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Political influence on non-cooperative international climate policy*

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Abstract: We analyze non-cooperative international climate policy in a setting of political competition by national interest groups. In the first stage, countries decide whether to set up an international emission permits market, which only forms if it is supported by all countries. In the second stage, countries non-cooperatively decide on the number of tradable or non-tradable emission allowances, depending on the type of regime. In both stages, special interest groups try to sway the government in their favor. We find that (i) both the choice of regime and the level of aggregate emissions only depend on the aggregate levels of organized stakes in all countries and not on their distribution among individual interest groups, and (ii) an increase in lobbying influence by a particular lobby group may backfire by inducing a change towards the less preferred regime.

Keywords: non-cooperative climate policy, political economy, emissions trading, organization of interest groups, environmental awareness

JEL-Classification: D72, H23, H41, Q58

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1 Introduction

When analyzing international (environmental) policy, we often consider individual countries to be represented by a single benevolent decision maker, e.g. a government, acting in the best interest of the country as a whole. In this paper, we depart from this idealized abstraction by assuming that each country's decision maker is vulnerable to the influence of national political competition. Then, international policy is governed by two forces: (i) the influence of political competition on a national level and (ii) the interplay of national governments on the international policy arena.

By political competition we mean that incumbent politicians do not only consider the welfare of the general electorate (national social welfare) but are also susceptible to the influence of lobby groups which try to sway them in their favor by providing campaign contributions, information or simply bribes. This may give them an advantage over their challengers at the next election and hence increases their likelihood of reelection. Deviating from the socially optimal policy, however, leads to an alienation of voters and decreases this likelihood. Policy-makers thus face a trade-off between maximizing political support by interest groups and maximizing national social welfare.

On the international level, the particular environmental policy we consider is the non-cooperative formation of an international emission permits market (Helm 2003). Our choice for non-cooperative climate policies is twofold. On the one hand, the international negotiations for a successor of the Kyoto Protocol[1] both in December 2009 in Copenhagen and a year later in Cancún have shown how difficult international cooperation is to achieve with respect to climate change. On the other hand, Carbone et al. (2009) have recently shown that even non-cooperative climate policies exhibit substantial potential for greenhouse gas reductions.

Thus, we analyze the political economy of international climate policy in a framework comprising two countries and two stages. In the first stage, governments in each country decide whether to join an international permit market or not. If both countries agree to form a permit market, the decision on the number of permits is taken in the second stage. If no agreement has been reached in the first stage, governments decide upon national emission targets in the second stage. In both stages, governments are subject to

[1] In the Kyoto Protocol, which expires by the end of 2012, the industrialized countries of the world, so called Annex B countries, committed themselves to a reduction of greenhouse gas emissions by 5.2% against 1990 levels over the period from 2008 to 2012.

political influence by national interest groups. As a consequence, governments are supposed to maximize a weighted sum of national social welfare and lobby contributions. Social welfare in each country comprises benefits of national and environmental damage costs of global emissions. If a permit market has been put in place, an additional term enters the welfare function which captures the revenues from permit sales or the costs associated with permit purchases. Within this framework, we analyze how national lobbying influences non-cooperative international environmental policy and if (and how) the distribution of special interest groups affects the equilibrium outcome.

We find that the number of tradable or non-tradable emission allowances, depending on the type of regime, is determined by the aggregate level of organized stakes in both countries, as long as all lobby groups exhibit strictly positive contribution schedules. This implies that for given national aggregates neither the number nor the composition of special interest groups matters for national and international emission levels. Further, we show that for the case of grandfathered emission permits, the influence of political competition on the national level can be captured by politically adjusted damage functions. Also the choice of regime in the first period, i.e. whether an international permits market is set up, does not depend on the distribution of organized stakes among special interest groups, as long as all lobby groups exhibit strictly positive contribution schedules. In addition, we find that an increase in influence of a particular lobby group may weaken the support for the interest group's preferred regime in both countries. The reason is that, although there exists a direct effect in favor of the interest group's preferred regime, there is also an indirect effect in both countries, due to the strategic interactions on the international level, which may outweigh the direct effect.

Our paper combines two strands of literature. It adds to the literature on non-cooperative international permit markets, originating in Helm (2003) and Carbone et al. (2009), by introducing a political economy framework in the tradition of Grossman and Helpman. While Helm (2003) and Carbone et al. (2009) assume benevolent national governments and leave out the possibility of swaying policy-makers, the literature on special interest groups originates from issues in international trade where stakeholders have long played an important role in determining a country's trade policies. In finding the equilibrium of our game, we use the political economy approach ("common agency") originally developed by Bernheim and Whinston (1986) and extended by Grossman and Helpman in various seminal contributions (Grossman and Helpman 1994, 1995a,b, 2002). We focus our analysis in the second stage on "truthful" Nash equilibria, i.e. we assume that lobbies, at the margin, contribute according to the marginal change in their welfare induced by a marginal change in policy. To determine the equilibrium in the first stage, we follow Grossman and Helpman (1995a) in their analysis of free trade agreements. In contrast to their model setting, our model comprises a continuous policy variable in the second stage, the number of tradable or non-tradable allowances.

There is another closely related strand of literature which examines the political economy of tradable emission permits, in particular the question whether permits will and should be auctioned or grandfathered in political equilibrium (Lai 2007, 2008). While Lai's analysis is confined to the national level, we are particularly interested in how political competition on the national level influences international policies.

The remainder of the paper is organized as follows: The following section introduces the basic economic model and the political actors. Section 3 is concerned with the second stage of the game in which the number of tradable or non-tradable allowances is chosen. The decision in the first stage is analyzed in Section 4 before we discuss and generalize our results in Section 5. Section 6 concludes.

2 The model

We consider two countries, indexed by $i = 1, 2$ and $-i = \{1, 2\} \setminus i$.[2] In each country i, emissions e_i imply country-specific benefits from productive activities $B_i(e_i)$ with $B_i(0) = 0$, $B_i' > 0$ and $B_i'' < 0$ for all $i = 1, 2$. Global emissions, $E = e_1 + e_2$, cause strictly increasing and convex country-specific damages $D_i(E)$ with $D_i(0) = 0$ and $D_i' > 0$, $D_i'' \geq 0$ for all $E > 0$ and $i = 1, 2$.

