits all regions have dominant abatement strategies. The chosen abatement level, the solutions of [5] or [6], is independent of others' abatement. Thus, there are no leakage effects in our model. The literature on the stability of IEAs recognizes that a setting with linear benefit functions offers the most favorable conditions for forming stable coalitions (Carraro and Siniscalco 1993, Finus 2001, 2003).

3.2. The abatement costs function

For the specification of the abatement cost function we rely on estimates from the EPPA model (Ellerman and Decaux 1998). The regional (discounted) abatement costs are given by

[7] We use the calibration suggested by Dellink *et al.* (2004) and Finus *et al.* (2006) who use $\delta_B = 37.4\ \$/\text{ton}$ of carbon.

$$C_i\left(q_i\right)=\delta_C\left[\frac{1}{3}\xi_i q_i^3+\frac{1}{2}\zeta_i q_i^2\right] \qquad [8]$$

where ξ_i and ζ_i are regional parameters and δ_C captures the discounting of abatement costs.[8]

The regional parameters for the abatement cost function are listed in Appendix A, Table A.1. In our setting, the large industrialized regions are the main beneficiaries of global abatement whereas energy exporting countries, the dynamic Asian economies and Brazil receive the smallest share of global benefits. The marginal abatement costs vary widely: China and USA have relatively flat curves whereas Brazil and Japan have relatively steep curves.

3.3. Lobby payoffs and contributions

To specify the lobby contribution functions, we assume that the environmentalist lobby contributions are related to the increase of environmental benefits as a result of the regional abatement policy. Thus, the environmentalist lobby contributes if the government decides to increase abatement above a benchmark level, q_i^g, that would be chosen by the government in the absence of lobby contributions. We define q_i^g as the equilibrium abatement level in the base case. Following Hillman and Ursprung (1992 and 1994), we assume that the environmentalist lobby may be either supergreen or green. A supergreen lobby is concerned (by self-interest, aesthetic or altruistic motives) about global environmental impacts of regional environmental policies. A green lobby is concerned only about the regional environmental impacts of the regional abatement polices.

[8] As in Dellink *et al.* (2004) and Finus *et al.* (2006), we use $\delta_C = 43.1\ \$/\text{ton}$ of carbon.

The contribution function for a supergreen lobby S_i is

$$L_{S_i} = \begin{cases} \varepsilon \cdot \delta_B \left(q_i - q_i^g\right) & \text{for } q_i \geq q_i^g \\ 0 & \text{for } q_i < q_i^g. \end{cases} \quad [9]$$

The contribution function for a green lobby G_i is

$$L_{G_i} = \begin{cases} \varepsilon \cdot \mu_i \cdot \delta_B \left(q_i - q_i^g\right) & \text{for } q_i \geq q_i^g \\ 0 & \text{for } q_i < q_i^g. \end{cases} \quad [10]$$

In [9] and [10], ε is a parameter ($0 < \varepsilon < 1$) that reflects the strength of the willingness to pay of environmentalist lobbies for increased abatement. The parameter δ_B is included in these expressions because lobby contributions, for consistency, have to be discounted in order to be included in the political revenue function of singletons and coalition members – see expressions [1] and [2]. Moreover, we assume that environmentalist contributions are linked to the benefits from abatement and that the stock effects of CO_2 emissions are also recognized by the environmentalist lobby. Hence, the discount factor of the benefit function is applied.

For further calculations and analysis, we need to determine q_i^g. We find the singleton coalition structure to be the unique stable coalition in the base case. Hence, the corresponding abatement levels serve as the reference abatement levels (q_i^g) to determine contributions. It is clear from [9] and [10] that the more the actual abatement exceeds q_i^g the higher the contributions of both types of environmentalist lobbies.

