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The Influence of Political Pressure Groups on the Stability of International Environmental Agreements

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Abstract

This paper examines the effects of political pressure groups (lobbies) on the emissions abatement decisions of countries and on the stability of international environmental agreements. We consider two types of lobbies, industry and environmentalists. We determine the influence of lobby-groups on the abatement decisions of countries. This influence affects members of an international environmental agreement as well as outsiders. However, in the case of agreement members, the effects of lobbying are not restricted to the lobby's host-country but spill over to other member countries and have ambiguous effects on the agreement stability.

JEL-Classification: C72, D72, D78, H41, Q28, Q54

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

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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 [1]. 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 [2].

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

[1] Hagen et al. (2016) and Wangler et al. (2013) argue for extending the game theoretical analysis of IEAs to consider actors that are not nation state governments

[2] Although there are some corporations that supports current US climate agenda, e.g. Mars, Ikea, Kellogg's and Unilever, these are outnumbered by the efforts of the powerful lobbies like the US Chamber of Commerce and the National Association of Manufacturers and the many lobbyists from the coal, oil and natural gas industries (Gunther, 2015). Only recently in 2015, the oil company BP announced that it will stop funding the American Legislative Exchange Council, a lobbying group that presents biased reports about climate science to US state legislators (Frumhoof and Oreskes, 2015).

in an IEA.

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, 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; Aidt and Hwang, 2014; Batina and Galinato, 2014). 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. Aidt and Hwang (2014) study the effects of foreign lobbying in another country's national welfare; they find that this lobby efforts, as means of political internalization of cross national externalities, only maximizes global social welfare under very restrictive assumptions. Batina and Galinato (2014) describe the tradeoffs between the influence of the environmental damage caused by the resource extraction and the contributions received from lobbies, when these contributions affect government's taxes and expenditures policy in the presence of tax competition with other governments. In 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. Altamirano-Cabrera et al. (2007) have studied the impact of lobby groups on the stability of climate agreements in a empirically calibrated simulation model. They find that although lobby contributions may help to stabilize IEAs the additional greenhouse gas abatement is insignificant. Anger et al. (2015) use a theoretical and empirical framework to assess the effect of lobbies on emission allowance allocations under the EU emissions trading scheme (ETS). They find that because of lobbying from energy-intensive firms within the ETS, the regulatory burden of emission abatement would be shifted to non-ETS sectors that will be subject to inefficiently high emission taxes.

A theoretical analysis that combines the influence of interest groups (e.g. using the political contributions approach) and stability of IEAs is largely missing. There are few examples of the combined approach, for instance, Soo-Kim (2013) analyzes, in a two-country, two-goods model, the conditions under which politically viable IEAs could evolve; he finds that two critical factors for viable IEAs are the price elasticity of supply and the weight the politicians place on the general welfare versus lobby contributions. Moreover, only Haffoudhi (2005) and Dietz et al. (2012) have studied the impact of lobby groups on the size and stability of IEAs for homogeneous countries. Haffoudhi (2005) finds that a global agreement would be sustained by means of industry lobby contributions. In contrast, Dietz et al. (2012) find that lobbying may increase the incentives for parallel multilateral action.

The aim of this paper is to study the influence of lobby groups on IEA participation and abatement policies. In our model analysis, 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.

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 po-

litical revenue function and are made conditional on a change of government's policy decisions. Different from Haffoudhi (2005) and Dietz et al. (2012), we consider heterogeneous countries. We test for stability using the concept of internal and external stability (d'Aspremont et al., 1983).

Our results show that the influence of lobby-groups has an effect on the abatement decisions of the respective countries. This influence appears for members of an IEA as well as for outsiders. However, in the case of IEA-members, the effects of lobbying are not restricted to the lobby's host-country but spill over to other member countries and have ambiguous effects on the IEA-stability.