2.1 Non-cooperative international climate policy

Countries may agree upon introducing an international emission permit market in which each country i non-cooperatively decides on the amount of emission permits ω_i it issues to its domestic firms. Firms in each country need (at least) emission permits amounting to emissions e_i. The permits are traded on a perfectly competitive international permit market at price p. As a consequence, national social welfare is given by:

$$W_i^T(\omega_i, E) = B_i\big(e_i(E)\big) - D_i(E) + p(E)\,[\omega_i - e_i(E)] \ . \tag{1a}$$

[2] All our results can be generalized to n countries in a straightforward manner.

Due to national sovereignty, an international permit market is only introduced if both countries are willing to participate. If this is not the case, both countries set national emission caps e_i non-cooperatively. Then, social welfare reads:

$$W_i^{NT}(e_i, E) = B_i(e_i) - D_i(E) \ . \tag{1b}$$

2.2 Political actors

We assume that each country i is represented by a government deciding on its environmental policy. Governments face two consecutive decisions: (i) a binary decision whether the respective country wants to participate in an international emission permit market and (ii) contingent on whether an international permit market is formed the choice of the level of issued permits or national emission caps. Governments in each country are assumed to care about national social welfare but are also vulnerable to lobbying contributions of special interest groups.

We assume that there are M_i interest groups in country i, which exhibit different stakes in the elements of the social welfare function W_i.[3] The degree to which interest group j benefits from emissions is defined as $0 \leq \beta_{ij} \leq 1$, with the aggregate national level being $\sum_{j=1}^{M_i} \beta_{ij} = b_i$, whereas it suffers from damages caused by emissions to the degree $0 \leq \delta_{ij} \leq 1$, with $\sum_{j=1}^{M_i} \delta_{ij} = d_i$. If an international permit market is set up, social welfare (1a) encompasses a third component, the net revenues from permit trade, which is positive if a country has lower emissions than emission permits issued. The interest groups' stakes in these revenues are denoted by $0 \leq \rho_{ij} \leq 1$, with $\sum_{j=1}^{M_i} \rho_{ij} = r_i$. Thus, b_i (d_i, r_i) denotes the share of emission benefits (damage costs, net revenues from permit sales) in country i which is under the control of organized special interest groups.

Organized interest groups in country i offer contributions to the local government in order to sway chosen policies in their own favor. We model the two policy decisions the governments face as a two-stage game. As a consequence, lobby groups may offer contributions for each of the policy decisions individually. Governments in all countries are assumed to care about the weighted sum of national social welfare and lobbying

[3] Note that not necessarily all stakeholders are able to overcome the collective action problem described by Olson (1971) and organize themselves as lobby groups. As we will see later, if not all stakes are represented equally, a political distortion in the allocation arises due to lobbying.

contributions:

$$G_i^R = W_i^R + \theta_i \sum_{j=1}^{M_i} (C_{ij}^{1,R} + C_{ij}^{2,R}) \ , \tag{2}$$

where $R = \{T, NT\}$ denotes the type of regime (T = trading if an international emission permit market is formed and NT = no-trading in case of national emission caps), θ_i the relative weight the government in country i attaches to lobbying contributions compared to national social welfare W_i^R, and $C_{ij}^{1,R}$ and $C_{ij}^{2,R}$ are the lobbying contributions of lobby group j in country i in the first and second stage, respectively, contingent on the implemented regime.

Lobby groups are assumed to maximize the total pay-off of their members, which is the organized stakes in national social welfare U_{ij}^R that the lobby group j in country i represents minus lobbying contributions in the first and second stage:

$$L_{ij} = U_{ij}^R - (C_{ij}^{1,R} + C_{ij}^{2,R}) \ , \tag{3}$$

with

$$U_{ij}^T(\omega_i, E) = \beta_{ij} B_i(e_i(E)) - \delta_{ij} D_i(E) + \rho_{ij} p(E) \left[\omega_i - e_i(E)\right] \ , \tag{4a}$$

$$U_{ij}^{NT}(e_i, E) = \beta_{ij} B_i(e_i) - \delta_{ij} D_i(E) \ . \tag{4b}$$

Note that the definition of equations (2) and (3) implies that the chronology of events is such that we may abstract from discounting outcomes accruing at different stages.

2.3 Structure of the game

We model the consecutive decisions on the choice of regime and the national environmental policy as a non-cooperative two-stage game. In the first stage, governments of both countries simultaneously decide whether to take part in an international emission permit market. An international permit market only forms if both countries consent to it. In the second stage, the governments simultaneously decide on the national environmental policy, which is the amount of emission permits issued in case an international permit market is formed in the first stage or the national emission caps otherwise.

In our model setup, two separate non-cooperative games coincide on each stage: On the one hand, organized interest groups act non-cooperatively in choosing their contribution schedules to influence the respective government's policy variable. On the other hand, countries decide non-cooperatively on international environmental policy. As a consequence, each of the two model stages comprises a lobbying game in each country (Grossman and Helpman 1994, 1995a).[4] In the following, the complete timing of events is outlined:

1. Regime choice

   a) All organized lobby groups j in both countries i simultaneously offer a contribution schedule contingent on the policy choice of the local government, taking the contribution schedules of all other lobby groups and the decision of the other country as given.

   b) Governments in all countries simultaneously decide on whether to participate in an international permit market. Lobby groups pay contributions contingent on policy choice.

   c) A permit market forms if the governments in both countries consent to it.

2. National emissions and allowance choices

   a) Contingent on the regime which was decided in the first stage, all organized lobby groups j in both countries i simultaneously offer a contribution schedule contingent on the policy choice of the local government, taking the decision of the other government as given.

   b) Governments in both countries simultaneously decide on the amount of emission permits they issue (in case of an international permit market) or on national emission caps (otherwise). Lobby groups pay contributions contingent on policy choice.

   c) If an international permit market was formed in stage one, emission permits are traded internationally.

3 The second stage: National emission and allowance choices

We solve the game by backward induction, starting with the second stage. In the second stage, the choice of regime is already determined. In addition, the contributions $C_{ij}^{1,R}$ paid

[4] In line with Grossman and Helpman (1994, 1995a), we assume that lobby groups offer contributions only to the local government.

in the first stage are sunk and do not influence the governments' and the lobby groups' decisions in the second stage. Depending on the type of regime chosen in the first stage, the governments of all countries simultaneously set either national emission caps or the level of emission permits they issue, while organized interest groups in all countries sway the local government to choose policies in their favor by offering contribution schedules. As outlined in Section 2.3, the second stage splits into multiple sub-stages.