Next, we assume that the industry is always harmed by the abatement decision of the government, given that the abatement costs are usually carried by the industry. Industry contributions are linked to the discounted costs saved when abatement levels are lower than q_i^g. Thus, considering expression [8] and assuming that the industry uses the same discount rate δ_C for contributions and abatement, we get:

$$L_{I_i} = \begin{cases} \delta_C \left\{ \frac{\xi_i}{3} \left[\left(q_i^g\right)^3 - q_i^3 \right] + \frac{\zeta_i}{2} \left[\left(q_i^g\right)^2 - q_i^2 \right] \right\} & \text{for } q_i \leq q_i^g \\ 0 & \text{for } q_i > q_i^g. \end{cases} \qquad [11]$$

From expression [11] it is clear that an industry lobby pays higher contributions the more the actual abatement level is below the government's benchmark decision without lobby contributions.

4. Results and sensitivity analysis

In this section, we present the results from our analysis for the base case, we examine the implication of lobby contributions and provide a sensitivity analysis.

Table 1 reports results of the base case. We find that all regions undertake some abatement effort even in the absence of an agreement – i.e. in the singleton coalition structure. The heterogeneity of the regions, in terms of cost-benefit structure (see Appendix A, Table A.1), implies different levels of abatements. For instance, USA undertakes the largest abatement effort in the singleton coalition structure given its low marginal abatement costs and high marginal benefits. Also China undertakes important abatement efforts because it has the lowest marginal costs. In contrast, regions like Brazil or the energy exporting countries (EEX) that have high marginal cost and low marginal benefits have little incentive to abate.

Table 1: Singleton Coalition Structure (Base case)

Regions	Abatement over century gton	Average annual abatement % of emissions in 2010	Abatement costs over century bln US$	Benefits from abatement over century bln US$	Payoff over century bln US$	Marginal abatement costs US$/ton	Marginal benefits US$/ton
USA	16	6.7	53	468	415	8.5	8.5
Japan	1	1.4	2	357	354	6.5	6.5
EU-15	7	4.7	24	488	464	8.8	8.8
O-OECD	2	3.1	1	71	71	1.3	1.3
EE	1	1.8	0	27	27	0.5	0.5
FSU	5	4.9	4	140	135	2.5	2.5
EEX	1	0.7	0	62	62	1.1	1.1
China	15	6.6	16	128	112	2.3	2.3
India	3	5.3	3	103	101	1.9	1.9
DAE	1	1.3	0	52	51	0.9	0.9
Brazil	0	0.1	0	32	32	0.6	0.6
ROW	4	5.3	4	141	137	2.5	2.5
World	55	4.6	109	2,069	1,960	-	-

4.1. Main results and stability analysis

A first analysis shows two features of our setting. First, from the first order conditions presented in Section 2 we know that $\partial B_i(q)/\partial q_i = \partial C_i(q_i)/\partial q_i$ for singletons in our base case and that $\partial B_i(q)/\partial q_i + \rho\,\partial L_{h_i}(q_i)/\partial q_i = \partial C_i(q_i)/\partial q_i$ for singletons in the case with lobby contributions. Considering our empirical calibration (see section 3) these conditions imply that a region, acting as a singleton, has a higher abatement level than in the base case if it receives contributions from the environmentalist lobby (because $\partial L_{E_i}(q_i)/\partial q_i > 0$) and has a lower abatement level than in the base case if it receives contributions from the industry lobby (because $\partial L_{I_i}(q_i)/\partial q_i < 0$) – see also Appendix B expressions [B1]-[B4]. Second, the decision of whether or not to take lobby contributions is independent of the decisions of the remaining regions concerning lobby contributions and coalition membership – both for singletons and coalition members. This is a result of the presence of constant marginal benefits – which imply dominant abatement strategies – in our model. Dominant strategies allow us to calculate regional abatement and corresponding lobby contributions without considering the behavior of other regions.

Note that the numerical results of this section are obtained assuming that the relative weight of contributions compared to social welfare, ρ, is equal to 1. Hence, we assume that governments give equal weight to the net benefits from abatement and to lobby contributions. We modify this assumption in the sensitivity analysis of section 4.2. In Table 2, we show the results for the singleton coalition structure once we include lobby contributions. We note that the influence of lobbies on abatement levels and on net benefits depends mainly on the type of environmentalist lobby. When we consider a supergreen lobby, contributions have a positive effect on global abatement and consequently on global payoff. For the singleton coalition structure, we find an increase in abatement of about 40 % compared to the base case. Global abatement increases even though there are three regions (USA, Japan and EU-15) that receive industry contributions and hence reduce their abatement below base case levels. However, when we consider a green lobby, contributions have a negative effect on global abatement. There is a decrease of 40 % compared with the base case. We find that all regions take contributions from the industry lobby and reduce their abatement levels below those of the base case.