The formation of IEAs is modeled as a game in which governments decide about their participation before they choose their abatement strategies - considering both net benefits from abatement and the prospective lobby contributions. We assume that there are two lobbies from which governments can 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. We assume that the industry lobby is always harmed if the government increases abatement. First, we lay out our model and explain the stages of the game. We then solve the game by backward induction and focus on the abatement decisions of the countries and the stability of the IEA before we conclude the paper with a summary and discussion.

2 Description of the model

We study the impact of lobbying on the formation and stability of IEAs in a sequential game. The players in our game are lobbies and governments in n countries of different types i. The set of countries is denoted N, the set of country types I. An IEA is a subset of all countries $S \subseteq N$ with the number of type i signatories denoted by k_i and the number of type i outsiders denoted by o_i. Thus the total

number of countries is given by $n = \sum_{i \in I} (k_i + o_i)$. There are two standard stages of the game: (I) IEA formation and (II) the transboundary pollution game. These are embedded in a political contributions model which includes (i) the announcement of the lobby-contributions and (ii) the payment of the lobby-contributions. We describe these stages in turn.

2.1 The announcement of the lobby-contributions and formation of an IEA

Lobbying takes place in all countries $i \in I$ and affects national policies. In our model the policy space is the level of abatement, reflecting the strictness of the environmental policy adopted. Hence, a particular policy is described by a variable $q_i \in [0, \bar{e}_i]$, where index i refers to an individual country of type i and $\bar{e}_i$ is the level of business-as-usual emissions of a country which is of type i. We denote the policy of a signatory country of type i by q_i^s and the policy of a type i outsider by q_i^{out}. Following a common assumption in the literature (c.f. Grossman and Helpman, 1996; Aidt, 1998; Conconi, 2003), we assume two exogenously given lobby groups, the industry, referred to as 'firms' f, and the environmentalists, referred to as the 'greens' g. The firms' preferred policy is $q_i = 0$, i.e. the preferred level of abatement is zero, while the greens' preferred policy is $q_i = \bar{e}_i$. Hence both lobbies pull in opposite directions. The government maximizes a political revenue function that reflects social welfare and the influence of 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 represent the monetary value assigned to all lobbying activities that influence the government's decisions [3]. The political revenue function thus has two components. First, it is a function of a country's net benefits from the climate policy

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

adopted. This may include the net benefits resulting from participating in an IEA. Second, political revenue depends on the contributions from lobby groups.
The political revenue function of the government in a type i country, π_i, reflects the benefits and costs of greenhouse gas abatement and the prospective contributions, L, from lobby groups supporting the government's policy. The political revenue function is

$$\pi_i(q_i, q) = B_i(q) - C_i(q_i) + \lambda_i L_i(q_i, q) \tag{1}$$

where $B_i(q)$ are the total discounted benefits from global abatement denoted by $q = \sum_{i \in I} (k_i q_i^s + o_i q_i^{out})$, and $C_i(q_i)$ are the total discounted abatement costs from own abatement q_i. We assume that $B_i(q)$ is concave, i.e. $\frac{\partial B_i}{\partial q} > 0$ and $\frac{\partial^2 B_i}{\partial q^2} \leq 0$, $C_i(q_i)$ is strictly convex, i.e. $\frac{\partial C_i}{\partial q_i} > 0$ and $\frac{\partial^2 C_i}{\partial q_i^2} \geq 0$. The parameter λ_i captures the relative weight of contributions compared to net benefits from abatement. Finally, $L_i(q_i, q) \geq 0$, represents the total contributions from local lobbies. Total lobby contributions are the sum of firms' and greens' contributions, $L_i(q_i, q) \equiv L_i^f(q_i) + L_i^g(q)$ with firms' contributions $\frac{\partial L_i^f}{\partial q_i} < 0$ and $\frac{\partial^2 L_i^f}{\partial q_i^2} < 0$ and greens' contributions $\frac{\partial L_i^g}{\partial q} > 0$ and $\frac{\partial^2 L_i^g}{\partial q^2} \leq 0$. In the first stage lobby groups announce their prospective contributions, which are contingent on the governments abatement decisions, to their countries' governments.