We seek the subgame perfect Nash equilibrium of this non-cooperative game in the second stage for truthful contribution schedules of all interest groups (Grossman and Helpman 1994).[5] Truthful contribution schedules reflect the true preferences of the lobby groups. For any policy, lobby groups pay to the local government their gross utility U_{ij}^R minus some base utility level $R_{ij}^{2,R}$, or formally

$$C_{ij}^{2,R} = \max\left[0, U_{ij}^R - R_{ij}^{2,R}\right] \ , \tag{5}$$

A truthful contribution schedule is always continuous and differentiable at least as long as it is positive, as $R_{ij}^{2,R}$ is a scalar and U_{ij}^R is twice continuously differentiable.

3.1 National emissions caps under lobby group pressure

We first assume that no international permit market has been formed in the first stage of the game. Then, the governments of both countries set national emissions caps non-cooperatively in the second stage while being influenced by the local organized special interest groups.

The government of country i sets the national emission cap e_i such as to maximize

$$G_i^{NT}(e_i, E) = W_i^{NT}(e_i, E) + \theta_i \sum_{j=1}^{M_i} \left[C_{ij}^{1,NT} + C_{ij}^{2,NT}(e_i, E)\right] \ , \tag{6}$$

given truthful contribution schedules (5) of the local organized interest groups and given the national emission cap e_{-i} of the other country.

[5] In fact, there exist other schedules that support an equilibrium. However, Bernheim and Whinston (1986) showed that lobby groups suffer no loss from playing truthful contribution schedules since each principal's set of best-response strategies contains a truthful contribution schedule. Furthermore, focussing on truthful payment schedules may be justified because they are a simple device to achieve efficiency without any player conceding his right to grab as much as she can for herself.

Assuming strictly positive contribution schedules for all lobby groups j in both countries i, the reaction function of government i is implicitly given by

$$B_i'(e_i) - D_i'(E) + \theta_i \sum_{j=1}^{M_i} \left[\beta_{ij} B_i'(e_i) - \delta_{ij} D_i'(E)\right] = 0 \ , \tag{7}$$

which implies

$$B_i'(e_i) = \frac{1+\theta_i d_i}{1+\theta_i b_i} D_i'(E) \ . \tag{8}$$

There exists a unique Nash equilibrium of this second stage of the game, as the following proposition states.

Proposition 1 (Unique Nash equilibrium in national emissions caps)
For truthful and strictly positive contribution schedules of all lobby groups, there exists a unique Nash equilibrium of the game in which all countries $i = 1, 2$ simultaneously set national emissions caps e_i such as to maximize (6) *for given emissions e_{-i} of the other country.*

The proof of Proposition 1 is given in the Appendix.

We obtain the same Nash equilibrium as in the corresponding game without lobbying if $\theta_i b_i = \theta_i d_i$ for all $i = 1, 2$ (although this equilibrium brings about payoffs which are different from the case without lobbying). This either holds if all governments assign no weight to lobbying contributions, $\theta_i = 0$, or if organized and participating lobby groups represent equally strong stakes in both components of national social welfare in all countries, $b_i = d_i$. Of course, this also includes the polar case that all citizens are organized and thus $b_i = d_i = 1$.

Equation (8) also implies that both national emissions caps e_i and total emissions E only depend on the national levels of organized stakes, b_i and d_i, in both components of social welfare in all countries and neither on the number nor the composition of lobby groups, as long as all lobby groups exhibit strictly positive equilibrium contribution schedules. In fact, by defining *politically adjusted* damage functions $\tilde{D}_i(E)$ as

$$\tilde{D}_i(E) = \alpha_i D_i(E) \ , \qquad \alpha_i \equiv \frac{1+\theta_i d_i}{1+\theta_i b_i} \ , \quad i = 1, 2 \ , \tag{9}$$

we are back to the standard case without lobbying, where in equilibrium marginal benefits equal marginal damages in both countries, $B_i'(e_i) = \tilde{D}_i'(E)$. The constant α_i is determined by the exogenously given political parameters θ_i, b_i and d_i and captures the aggregate political environment of country i. The following corollary states how national and global emissions in the Nash equilibrium change dependent on these political parameters:

Corollary 1 (Comparative statics of national emissions caps)
The following conditions hold for the levels of national emissions e_i, e_{-i} and total emissions E in the Nash equilibrium:

$$\frac{de_i}{db_i} > 0 \ , \qquad \frac{de_{-i}}{db_i} < 0 \ , \qquad \frac{dE}{db_i} > 0 \ , \tag{10a}$$

$$\frac{de_i}{dd_i} < 0 \ , \qquad \frac{de_{-i}}{dd_i} > 0 \ , \qquad \frac{dE}{dd_i} < 0 \ , \tag{10b}$$

$$\frac{de_i}{d\theta_i} \gtreqless 0 \ , \qquad \frac{de_{-i}}{d\theta_i} \lesseqgtr 0 \ , \qquad \frac{dE}{d\theta_i} \gtreqless 0 \quad \Leftrightarrow \quad b_i \gtreqless d_i \ . \tag{10c}$$

The proof of Corollary 1 is given in the Appendix.

Corollary 1 states that national emissions e_i of country i and also global emissions E are higher the higher are the organized stakes in the benefits and the lower are the organized stakes in the environmental damages in country i. An increase in θ_i increases national emissions e_i and total emissions E if and only if $b_i > d_i$, i.e. if the share of organized stakes is higher for benefits than for environmental damages. Moreover, emission caps are strategic substitutes. If country i increases emission levels in response to a change in the political parameters b_i, d_i and θ_i, country $-i$ decreases its national emission cap and vice versa. However, the direct effect outweighs the indirect effect and the total emissions E follow the national emission cap e_i.

3.2 International permit markets under lobby group pressure

If the countries have decided to form an international permit market in the first stage of the game, the governments of both countries non-cooperatively decide on the amount of emission permits ω_i they will issue in the second stage, which are then traded on a perfectly competitive international permit market at price p. After trade, firms in all countries need (at least) emission permits amounting to emissions e_i.

3.2.1 Permit market equilibrium

In the permit market equilibrium, profit maximization in each country implies that marginal benefits equal the permit price:

$$p = B_i'(e_i) \ , \quad i = 1, 2 \ . \tag{11}$$

This implies the well-known equi-marginal principle stating that in equilibrium the marginal benefits of all participating countries are equal. As all marginal benefit functions B_i' are strictly monotonic, the inverse functions $B_i'^{-1}$ exist with

$$e_i(p) = B_i'^{-1}(p) \ , \quad i = 1, 2 \ . \tag{12}$$

A permit market equilibrium requires total supply of emission permits to equal total emissions:

$$\sum_{i=1}^{2} \omega_i = \sum_{i=1}^{2} B_i'^{-1}(p) = \sum_{i=1}^{2} e_i(p) = E \ . \tag{13}$$

Equation (13) implicitly determines the permit price $p(E)$ in the market equilibrium, which is a function of the total number of issued emission allowances E. Existence and uniqueness follow directly from the assumed properties of the benefit functions B_i.