Table 2: Results for singleton coalition structure with lobby contributions (supergreen and green lobbies)

Region	Industry or supergreen lobby contributions			Industry or green lobby contributions		
	Abatement over century (Gton)	Net benefits over century (bln $)	Contributions over century [a)] (bln $)	Abatement over century (Gton)	Net benefits over century (bln $)	Contributions over century [a)] (bln $)
USA	11	657	35*	11	273	35*
Japan	0	514	2*	0	221	2*
EU-15	4	696	16*	4	296	16*
O-OECD	4	97	7	1	44	1*
EE	3	34	9	1	17	0*
FSU	8	185	11	3	85	3*
EEX	3	83	8	0	39	0*
China	31	106	58	9	75	11*
India	7	133	14	2	64	2*
DAE	2	69	6	0	32	0*
Brazil	0	45	0	0	20	0*
ROW	7	186	11	2	86	3*
World	80	2,804	176	34	1,252	73

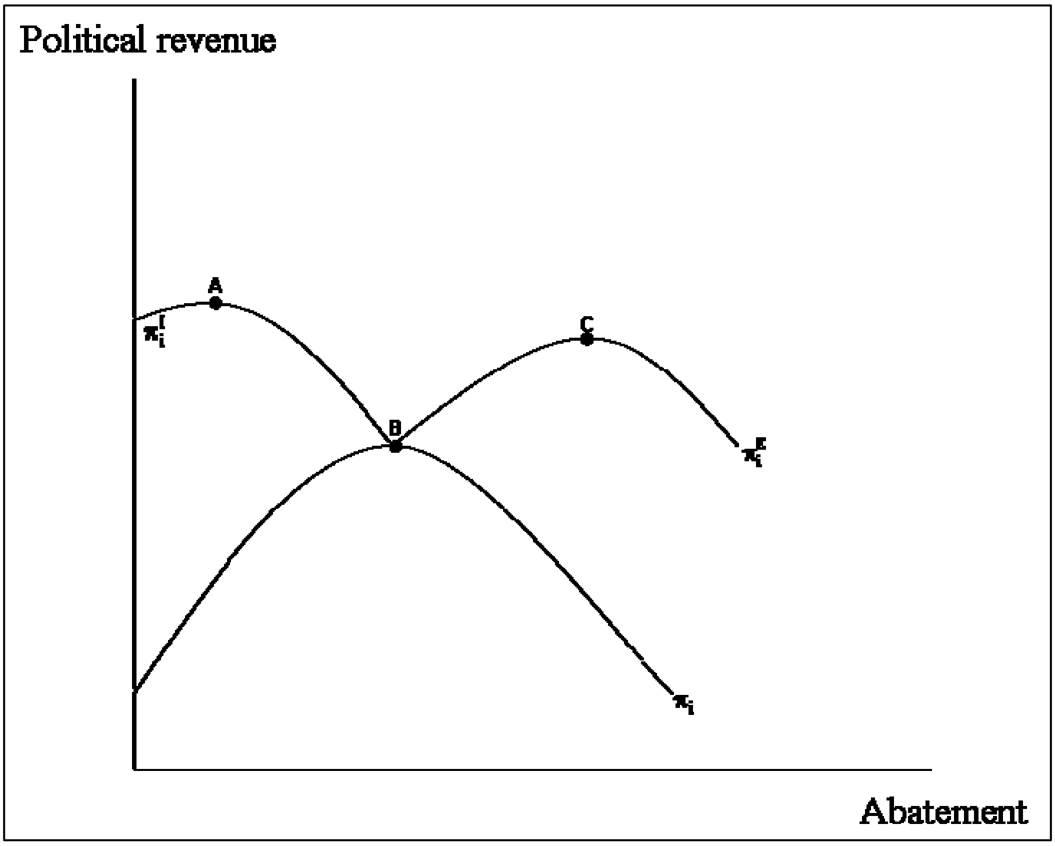
*Note: a) regions indicated with an * are receiving industry contributions, otherwise they receive environmentalist contributions.*