At stage I all countries $i \in I$ decide simultaneously whether or not to join an IEA. We denote a country of type i's choice to join and become a signatory by $\sigma_i = 1$. If a type i country does not join, $\sigma_i = 0$, it remains a singleton player. The signatories $S \subseteq N$ act jointly, i.e. as a single player in the subsequent transboundary pollution game. If no country or only a single country joins the IEA, then there is no effective agreement. We refer to this situation as 'All Singletons' and denote it by $S = \emptyset$. If $S = N$, we have the Grand Coalition. We assume that signatories make a binding agreement and behave like a single player. Hence, we restrict our

attention to participation and do not discuss enforcement[4].

2.2 The transboundary pollution game and payment of the lobby-contributions

Our model of transboundary pollution is standard in the literature and has been used in recent contributions (e.g. Asheim and Holtsmark, 2009). We assume a uniformly mixing pollutant (such as greenhouse gases). In this setting, abatement is a pure public good. At this stage the IEA has been formed and, as indicated before, we assume that it behaves like a single player. Hence the players of the transboundary pollution game are the IEA and the remaining singletons. Each non-signatory government chooses abatement to maximize its political revenue given by (1). To arrive at closed form solutions we assume that benefits are linear and costs are quadratic in abatement. Further we aim to determine the effects of lobby-groups on governments that are differently affected by lobby-groups and therefore assume in the following that countries are symmetric in their direct costs and benefits from abatement but differ in their relative weight of contributions. Thus we have

$$\pi_i(q_i, q) = bq - \frac{1}{2}c{q_i}^2 + \lambda_i L_i(q_i, q). \tag{2}$$

Signatory governments cooperatively decide about their abatement to maximize the joint payoffs, including lobby contributions. The abatement decisions are taken in a simultaneous-move game. After the governments have decided about their emissions abatement, payoffs are determined on the bases of abatement costs and benefits, and lobby groups pay the contributions according to their announcements. Given our specifications this game has a unique Nash equilibrium.

[4]McEvoy and Stranlund (2009) introduce a model that addresses both issues.

3 Emission Abatement

The game is solved by backward induction. We start the analysis at the last stage of the game. In this stage, lobbies pay their contributions depending on the abatement decisions of the countries. The lobby contributions are specified as follows. Firms in a country of type i face additional abatement costs. They bear a fraction ϕ_i of these costs while a fraction $1 - \phi_i$ is passed on to consumers. Hence we stipulate that firms' willingness to pay for reducing abatement is given by

$$L_i^f(q_i) = \phi_i \frac{1}{2} c(\hat{q_{if}}^2 - {q_i}^2) \tag{3}$$

where $\hat{q_{if}}$ denotes the preferred policy in a country of type i in the absence of lobbying, i.e. the policy preferred by the electorate. As firms do not know the true $\hat{q_{if}}$ we assume that they calculate with the worst case scenario which is the fully cooperative quantity of abatement[5]. The greens appreciate any avoided damage from emissions, i.e. the benefits of abatement. Their willingness to pay for additional abatement is as follows

$$L_i^g(q) = \gamma_i(q - \hat{q_g}) \tag{4}$$

where γ_i is a scaling parameter that captures the greens preference for money vis-à-vis the avoided damage. Similar to the firms the greens do not know the true $\hat{q_g}$ and we assume that they take into account their worst case scenario which is zero abatement[6]. We consider only positive lobby contributions (c.f. Habla and Winkler, 2013) so that lobbies are not compensated for potential losses from the government's decisions. Firms are committed to the contribution schedules announced in the first

[5]Other assumptions for the firms are possible as well and do not change the results as long as both lobby groups choose to pay lobby contributions and we have an interior solution. Since we observe both environmentalists and firms lobbying activities in the international policy arena this is seems to be a reasonable assumption.