The following lemma states some important relationships for later use:

Lemma 1
Defining $e_i(E) \equiv e_i\big(p(E)\big)$ and introducing the abbreviations

$$\phi_i\big(p(E)\big) \equiv -\frac{1}{B_i''\big(e_i(p(E))\big)} \ , \quad \Phi\big(p(E)\big) \equiv \phi_1\big(p(E)\big) + \phi_2\big(p(E)\big) \ , \tag{14}$$

the following relationships hold:

$$p'(E) = -\frac{1}{\Phi\big(p(E)\big)} < 0 \ , \quad {e_i}'(E) = \frac{\phi_i\big(p(E)\big)}{\Phi\big(p(E)\big)} \in [0, 1] \ . \tag{15}$$

The proof of Lemma 1 is given in the Appendix.

3.2.2 Issuance of emissions permits

If an international permit market is formed in the fist stage, both countries simultaneously choose the level of emission permits ω_i in the second stage, taking the truthful contribution schedules (5) and the actions ω_{-i} of the other country as given. Thus, the government in country i chooses ω_i such as to maximize its payoff function

$$G_i^T(\omega_i, E) = B_i(e_i(E)) - D_i(E) + p(E)\left[\omega_i - e_i(E)\right] + \theta_i \sum_{j=1}^{M_i} \left[C_{ij}^{1,T} + C_{ij}^{2,T}(\omega_i, E)\right], \quad (16)$$

subject to equations (5), (12), (13) and given ω_{-i}.

Considering again only strictly positive truthful contribution schedules and taking into account that $p(E) = B_i'(e_i(E))$, the reaction function of country i is given by

$$\begin{aligned} &p(E)\left\{(1+\theta_i r_i) + \theta_i(b_i - r_i)e_i'(E)\right\} \\ &\quad - (1+\theta_i d_i)D_i'(E) + (1+\theta_i r_i)p'(E)[\omega_i - e_i(E)] = 0 \ , \end{aligned} \quad (17)$$

Under mild conditions on the benefit functions B_i, there exists a unique Nash equilibrium, as the following proposition states.

Proposition 2 (Unique Nash equilibrium in emissions permits levels) *For truthful and strictly positive contribution schedules of all lobby groups and* $\phi_i'(p)$ *sufficiently small for all* $i = 1, 2$, *there exists a unique Nash equilibrium of the game in which both countries simultaneously set the level of emission permits* ω_i *such as to maximize* (16) *subject to equations* (5), (12), (13) *and taking the permit level* ω_{-i} *of the other country as given.*

The proof of Proposition 2 is given in the Appendix.

The conditions $\phi_i'(p)$ sufficiently small imply that the benefit functions B_i for both countries $i = 1, 2$ are *almost quadratic*. For the remainder of the paper we assume that $\phi_i'(p)$ is so small for both countries $i = 1, 2$ that we may neglect the influence of $e_i''(E)$ and $p''(E)$ when we determine the sign of an expression. Under these conditions there exists a unique Nash equilibrium in the second stage, as shown in the proof of Proposition 2.

Again, we observe from equation (17) that the allowance choices ω_i and, thus, also national and total emissions only depend on the national levels of organized stakes b_i, d_i and r_i and neither on the number nor the composition of lobby groups, as long as all lobby groups exhibit strictly positive equilibrium contribution schedules. However, by re-writing the reaction function (17) to yield

$$p(E) + p'(E)[\omega_i - e_i(E)] - \frac{1+\theta_i d_i}{1+\theta_i r_i} D_i'(E) + \frac{\theta_i(b_i - r_i)}{1+\theta_i r_i} p(E) e_i'(E) = 0 \ , \tag{18}$$

we find that, in contrast to the case of national emission caps, the influence of lobbying on the equilibrium outcome can, in general, not be reduced to politically adjusted damage functions because of the last term on the left-hand side of equation (18). In the special case that $r_i = b_i$ for both countries, this term vanishes and again, the influence of lobbying can be solely reduced to the politically adjusted damage functions (9). In fact, the case of $r_i = b_i$ is compatible with a scenario in which the permit market revenues (or costs) accrue solely to the stakeholders of the firms. This is the case, if firms in all countries receive the national permit allocation for free. As this has been the case for most trading schemes that have been implemented so far, we assume for the remainder of this section that

$$\beta_{ij} = \rho_{ij} \ , \quad i = 1,2, \ j = 1,\ldots,M_i \qquad \Rightarrow \qquad b_i = r_i \ , \quad i = 1,2 \ . \tag{19}$$

Assumption (19) also allows for a straightforward comparison of the two regimes.

Corollary 2 (Comparative statics of permit issuance)
For $r_i = b_i$, the following conditions hold for the levels of emission allowances ω_i, ω_{-i} and total emissions E in the Nash equilibrium:

$$\frac{d\omega_i}{db_i} > 0 \ , \qquad \frac{d\omega_{-i}}{db_i} < 0 \ , \qquad \frac{dE}{db_i} > 0 \ , \tag{20a}$$

$$\frac{d\omega_i}{dd_i} < 0 \ , \qquad \frac{d\omega_{-i}}{dd_i} > 0 \ , \qquad \frac{dE}{dd_i} < 0 \ , \tag{20b}$$

$$\frac{d\omega_i}{d\theta_i} \gtreqless 0 \ , \qquad \frac{d\omega_{-i}}{d\theta_i} \lesseqgtr 0 \ , \qquad \frac{dE}{d\theta_i} \gtreqless 0 \quad \Leftrightarrow \quad b_i \gtreqless d_i \ . \tag{20c}$$

The proof of Corollary 2 is given in the Appendix.

As in the case of national emission caps, national emission allowances ω_i of country i and also global emissions E are higher the higher are the organized stakes in the benefits and the lower are the organized stakes in the environmental damages in country i. An increase in θ_i increases national emission allowances ω_i and total emissions E if and only if $b_i > d_i$, i.e. if the share of organized stakes is higher for benefits than for environmental damages. Again, emission allowances are strategic substitutes. If country i increases its level of emission allowances in response to a change in the political parameters b_i, d_i and θ_i, country $-i$ decreases its level of emission allowance and vice versa. However, the direct effect outweighs the indirect effect, thus the change in total emissions E exhibits the same sign as the change in national emission allowances ω_i. However, the national emission levels $e_i(E)$ in both countries always change in the same direction and follow total emissions E, as $e_i'(E) > 0$.