In the base case, a singleton region chooses the abatement level q_i^g that maximizes net benefits from abatement – see expression [3]. From expressions [9]-[11], and for all $\rho > 0$, we know that any compromise on the abatement level of the government (i.e. for any $q_i \neq q_i^g$) will be rewarded with a contribution from one of the lobbies. When $q_i < q_i^g$, the industry makes a contribution that compensates for the foregone benefits from a lower abatement level. Whereas, when $q_i > q_i^g$, the environmentalist makes a contribution compensating for the additional abatement costs resulting from increased abatement. Hence, for all regions, any abatement level different from q_i^g results in a higher payoff than in the base case. With the presence of lobby groups it is always better, then, to change the abatement decision and collect contributions.

The political revenue function [1] has two local optima. Figure 1 gives a schematic representation of its shape for a singleton government. The curves depict the political revenue function with industry lobby contributions π_i^I, with environmentalist contributions π_i^E and without contributions π_i . In order to find the maximum political revenue we compare payoffs at the two local maxima. Figure 1 depicts a case where the industry is successful in influencing the government's abatement decision. It is straightforward to see from Figure 1 that it is always better to accept lobby contributions as we argued before. The local optima for the payoff with lobby contributions (points A and C) represent higher payoffs than the base case optimum (point B).

The situation is different for coalition members. A closer inspection of the first order conditions for singletons and coalition members – expressions [3]-[6] – reveals that a region, acting as a coalition member, will always have a higher abatement level than when acting as a singleton, simply because coalition members take the positive externalities from abatement accruing to their coalition partners into account. When joining a coalition, members have to consider the marginal benefits of their partners. Hence, the left-hand sides of [4] and [6] increase. Thus [4] and [6] can only hold if the abatement level increases upon joining a coalition. Hence in Figure 1, the abatement level of the region as a coalition member will correspond to points that are to the right of points A, B and C.

Figure 1: Political revenue curves for a representative region as a singleton



It is possible to determine for coalition members which lobby would be successful in influencing the abatement decision of a government. In our setting, with heterogeneous regions, it depends on the identity of the coalition partners, in particular on their marginal benefits. We find that for our specification a sufficient condition for a government's switch from taking industry contributions to accept environmentalist contributions is that it forms a coalition with partners whose marginal benefits match or exceed its own marginal benefits. To see this, first consider a government that as a singleton accepts contributions from the industry (as in Figure 1). Its abatement decision is taken following expression [B4] – see appendix B. Now consider that this government enters a coalition. Using [6], [7], [8] and [11] we obtain

$$\frac{\sum_{j\in K}\mu_j\delta_B}{1+\rho}=\delta_C\left[\xi_i q_i^2+\zeta_i q_i\right]. \quad [12]$$

Note now that the industry would stop contribution payments if $q_i \geq q_i^g$. This condition is met if the right hand side of [12] is at least as large as the marginal benefits in the base case. Hence, if government i takes industry contributions in the base case, it switches to taking environmentalists contributions if

$$\frac{\sum_{j\in K} \mu_j \delta_B}{1+\rho} \geq \mu_i \delta_B \Leftrightarrow \sum_{j\in K-\{i\}} \mu_j \geq \rho \mu_i . \qquad [13]$$

It is obvious that a government that is taking environmentalist contributions as a singleton will continue to do so upon entering a coalition. For our specific case where $\rho = 1$ we observe from [13] that a government switches from industry to environmentalist contributions if it forms a coalition with regions whose sum of marginal benefits of abatement are at least as large as their own. Regions accepting industry contributions as singletons do not switch to environmentalist contributions when joining coalition partners with a lower sum of marginal benefits than their own.