[6]For the same reason as for firms, different assumptions about $\hat{q_g}$ are possible and do not change the results.

stage of the game that reflect the willingness to pay of a lobby to influence the government's policy decisions in their favor. We only consider truthful contribution schedules here as Bernheim and Whinston (1986) have shown that lobby-groups do not lose by playing truthful contribution schedules. A truthful contribution schedule is given if a lobby-group offers the change in its welfare that is induced by a corresponding change of the government's policy completely as lobby contributions. Thus (3) and (4) characterize the willingness to pay of the lobbies.

In the second stage of the game the amount of emissions abatement is chosen. All non-signatories maximize their political revenue functions simultaneously with the signatories' joint decision. Maximization of (2) yields the non-signatories' abatement decision dependent on the lobby-contributions proposed in the first stage:

$$q_i^{out} = \frac{b + \lambda_i L_i'(q_i^{out})}{c}. \tag{5}$$

The signatories of the IEA reveal their political revenue as a function of $\boldsymbol{q^S}$ and all signatories cooperatively maximize their joint revenue $\Pi(\boldsymbol{q^S})$ with $\boldsymbol{q^S}$ being a vector of the abatement quantities q_i^s of all signatories and k_i the number of signatories of type i

$$\Pi(\boldsymbol{q^S}) = \sum_{i \in S} k_i \pi_i(q_i^s, q) = \sum_{i \in S} k_i [bq - \frac{1}{2} c q_i^{s\,2} + \lambda_i L_i(q_i^s)]. \tag{6}$$

The solution of this maximization problem yields the abatement decision for each type i signatory dependent on the lobby contributions

$$q_i^s = \frac{\sum_i k_i b + \sum_i k_i \lambda_i L_i(q_i^s)}{c}. \tag{7}$$

Inserting (3) and (4) in (5) we yield the quantities of emissions abatement that

are undertaken by outsiders

$$q_i^{out} = \frac{b + \lambda_i \gamma_i}{c(1 + \lambda_i \phi_i)}. \tag{8}$$

We see that non-signatories have dominant abatement strategies that do neither depend on the number of IEA-signatories or their amount of abatement nor on the amount of abatement from the other non-signatories. The quantities of emission abatement of a signatory country of type i may be found by inserting (3) and (4) in (7) and reads

$$q_i^{s} = \frac{\sum_j k_j (b + \lambda_j \gamma_j)}{c(1 + \lambda_i \phi_i)}. \tag{9}$$

We directly see that signatories abate a higher amount of emissions than the non-signatories of the IEA.

Proposition 1. *The inclusion of lobby groups has an effect on the optimal abatement quantities of signatories and non-signatories. The inclusion of green lobbies in country i results in higher abatement while the inclusion of firms results in lower abatement. For signatories lobby effects of green lobbies spill over to all other signatories, i.e. other signatories abate more as a response to green lobby contributions in country i.*

Proof. The proof of Proposition 1 is given in the Appendix. □

Already at this stage we see how lobby groups influence global emissions abatement in the 'All Singletons' situation with $S = \emptyset$ and the case of the grand coalition with $S = N$. While the presence of greens leads to a greater amount of globally abated emissions, firms' lobbying reduces global efforts to mitigate climate change.

4 IEA Formation

To solve the participation stage of the game we apply the concepts of internal and external stability. Initially borrowed from cartel-theory (d'Aspremont et al., 1983) these are widely used in IEA-Theory (e.g. Barrett, 1994; Carraro and Siniscalco, 1993) and define a stable coalition as one in which no member is better off by leaving the coalition and no non-member gains by joining the coalition. Formally it has been shown in a standard setting with symmetric players that if a stability function $\Lambda(k)$ is defined as $\Lambda(k) = P_s^*(k) - P_{out}^*(k-1)$ such stable coalitions are characterized generally by the largest integer k that satisfies $\Lambda(k) \geq 0$ (c.f. Dietz et al., 2012; Carraro and Siniscalco, 1993) if $\frac{\partial \Lambda(k)}{\partial k} < 0$. The number of signatories is denoted by k while $P_s^*(k)$ denotes the optimal payoff of a signatory country and $P_{out}^*(k)$ the optimal payoff of a singleton. In our case a stable coalition is defined by a set of stability functions: one for each type of country. Defining $\boldsymbol{k}$ as the vector of the numbers k_i of signatories of all types the stability function of a type i country is given by