Taking into account that $r_i = b_i$ $(i = 1, 2)$ and summing up the reaction functions (18) for both countries, we find that the equilibrium permit price equals the average politically adjusted marginal damage:

$$p(E) = \frac{1}{2}\left[\tilde{D}_i'(E) + \tilde{D}_{-i}'(E)\right] \ . \tag{21}$$

Inserting this equation for the permit price back into the reaction function (18) yields the straightforward generalization of Proposition 1 of Helm (2003):

$$\omega_i - e_i(E) = -\frac{1}{p'(E)}\left\{\frac{1}{2}\left[\tilde{D}_i'(E) + \tilde{D}_{-i}'(E)\right] - \tilde{D}_i'(E)\right\} \ , \tag{22}$$

implying that the country with above average politically adjusted marginal damages buys permits from the country with below average politically adjusted marginal damages. Even if countries are economically identical, an argument for permit trading arises whenever the countries' political environments differ.

3.3 Global emissions with and without trading

For the special case $r_i = b_i$ for $i = 1, 2$, also Proposition 2 of Helm (2003) carries over in a straightforward manner. Denote the Nash equilibrium in case of national emission caps by e_i^{NT}, E^{NT}, and by ω_i^T, E^T in case of an international permit market. Summing up the reaction functions (8) and (18) over both countries, we obtain

$$B_i'(e_i^{NT}) + B_{-i}'(e_{-i}^{NT}) = \tilde{D}_i'(E^{NT}) + \tilde{D}_{-i}'(E^{NT}) \ , \tag{23a}$$

$$B_i'(e_i(E^T)) + B_{-i}'(e_{-i}(E^T)) = \tilde{D}_i'(E^T) + \tilde{D}_{-i}'(E^T) \ . \tag{23b}$$

Then, the following relationship between total emissions in the trade and no-trade regime follows directly from $\tilde{D}_i'' \geq 0$:

$$E^T \gtreqless E^{NT} \quad \Leftrightarrow \quad B_i'(e_i(E^{NT})) + B_{-i}'(e_{-i}(E^{NT})) \gtreqless B_i'(e_i^{NT}) + B_{-i}'(e_{-i}^{NT}) \ . \tag{24}$$

For quadratic benefit functions this implies that $E^{NT} > E^T$ if the country with smaller marginal damages also exhibits a smaller $|B_i''|$.[6]

4 The first stage: To trade or not to trade permits

Having characterized tradable and non-tradable allowance choices depending on the political situation, we now move on to analyze the governments' decision in the first stage. In a first step, we analyze the governments' payoff in both regimes. To this end, we have to determine the contribution schedules of all organized lobby groups in all countries. Obviously, without any political pressure in the first stage, a government would prefer the institutional setting that yields higher payoffs in the second stage. But as interest groups either gain or lose depending on whether an international permit market is formed, the decision process in the first stage is also prone to be affected by lobbies. Therefore, we analyze in a second step how political competition between interest groups influences the formation of an international permits market. As already mentioned above, we assume that an international permit market is introduced if and only if both countries consent to it in the first stage. If at least one country decides against the permit market in the first stage, all countries choose national emissions caps in the second stage.

4.1 Second stage equilibrium contributions

Following Grossman and Helpman (1995a) who characterize equilibrium outcomes for the viability of an international free trade agreement under political pressure, we determine when a country takes a pressured and when it takes an unpressured stance. In order to determine the amount of money which a lobby group is willing to contribute in the first stage, we need to find the equilibrium utility levels of the lobby groups net of their contributions in the second stage.

To this end, we utilize the indifference condition of the government stating that the government must be at least equally well off if the lobby is active compared to the case

[6] To see this, note that for the quadratic case, equation (24) can be written as $B_i''\left[e_i(E^{NT}) - e_i^{NT}\right] + B_j''\left[e_j(E^{NT}) - e_j^{NT}\right] \gtreqless 0$. Furthermore, $e_i(E^{NT}) - e_i^{NT} = -\left[e_j(E^{NT}) - e_j^{NT}\right]$. Then, the country with smaller marginal damages (the permit-selling country) exhibits a higher B_i'' (which is equivalent to a lower absolute value of B_i'') for $E^{NT} > E^T$.

when it is inactive. Depending on whether a permit market is formed in the second stage, the following conditions hold:

$$
\begin{aligned}
&W_i^{NT}(e_i^{NT}, E^{NT}) + \theta_i \sum_{j=1}^{M_i} C_{ij}^{2,NT}(e_i^{NT}, E^{NT}) = \\
&\qquad W_i^{NT}(e_i^{-k}, E^{-k}) + \theta_i \sum_{\substack{j=1 \\ j\neq k}}^{M_i} C_{ij}^{2,NT}(e_i^{-k}, E^{-k}) \ ,
\end{aligned} \tag{25a}
$$

$$
\begin{aligned}
&W_i^{T}(\omega_i^{T}, E^{T}) + \theta_i \sum_{j=1}^{M_i} C_{ij}^{2,T}(\omega_i^{T}, E^{T}) \\
&\qquad = W_i^{T}(\omega_i^{-k}, E^{-k}) + \theta_i \sum_{\substack{j=1 \\ j\neq k}}^{M_i} C_{ij}^{2,T}(\omega_i^{-k}, E^{-k}) \ ,
\end{aligned} \tag{25b}
$$

where equilibrium emissions and permit choices are denoted by a superscript $R \in \{NT, T\}$ (depending on the regime) when all lobbies are active, and ω_i^{-k}, e^{-k} and E^{-k} indicate permits and emission levels that would arise if lobby group k did not offer any contributions.

Then, the following proposition holds for the equilibrium contributions of all lobbying groups.