We test for stability using the concept of internal and external stability. Internal stability means that no coalition member has an incentive to leave the coalition. External stability means that non-members have no incentives to join the coalition. In the base case we do not find a stable coalition and we find only 14 internally stable coalition structures. This indicates that there are strong free-rider incentives. The situation changes once we consider lobby contributions. We notice that lobby contributions help to reach a stable agreement. We find one stable coalition comprising Japan and the European Union (EU-15). This coalition is stable when considering industry and supergreen contributions and when considering industry and green contributions – see Table 3.

Table 3: Results for selected coalition structures

Case	Coalition	Global abatement over century (Gton)	Global net benefits over century (bln $)
Base case	singleton coalition*	55	1,960
	{Japan, EU-15}	59	2,056
	grand coalition	256	6,031
With industry and supergreen contributions	singleton coalition*	80	2,804
	{Japan, EU-15}*	83	2,908
	grand coalition	270	6,005
With industry and green contributions	singleton coalition*	34	1,252
	{Japan, EU-15}*	38	1,350
	grand coalition	258	6,031

*Note: * stable coalition.*

In our base case, the coalition between Japan and EU-15 is internally unstable. The extra benefits that EU-15 would obtain from the augmented abatement level in the coalition would be offset by the increase in its abatement costs. Hence, it will not join Japan but remain a singleton. Lobby contributions help to make this coalition stable. We find that EU-15 collects industry contributions in the stable coalition. At a first glance this result seems counterintuitive as a region will always increase abatement when joining a coalition. Why, then, would a region sign an agreement with the support of the industry? In the end, an agreement is meant to foster abatement. A closer inspection of our results reveals why a coalition member receives industry contributions. In the stable coalition, EU-15 indeed increases its abatement level compared to the singleton case (by 50%). Even after the increase, however, this level of abatement is still lower than its base case level. Hence, EU-15 collects industry contributions. Furthermore, we find that at least one coalition member receives industry contributions in about 1,000 of the coalitions that we tested – among these only the coalition of Japan and EU-15 is stable. In these coalitions, the increase in benefits is not sufficient to compensate for the increase in abatement costs and the loss of industry contributions for some members, even with supergreen contributions. Governments, thus, choose a compromise. They increase their abatement level from the singleton coalition structure but to an extent less than in the base case. Hence, they still collect from the industry. EU-15 will only change its decision about lobby contributions if it joins a coalition partner with higher marginal benefits, such as USA, or if the coalition with Japan is enlarged; see condition [13]. In contrast, upon joining the coalition, Japan changes its decision to take contributions – the marginal benefits of EU-15 clearly exceed those of Japan, see Table 3 and Appendix A, Table A1. In the stable coalition, Japan collects contributions from the supergreen or the green lobby.[9] Because the coalition increases global abatement, both regions have larger benefits and abatement costs. For Japan, the increase in abatement costs is overcompensated by environmentalist contributions.

Although lobby contributions help to stabilize a coalition, we find that this coalition does little to tackle climate change. From Table 3 we observe that the increase in abatement for the stable coalition is only a small improvement compared to the singleton coalition structure. Furthermore, when green and industry contributions are considered the stable coalition falls short of achieving the abatement level of the singleton coalition structure in the base case – there is 30% less abatement. The predominant effect of lobby activities is a reduction of abatement as governments collect industry contributions. This effect is only partly offset by coalition formation. We also observe that the stable coalition (Japan, EU-15) does not reap

[9] A switch of this nature may actually happen. For instance, the administration of George Bush Sr., with the support of several industry lobbies, considered climate change a lesser problem. This attitude changed in the subsequent administration in which Vice-president Al Gore (backed by several environmentalist groups) heavily pushed for the ratification of the Kyoto Protocol.

much of the possible gains from cooperation. It closes the gap, in terms of net benefits, between the situation without cooperation (singleton coalition structure) and with full cooperation (grand coalition) by just 2% in both of our lobby cases.