$$\begin{aligned}\Lambda_i(\boldsymbol{k}, \lambda_i) = bq(\boldsymbol{k}^*) - \frac{1}{2}c(q_i^s(\boldsymbol{k}^*))^2 + \lambda_i[L_i^f(q_i^s(\boldsymbol{k}^*)) + L_i^g(q_i^s(\boldsymbol{k}^*))] \\ -bq(\boldsymbol{k}^{*-1}) + \frac{1}{2}c(q_i^{out})^2 - \lambda_i[L_i^f(q_i^{out}) + L_i^g(q_i^{out})] \qquad (10)\end{aligned}$$

The number of signatories of all types is given by $\boldsymbol{k}$, the superscript $*$ characterizes the situation with the respective country of type i being a member and the superscript $*-1$ the situation if the respective country i would have left the agreement.

From equation (10) we see that in absence of lobbying countries are symmetric and the stability function can be written as

$$\Lambda(k) = b(\Delta q) - \frac{1}{2}c(q^s(k^*))^2 + \frac{1}{2}c(q^{out})^2 \tag{11}$$

with $\Delta q = q(k^*) - q(k^{*-1})$.

(11) is negative for all non-trivial coalitions $k > 2$ so that the size of the internally and externally stable coalition is given by the largest integer k that satisfies $\Lambda(k^*) \geq 0$, in this case by a coalition of three countries $k^* = 3$. This result is known in the literature on IEAs (c.f. e.g. Dietz et al., 2012; Carraro and Siniscalco, 1993) so that we now turn to the effects of lobby groups on the stability of IEAs.

Proposition 2. *The influence of firms*

1. *has ambiguous effects on the host countries incentives to join an agreement*

2. *lowers other countries' incentives to join the IEA.*

Proof. The proof of Proposition 2 is given in the Appendix. □

The effect of firms' contributions on international cooperation for global abatement is twofold. These contributions reduce the additional amount of emissions abatement that the host country undertakes if it joins the IEA. Firstly, this directly influences the host country's incentives to join ambiguously as it reduces additional costs from joining as well as additional benefits from increased global abatement. Secondly, in case of an IEA-membership it negatively affects other countries' incentives to join the agreement because the firms contributions lead to a decreased reaction to the growth of the coalition. The country increases its abatement efforts less if another country joins the coalition so that the other country's incentives to join are reduced.

Proposition 3. *The influence of green lobby groups*

1. *increases the own country's incentives to join the IEA and*

2. *makes it less attractive for other countries to be a member of the IEA.*

Proof. The proof of Proposition 3 is given in the Appendix. □

Lobby contributions from environmentalists increase the incentives of the host country to join an IEA as the lobby contributions partly compensate the increased costs of the higher abatement that follows from the IEA membership. The effect of green lobby contributions on other countries is less straightforward: as green contributions raise the abatement ambition of an IEA member every other member country has to fulfil higher abatement targets as well (following from the joint maximisation assumption for IEA signatories). This leads to higher abatement costs for a potentially joining country which reduces the incentives to join. In total the effects of lobbying activities on the size and stability of IEAs are ambiguous. This is in contrast to the clear results that we obtain for the 'All-Singletons' case and the situation with the grand coalition. However, we clearly show that lobby contributions not only affect the abatement decisions of the host countries but have an effect on the size and stability of IEAs as well.