Proposition 3 (Equilibrium contributions in the second stage)
For truthful and strictly positive contribution schedules of all lobby groups, the equilibrium contribution of lobby group k dependent on the choice of regime yields:

$$
\begin{aligned}
C_{ik}^{2,NT}(e_i^{NT}, E^{NT}) &= \frac{1}{\theta_i}\left[W_i^{NT}(e_i^{-k}, E^{-k}) - W_i^{NT}(e_i^{NT}, E^{NT})\right] \\
&\quad + (b_i - \beta_{ik})\left[B_i(e_i^{-k}) - B_i(e_i^{NT})\right] - (d_i - \delta_{ik})\left[D_i(E^{-k}) - D_i(E^{NT})\right] \ ,
\end{aligned} \tag{26a}
$$

$$
\begin{aligned}
C_{ik}^{2,T}(\omega_i^{T}, E^{T}) &= \frac{1}{\theta_i}\left[W_i^{T}(\omega_i^{-k}, E^{-k}) - W_i^{T}(\omega_i^{T}, E^{T})\right] \\
&\quad + (b_i - \beta_{ik})\left[B_i(e_i(E^{-k})) - B_i(e_i(E^{T}))\right] - (d_i - \delta_{ik})\left[D_i(E^{-k}) - D_i(E^{T})\right] \\
&\quad - (r_i - \rho_{ik})\left[p(E^{-k})(e_i(E^{-k}) - \omega_i^{-k}) - p(E^{T})(e_i(E^{T}) - \omega_i^{T})\right] \ .
\end{aligned} \tag{26b}
$$

The proof of Proposition 3 is given in the Appendix.

Proposition 3 states that a particular lobby group k has to compensate the government twofold: On the one hand, it has to recompense proportionally for the loss (gain) in national welfare attributable to the change in emissions or issued permits levels due to the lobby's influence ("social welfare compensation effect"). The proportionality factor equals $1/\theta_i$ since lobby contributions enter the government's objective function with a weight of θ_i. On the other hand, lobbies have to compensate for the loss (gain) in contributions from all other lobbies due to the change in the government's policy choice resulting from the lobby's influence ("political competition effect").[7]

Proposition 3 yields an important insight. In Section 3 we have seen that – assuming truthful and strictly positive contribution schedules for all lobby groups – the equilibrium outcome only depends on the aggregate national strength b_i, d_i and r_i of lobbying groups but neither on their absolute number nor their composition. However, from Proposition 3 we learn that equilibrium contributions of individual lobbying groups and, thus, also the aggregate lobbying contributions the government receives in the second stage depend on the composition of pressure groups within each country.

4.2 Unilateral stances

Knowing the equilibrium contributions of all participating lobbies in the second stage, we are now ready to analyze the equilibrium outcomes in the first stage. Following Grossman and Helpman (1995a), we first examine unilateral stances. A unilateral stance of country i is the subgame perfect Nash equilibrium of the game if the decision about the regime in the second stage were unilaterally determined by the decision of country i's government in the first stage. For a unilateral stance, governments choose the regime $R = \{NT, T\}$ such as to maximize their total payoff G_i^R, which is given by the social welfare and the weighted lobbying contributions in stage 1 and 2.

Denoting the governments' payoffs minus the lobbying contributions in the first stage by G_{i0}^R, country i's government would oppose the formation of an international emissions permits market if there were no lobbying in the first stage if and only if $G_{i0}^{NT} > G_{i0}^{T}$. As the choice of regime influences, in general, also the payoffs of all lobby groups, lobbies have a strong incentive to offer contributions in the first stage, too. Again, contributions must be non-negative. A lobby is willing to pay to the government in the first stage at most as much as it gains by a change of regime in the second stage, which is given by the difference in the lobby's utilities between both regimes net of lobbying contributions

[7] Depending on the strength and sign of these effects, a higher fragmentation among lobby groups may cause lobbies to refrain from lobbying since contributions can turn negative. This would be equivalent to a reduction of organized stakes. See also the discussion in Section 5.

in the second stage. For later reference, we define

$$\Delta U_{ij}^{NT,T} \equiv U_{ij}^{NT}(e_i^{NT}, E^{NT}) - C_{ij}^{2,NT}(e_i^{NT}, E^{NT}) - U_{ij}^{T}(\omega_i^T, E^T) + C_{ij}^{2,T}(\omega_i^T, E^T) \ , \tag{27a}$$

$$\Delta U_{ij}^{T,NT} \equiv -\Delta U_{ij}^{NT,T} \ . \tag{27b}$$

First, we examine under which conditions no contributions of all lobby groups in the first stage is a unilateral stance. Therefore, suppose that without lobbying in the first stage the government in country i supports regime R, i.e. $G_{i0}^R > G_{i0}^{\bar{R}}$, where $\bar{R} = \{NT, T\} \setminus R$. Suppose further that the first stage contributions of all lobbies in country i are equal to zero. Given that all other lobby groups in country i do not contribute, not contributing itself is a best response for lobby group j if and only if

$$G_{i0}^R - G_{i0}^{\bar{R}} > \theta_i \Delta U_{ij}^{\bar{R},R} \ . \tag{28}$$

If inequality (28) holds, then no single lobby group can profitably contribute enough in the first stage to unilaterally sway the government to change its support from regime R to regime $\bar{R}$. Thus, no contributions from all lobby groups in the first stage is a unilateral stance if and only if condition (28) holds simultaneously for all organized lobby groups in country i. Grossman and Helpman (1995a) call this equilibrium an *unpressured* unilateral stance. The following proposition summarizes this result:

Proposition 4 (Unpressured unilateral stance)
Given that the government of country i supports regime R without lobby pressure in the first stage, no lobbying contributions of all lobby groups is a unilateral stance if and only if condition (28) *holds simultaneously for all organized lobby groups in country i.*

Second, we examine under which conditions there exists a unilateral stance with positive lobbying contributions in the first stage, which Grossman and Helpman (1995a) call a *pressured* unilateral stance. For a pressured stance the government must be indifferent with respect to the choice of regime, i.e.,

$$G_{i0}^R + \theta_i \sum_{j=1}^{M_i} C_{ij}^{1,R} = G_{i0}^{\bar{R}} + \theta_i \sum_{j=1}^{M_i} C_{ij}^{1,\bar{R}} \ , \tag{29}$$

as otherwise it would be possible for the lobby groups on the winning side to reduce their lobbying contributions and still having their preferred regime choice being adopted. Moreover, lobby groups on the losing side would offer their total net gain in case the government would adopt their preferred choice. If this were not true, the losers could sway the government in favor of their preferred regime choice by increasing their contributions. And finally, lobbies only pay positive contributions if the government adopts their preferred choice of regime. Let S_R ($S_{\bar{R}}$) be the set of lobbies which support regime R ($\bar{R}$), i.e. for all $j \in S_R$ ($S_{\bar{R}}$), $\Delta U_{ij}^{R,\bar{R}} > (<)\ 0$ holds. Then, a unilateral stance with positive lobbying contributions in favor of regime R requires:

$$G_{i0}^{R} + \theta_i \sum_{j \in S_R} \Delta U_{ij}^{R,\bar{R}} > G_{i0}^{\bar{R}} + \theta_i \sum_{j \in S_{\bar{R}}} \Delta U_{ij}^{\bar{R},R} \ . \tag{30}$$

This condition states that the *potential* payoff the government is able to collect in the first stage under regime R, consisting of its second-stage equilibrium payoff and the difference in utilities of all lobbies that gain by the introduction of R, must be higher than the *potential* payoff under the alternative regime. The sum of actual contributions is determined by equation (29).