4.2. Sensitivity analysis

We conduct a sensitivity analysis with respect to a selection of parameters from our model. The aim of this exercise is to investigate whether the qualitative results presented in Section 4.1 are robust to changes of some critical parameters of our model. We focus on three parameters, the strength of environmentalist lobbies' willingness to pay for abatement policies (ε), the relative weight of contributions compared to social welfare (ρ) and the discount rate. Firstly, we analyze the effects of having an environmentalist lobby (supergreen or green) with stronger or weaker willingness to pay for increased abatement. We test this through an increase or decrease in the parameter ε. We change ε from 0.1 (its original level) to 0.5 and 0.01 in order to reflect a stronger and a weaker willingness to pay, respectively. Secondly, we investigate the effect of having a government that is less or more concerned about lobby contributions. We test this through a change in the parameter ρ from 1 (its original level) to 0.5 and 1.5 in order to reflect less or more concern of government about contributions. Third, we investigate a change in the discount rate. Note that in the STACO calibration, discounting enters the benefit and abatement costs functions through parameters δ_B and δ_C respectively. Following our assumption of constant abatement strategies, a change in the discount rate has only a scaling effect on the discounted benefits and abatement costs. Given that the parameter δ_B also captures the stock effects of CO_2 emissions, a change in the discount rate, however, has stronger scaling effects on the benefits than on the abatement costs. In STACO, an increase in the discount rate has a similar effect to having lower benefits or higher abatement costs. Conversely, lowering the discount rate has a similar effect to having higher benefits or lower abatement costs. We can simplify these effects and express the variation of the discount rate as a re-scaling in the benefit function. Then, we perform the sensitivity analysis by changing the discount rate from 2% (its original level) to 1% (that is equivalent to scaling up benefits by a factor of 1.18) and to 3% (that is equivalent to scaling down benefits by a factor of 0.85).

We find that our qualitatively results are robust to the changes in the parameters described above. Firstly, our stability results are quite robust. The coalition between Japan and EU-15 is stable under all changes of the parameters that we tested – the only exception is when $\rho=1.5$. In this case both, Japan and EU-15, would continue to take industry contributions in a coalition. In fact, condition [13] is not satisfied for either region. These results hold irrespective of the type of the environmentalist lobby. Secondly, we confirm that, for all parameter changes that we have examined, the influence of lobbies depends on the type and strength of the environmentalist lobby. When there are supergreen and industry contributions, both the singleton and stable coalition of Japan and EU-15 achieve better results (in terms of abatement and net benefits) than in the case without contributions. Whereas, when there are green and industry contributions, all singletons are collecting contributions from the industry and the abatement of the stable coalition is below the level of the singleton coalition structure in the base case. Third, we find that the decisions of taking contributions are also robust to a change in the discount rate. Only if the benefits become sufficiently high (with a discount rate of 1%) all governments in our regions have an incentive to change their decisions and take environmentalist contributions in the singleton coalition structure and in the stable coalition of Japan and EU-15.

5. Summary and conclusions

In this paper, we study the effect of political pressure groups (lobbies) on the size and stability of international climate agreements (ICAs). We study ICAs as a coalition formation process. The formation of ICAs is modeled as a two-stage game in which governments choose their participation at the first stage and their abatement strategies at the second stage – considering both net benefits from abatement and lobby contributions. We assume that there are two lobbies from which governments obtain contributions: industry and environmentalist. We consider that the level of contributions depends on each lobby's payoff functions and the abatement strategy chosen by the government. The payoff of an environmentalist lobby depends on the additional abatement efforts undertaken by the government. We consider two types of environmentalist lobbies, supergreen and green. A supergreen lobby is interested in the global effects of the abatement policies. A green lobby is only interested in the regional effects of abatement policies. We assume that the industry lobby is always harmed if the government increases abatement.

We test stability of ICAs using the concept of internal and external stability. We use the STAbility of COalitions (STACO) model that provides us with benefit and cost estimates for twelve world regions. We incorporate the level of pressure exerted by lobbies into STACO. In our setting, government's political revenue depends on the abatement strategy chosen by a region and the prospective contributions from a lobby. We perform a sensitivity analysis with respect to the parameters that reflect the strength of environmentalists' willingness to pay for abatement policies, the relative weight of contributions compared to social welfare and the discount rate. We find that our main results and conclusions are robust to these changes.