5 Conclusions

In this paper, we study the effect of political pressure groups (lobbies) on the emissions abatement decisions of countries and on the stability of international environmental agreements. We study IEAs as a coalition formation process. The formation of IEAs is modeled as a game in which lobbies announce their contributions at the first stage before governments choose their participation. In the next stage countries decide about their abatement strategies considering both net benefits from abatement and lobby contributions. Finally lobby contributions are paid contingent on

the governments abatement decisions. 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 assume that the industry lobby is always harmed if the government increases abatement. Our results show that lobby contributions have an effect on the abatement decisions of IEA signatories and outsiders in the absence of an agreement as well as in the cases of partial cooperation and of the grand coalition. Firms' contributions reduce emissions abatement of the affected country while environmentalists' contributions give incentives for more ambitious abatement targets. The effects on the stability and size of IEAs are ambiguous. Firms' contributions have an ambiguous effect on the stability of IEAs while greens may incentivize countries to join an agreement. However, the increase of ambition in the abatement goals of members that are influenced by environmentalist lobby groups may deter less ambitious countries from joining the agreement. We thus show that the influence of lobby groups not only changes the abatement decisions of countries but may as well affect the stability of IEAs and deserves more attention in the theoretical literature on IEA formation.

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6 Appendix

6.1 Proof of Proposition 1

As the abatement decisions are given by (8) for singletons and (9) for IEA-signatories, comparative statics show that

$$\forall i \in I : \frac{\partial q_i^{out}}{\partial \phi_i} = -\frac{\lambda_i(b + \lambda_i \gamma_i)}{c(1 + \lambda_i \phi_i)^2} < 0 \tag{12}$$

$$\forall j \neq i : \frac{\partial q_i^{out}}{\partial \phi_j} = 0 \tag{13}$$

$$\forall i \in I : \frac{\partial q_i^{out}}{\partial \gamma_i} = \frac{\lambda_i}{c(1 + \lambda_i \phi_i)} > 0 \tag{14}$$

$$\forall j \neq i : \frac{\partial q_i^{out}}{\partial \gamma_j} = 0 \tag{15}$$

and

$$\forall i \in I : \frac{\partial q_i^{s}}{\partial \phi_i} = -\frac{\lambda_i \sum_i k_i(b + \lambda_i \gamma_i)}{c(1 + \lambda_i \phi_i)^2} < 0 \tag{16}$$

$$\forall j \neq i : \frac{\partial q_i^{s}}{\partial \phi_j} = 0 \tag{17}$$

$$\forall i \in I : \frac{\partial q_i^s}{\partial \gamma_i} = \frac{k_i \lambda_i}{c(1+\lambda_i \phi_i)} > 0 \tag{18}$$

$$\forall j \neq i : \frac{\partial q_i^s}{\partial \gamma_j} = \frac{k_j \lambda_j}{c(1+\lambda_i \phi_i)} > 0 \tag{19}$$

□

6.2 Proof of Proposition 2

Writing the stability function (10) including the lobby-contributions of firms for two types of countries i and j allows us to analyze the effects of lobbying on the host country as well as on other countries:

$$\begin{aligned}\Lambda_i(k_i, \lambda_i, \gamma_i, \phi_i, k_j, \lambda_j, \gamma_j, \phi_j) = bq(k_i^*, \lambda_i, \gamma_i, \phi_i, k_j, \lambda_j, \gamma_j, \phi_j) \\ -\frac{1}{2}c(q_i^s(k_i^*, \lambda_i, \gamma_i, \phi_i, k_j, \lambda_j, \gamma_j, \phi_j))^2 + \lambda_i[\phi_i \frac{1}{2} c(\hat{q_{if}}^2 - (q_i^s(k_i^*, \lambda_i, \gamma_i, \phi_i, k_j, \lambda_j, \gamma_j, \phi_j))^2) \\ +\gamma_i(q(k_i^*, \lambda_i, \gamma_i, \phi_i, k_j, \lambda_j, \gamma_j, \phi_j) - \hat{q_g})] - bq(k_i^{*-1}, \lambda_i, \gamma_i, \phi_i, k_j, \lambda_j, \gamma_j, \phi_j) + \frac{1}{2}c(q_i^{out})^2 \\ -\lambda_i[\phi_i \frac{1}{2} c(\hat{q_{if}}^2 - (q_i^{out})^2) + \gamma_i(q(k_i^{*-1}, \lambda_i, \gamma_i, \phi_i, k_j, \lambda_j, \gamma_j, \phi_j) - \hat{q_g})].\end{aligned} \tag{20}$$