Note that condition (30) is necessary but not sufficient for a pressured stance in favor of regime R to exist. In addition we need that

$$G_{i0}^{R} < G_{i0}^{\bar{R}} + \theta_i \sum_{j \in S_{\bar{R}}} \Delta U_{ij}^{\bar{R},R} \ , \tag{31}$$

otherwise, the supporters of regime R could refrain from positive lobbying contributions and still their preferred regime would be adopted, and we would be back to the case of an unpressured stance. The following proposition summarizes this result.

Proposition 5 (Pressured unilateral stance)
There exists a unilateral stance with positive lobbying contributions in favor of regime R in country i if and only if conditions (30) *and* (31) *hold simultaneously.*

For a pressured unilateral stance only the sum of lobbying contributions of all winning lobby groups is determined but not its distribution among individual lobby groups. Thus, there exist, in general, a continuum of pressured unilateral stances, which differ in individual contributions but coincide in the sum of contributions and the adopted regime choice.[8]

[8] Of course, each individual lobby group j will contribute at most its total utility gain $\Delta U_{ij}^{R,\bar{R}}$.

4.3 The choice of regime

It may happen that both an unpressured and a pressured unilateral stance exist simultaneously. This holds if condition (28) holds for one regime $R = \{NT, T\}$ and at the same time conditions (30) and (31) hold for the same or the other regime. If, in addition,

$$G_{i0}^{\bar{R}} < G_{i0}^{R} < G_{i0}^{\bar{R}} + \theta_i \sum_{j \in S_{\bar{R}}} \Delta U_{ij}^{\bar{R},R} \,, \tag{32}$$

then both stances select the same regime R. Otherwise, there exists a pressured stance in favor of regime R and an unpressured stance supporting regime $\bar{R}$. As Grossman and Helpman (1995a) pointed out, in the case of coexistence unpressured stances are not coalition-proof, a notion introduced by Bernheim et al. (1987). Thus, allowing for a minimum level of communication between the lobby groups eliminates unpressured stances whenever there are also pressured stances. As a consequence, we assume that the pressured stance prevails unless there exists only an unpressured stance.

We know from Sections 3 and 4.1 that the emission levels and the allowance choices in both regimes only depend on the total organized stakes b_i, d_i and r_i within a country i, but the lobby contributions and, thus, the government's payoffs depend on the distribution of these stakes among individual lobby groups. As both governments' payoffs and lobby contributions in the second stage determine the unilateral stances in the first stage, we analyze how the distribution of stakes among lobby groups within one country i may influence the unilateral stances and the regime choice. Although the unilateral stance may switch from pressured to unpressured or vice versa, the following proposition shows that the selected regime remains the same.

Proposition 6 (Regime choice and distribution of organized stakes)
For truthful and strictly positive equilibrium contributions of all lobby groups in the second stage, the choice of regime only depends on the aggregate organized stakes b_i, d_i and r_i in both countries.

The proof is given in the Appendix.

The intuition for this result is that the necessary condition (30) for the existence of a pressured stance does not depend on the distribution of stakes as long as the national aggregates are constant. This implies that whenever there exists a pressured stance, the selected regime R only depends on the national aggregates of organized stakes. However, for a pressured stance in favor of R to exist, also the necessary condition (31) has to hold. In fact, this condition does depend on the distribution of organized stakes β_{ij}, δ_{ij} and ρ_{ij}. But if condition (30) holds for regime R while condition (31) is violated, then there exists an unpressured stance in favor of R. Of course, it may be that a pressured stance in favor of regime R and an unpressured stance in favor of regime $\bar{R}$ exists. But assuming that pressured stances beat unpressured stances, as discussed above, again regime R would be selected. In summary, condition (30), which only depends on the aggregate organized stakes, always holds for one of the two regimes and this regime is also the regime choice of the government (or the government is indifferent between both regimes). Wether the selected regime is a pressured or unpressured stance, however, does depend on the distribution of aggregate organized stakes among individual lobby groups. Of course, also the contributions in the first stage and, thus, the government payoffs and the net utility of the lobby groups depend on the distribution of organized stakes β_{ij},δ_{ij} and ρ_{ij}.

4.4 International permit markets

Having established each country's choice of regime, it is now straightforward to characterize the conditions under which an international permit market is established. By definition, an international permit market only forms if both countries consent to it, i.e. if the trading regime is a unilateral stance in both countries. By virtue of Proposition 6, a permit market is thus established if and only if the following condition holds for both countries simultaneously:

$$G_{i0}^{T} + \theta_i \sum_{j \in S_T} \Delta U_{ij}^{T,NT} > G_{i0}^{NT} + \theta_i \sum_{j \in S_{NT}} \Delta U_{ij}^{NT,T} \ , \quad i = 1, 2 \ . \tag{33}$$

Assuming again that equation (19) holds, which implies that $r_i = b_i$ for both countries, condition (33) reduces to:

$$\begin{aligned} \Delta G_i = G_i^T - G_i^{NT} &= \left[B_i(e_i(E^T)) - B_i(e_i^{NT}) \right] - \left[\tilde{D}_i(E^T) - \tilde{D}_i(E^{NT}) \right] \\ &\quad + p(E^T) \left[\omega_i^T - e_i(E^T) \right] > 0 \ , \quad i = 1, 2 \ . \end{aligned} \tag{34}$$

As already pointed out by Proposition 4 in Helm (2003), there are three possible cases: (i) The trading regime may lead to lower total emissions and higher payoffs for the governments of both countries. (ii) Even if total emissions are lower with trading, an international permit market may not be established because the government's payoff in one of the countries is lower with than without trading. (iii) Although total emissions are lower in the no-trading regime both governments may consent to an international permit market because their payoffs with trading are higher than without.

In the following, we analyze how the likelihood for establishing an international permit market depends on the political parameters θ_i, b_i and d_i. The likelihood is not only determined by the reaction of the home country where the political change takes place but also by the reaction of the other country to a change in its neighbor's political environment, as the following corollary states.