There are three key results from our analysis. Firstly, we find that in the absence of an agreement (i.e. the singleton coalition structure) environmentalist lobby contributions may help to foster abatement efforts. When we consider supergreen and industry lobby contributions, we find that the singleton coalition structure improves upon our base case. There are only three regions that receive industry contributions but this does not offset the global increase in abatement. In contrast, when we consider industry and green lobby contributions, all regions take contributions from the industry. This has a clear detrimental effect for both global abatement and global payoff.

Secondly, since we do not consider transfers between members of an ICA, such as emission trading, we confirm the general picture in the literature: Only small coalitions are stable. In our case this is a coalition between Japan and the European Union (EU-15) where governments are supported by environmentalist (supergreen or green) and industry contributions. This stable coalition does little to close the gap, in terms of abatement and net benefits, between the situation without cooperation (singleton coalition structure) and full cooperation (grand coalition structure). We find that lobby contributions help to increase stability in our model (there are no stable coalitions in our base case). However, with green and industry lobby contributions, the stable coalition falls short of achieving the abatement level of the singleton coalition structure in the base case.

Thirdly, we find that, contrary to intuition, industry contributions are compatible with membership in an ICA. We observe that in the stable coalition between Japan and EU-15, the latter are taking industry contributions. The government of EU-15 goes for a compromise increasing its abatement upon joining the coalition but remaining below base case levels. Thus, it still collects industry contributions and benefits from the increased global abatement as a result of the coalition formation process.

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Appendix A –Parameters

Table A.1: Emissions, Benefit and Abatement Cost Parameters*

Regions	Emissions in 2010 (Gton)	Share of global benefits μ_i	Abatement cost parameter ξ_i	Abatement cost parameter ζ_i
1 USA	2.42	0.226	0.0005	0.00398
2 Japan	0.56	0.173	0.0155	0.18160
3 European Union (EU-15)	1.4	0.236	0.0024	0.01503
4 Other OECD Countries (O-OECD)	0.62	0.035	0.0083	0.0
5 Eastern European Countries (EE)	0.51	0.013	0.0079	0.00486
6 Former Soviet Union (FSU)	1.0	0.068	0.0023	0.00042
7 Energy Exporting Countries (EEX)	1.22	0.030	0.0032	0.03029
8 China	2.36	0.062	0.00007	0.00239
9 India	0.63	0.050	0.0015	0.00787
10 Dynamic Asian Economies (DAE)	0.41	0.025	0.0047	0.03774
11 Brazil	0.13	0.015	0.5612	0.84974
12 Rest of the World (ROW)	0.7	0.068	0.0021	0.00805
World	11.96	1	-	-

Source: Dellink et al. (2004) and Finus et al. (2006).

Appendix B

From the model outlined in section 2 and the functional specification in section 3 we can derive the first order conditions for the singleton coalition structure for different lobby cases. For the case without lobby contributions (i.e. the base case) we obtain from [3], [7] and [8]

$$\mu_i\delta_B = \delta_C\left[\xi_i q_i^2 + \zeta_i q_i\right]. \qquad \text{[B1]}$$

For a singleton receiving only contributions from the supergreen lobby we obtain from [5], [7], [8] and [9]

$$\mu_i\delta_B + \varepsilon\rho\delta_B = \delta_C\left[\xi_i q_i^2 + \zeta_i q_i\right]. \qquad \text{[B2]}$$

For a singleton receiving only contributions from the green lobby we obtain from [5], [7], [8] and [10]

$$\mu_i\delta_B(1+\rho\varepsilon) = \delta_C\left[\xi_i q_i^2 + \zeta_i q_i\right]. \qquad \text{[B3]}$$

For a singleton receiving only contributions from the industry lobby we obtain from [5], [7], [8] and [11]

$$\mu_i\delta_B/(1+\rho) = \delta_C\left[\xi_i q_i^2 + \zeta_i q_i\right]. \qquad \text{[B4]}$$

The left-hand side of [B1]-[B4] represents the sum of marginal benefits and marginal contributions, whereas the right-hand side represents marginal abatement costs. Comparing [B1] with [B2] and [B3] we note that a region, acting as a singleton, has a higher abatement level than in the base case if it receives contributions from an environmentalist lobby. It has a lower abatement level than in the base case if it receives contributions from the industry (compare [B1] with [B4]).