Rearranging yields

$$\begin{aligned}\Lambda_i(k_i, \lambda_i, \gamma_i, \phi_i, k_j, \lambda_j, \gamma_j, \phi_j) = (b + \lambda_i \gamma_i)\Delta_i q \\ -\frac{1}{2}(c + \lambda_i \phi_i)[(q_i^s(k_i^*, \lambda_i, \gamma_i, \phi_i, k_j, \lambda_j, \gamma_j, \phi_j))^2 - (q_i^{out})^2]\end{aligned} \tag{21}$$

with $\Delta_i q = q(k_i^*, \lambda_i, \gamma_i, \phi_i, k_j, \lambda_j, \gamma_j, \phi_j) - q(k_i^{*-1}, \lambda_i, \gamma_i, \phi_i, k_j, \lambda_j, \gamma_j, \phi_j)$ being the difference in global emissions abatement between the case of country i being a

signatory of the agreement and the case of country i being a singleton.

6.2.1 Proof of Proposition 2.1

Differentiation of (20) with respect to ϕ_i shows that

$$\begin{aligned}\forall i \in I : \frac{\partial \Lambda_i}{\partial \phi_i} = \frac{1}{2c(1+\lambda_i\phi_i)^2}\lambda_i(b^2(-1+k_i^2+2k_i(-2+k_j)+k_j(-2+k_j)) \\ +\gamma_i^2\lambda_i^2(-1+k_i(-4+k_i))+2\gamma_i\gamma_j\lambda_i\lambda_j k_j(-1+k_i)+\gamma_j^2\lambda_j^2k_j^2 \\ +2b(\gamma_i\lambda_i(-1-k_j+k_i(-4+k_i+k_j))+\gamma_j k_j\lambda_j(-1+k_i+k_j))).\end{aligned} \tag{22}$$

The sign of this term indicates the effect of firms' contributions on the incentive of the host country to join the IEA and can be positive or negative, depending on the parameter values.

□

6.2.2 Proof of Proposition 2.2

Differentiation of (20) with respect to ϕ_j shows that

$$\forall j \neq i : \frac{\partial \Lambda_i}{\partial \phi_j} = -\frac{\lambda_j k_j (b+\lambda_i\gamma_i)^2}{c(1+\lambda_j\phi_j)^2} < 0 \tag{23}$$

The sign of this term indicates the effect of firms' contributions on the incentive of other countries to join the IEA. As it is negative firms' contributions lower other countries' incentives to join the IEA.

□

6.3 Proof of Proposition 3

6.3.1 Proof of Proposition 3.1

Differentiating (20) with respect to γ_i for $k_i = 1$ yields

$$\forall i \in I : \frac{\partial \Lambda_i}{\partial \gamma_i} = \frac{2\lambda_i(b + \lambda_i\gamma_i)(2 + k_j + \lambda_i\phi_i k_j + 2\lambda_j\phi_j)}{c(1 + \lambda_i\phi_i)(1 + \lambda_j\phi_j)} > 0. \tag{24}$$

As this term is positive, we see that green lobby contributions raise the incentives for participation in the IEA for the host country.[7] □

6.3.2 Proof of Proposition 3.2

Differentiation of (20) with respect to γ_j yields

$$\forall j \neq i : \frac{\partial \Lambda_i}{\partial \gamma_j} = -\frac{\lambda_j k_j(b(-1 + k_i + k_j) + \lambda_i\gamma_i(-1 + k_i) + \lambda_j\gamma_j k_j)}{c(1 + \lambda_i\phi_i)} < 0. \tag{25}$$

Thus, green lobby contributions in country i make it less attractive for other countries to participate in the IEA. □

[7] All other general results also hold for the case of $k_i = 1$. As we are interested here only in the effects of lobbying on the host country we restrict k_i to 1.

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