Corollary 3 (Comparative statics of regime choice)
For $r_i = b_i$ in both countries, the following conditions hold for the change in the difference of government payoffs:

$$\frac{d\Delta G_i}{d\Box_i} = \frac{d\alpha_i}{d\Box_i}\left[D_i(E^{NT}) - D_i(E^T)\right] + \left[B_i'(e_i^{NT})\frac{de_{-i}^{NT}}{d\Box_i} - B_i'(e_i(E^T))\frac{d\omega_{-i}^T}{d\Box_i}\right] , \tag{35a}$$

$$\frac{d\Delta G_{-i}}{d\Box_i} = B_{-i}'(e_{-i}^{NT})\frac{de_i^{NT}}{d\Box_i} - B_{-i}'(e_{-i}(E^T))\frac{d\omega_i^T}{d\Box_i} , \tag{35b}$$

where $\Box \in \{b, d, \theta\}$ denotes one of the political parameters.

The proof of Corollary 3 is given in the Appendix.

Corollary 3 says that a change in one of the political parameters in country i has a direct effect by changing the politically adjusted damage function $\tilde{D}_i(E)$ (first term on the right-hand side of equation 35a) and an indirect effect by changing the equilibrium choices of emission allowances in both the trading and no-trading regimes. While the first effect is confined to the country whose political parameter changes, the second effect impacts on both countries. The indirect effect can have the same or a different sign in both countries, and it can also have the same or a different sign as the direct effect for the country subject to a change in the political parameters. As a consequence, it may happen that while the direct effect goes in favor of the regime with lower (higher) global emissions due to an increase (decrease) of the politically adjusted damages, the change in ΔG_i and/or ΔG_{-i} goes towards the regime with higher (lower) global emissions. If the change in ΔG_i and/or ΔG_{-i} is sufficiently strong and opposing the direct effect, we get the counterintuitive result of the following proposition.

Proposition 7 (Lobbying may backfire)
An increase in the influence of organized interest groups favoring higher (lower) global

emissions may actually result in a decrease (increase) of global emissions.

The proof of Proposition 7 is given in the Appendix.

The intuition is as follows. Suppose the current regime is the regime with higher (lower) global emissions. Suppose further that in country i organized interest groups in favor of higher (lower) emissions gain influence in government i's decision. Then there is a direct effect of this influence on government i in favor of the regime with higher (lower) global emissions. In addition, there is an indirect effect by increasing (decreasing) global emissions in both regimes. The impact of this indirect effect may go in the opposite direction of the direct effect, i.e. it may influence government j ($j = i, -i$) in favor of the regime with lower (higher) global emissions, and may even outweigh the direct effect. If the indirect effect is strong enough to change the regime choice in at least one country this may lead to a regime change in favor of the regime with lower (higher) global emissions. In this case, global emissions may be lower (higher) compared to the initial regime.

5 Discussion

Within our framework of legislative lobbying, we found that both the choice of regime in the first stage and the amount of emission allowances issued in the second stage only hinge on the aggregate organized stakes b_i, d_i and r_i of the different components of social welfare within a country and not on their distribution among different interest groups. However, for this result to hold the lobbying contributions in the second stage of all lobby groups have to be strictly positive. What would happen if we relax this assumption?

Consider a lobby group k in country i refraining from offering contributions in equilibrium. Then the amount of emission allowances issued in equilibrium is determined by $b_i - \beta_{ik}$, $d_i - \delta_{ik}$ and $r_i - \rho_{ik}$ instead of b_i, d_i and r_i. Thus, all our results still hold for the adjusted aggregate stakes $\hat{b}_i$, $\hat{d}_i$ and $\hat{r}_i$, which are the sum of β_{ij}, δ_{ij} and ρ_{ij} of all lobby groups $j \neq k$ offering strictly positive contributions. However, according to Proposition 3, the contribution schedules offered by the lobby groups and also the sum of contributions the government receives depend on the distribution of aggregate organized stakes among individual interest groups. As a consequence, both the choice of regime and the choice of emission allowances are not immune to a redistribution of given aggregate stakes b_i, d_i and r_i among different interest groups if this redistribution alters the adjusted aggregate stakes $\hat{b}_i$, $\hat{d}_i$ and $\hat{r}_i$.

For the important special case of $r_i = b_i$ in both countries, we have shown that the influence of legislative lobbying can be reduced to a politically adjusted damage function. That is, for a given α_i determined by the lobbying parameters the government behaves like a government immune to lobbying but applying the damage function $\alpha_i D_i(E)$ instead of $D_i(E)$. This has an important consequence: All our results are not only restricted to the influence of legislative lobbying, but extend to all influences that alter the government's perception of the damages caused by emissions. Examples for such a change in damage perception include not only increasing (or decreasing) environmental awareness of the voters and/or the government, but also new scientific intelligence on the harmfulness of emissions.

This also implies that the intriguing insight of Proposition 7 – that the direct effect of a change in the politically adjusted damage function may be outweighed by the indirect effect of the non-cooperative interaction on the international level – does not only hold for legislative lobbying in case of $r_i = b_i$, but for any possible change in damage perception. In particular, this challenges the conventional wisdom that higher environmental awareness leads to lower global emissions and acts as a partial remedy to failures in the international coordination of public goods problems (e.g. Franzen 2003). Indeed, an increase in environmental awareness in one country (which corresponds to an increase in α_i in our model framework) reduces global emissions in both regimes but may, at the same time, induce a switch from the regime with lower to the regime with higher global emissions. If the indirect outweighs the direct effect, then global emissions increase with environmental awareness.[9]

6 Conclusion

We have analyzed the non-cooperative formation of an international emission permits market in a setting of political competition by national interest groups. We find that for both the continuous choice of emission allowances in the second stage and the binary choice whether an international permit market is formed only the aggregate levels of organized stakes in each country matter and not their distribution among individual

[9] A similar result arises in Endres (1997) and Endres and Finus (1998). In a coalition formation game, increasing environmental awareness has a positive effect on the reduction targets but may also induce smaller stable coalition sizes. Conconi (2003) finds that within a framework of international goods trading and environmental policy lobbies may reduce their efforts for a higher domestic pollution tax if they are aware of the associated emission leakages via international trade.

lobby groups. In addition, an increase in lobbying influence by a particular lobby group may weaken the support for the interest group's preferred regime in both countries.

Although we found that for given national levels of organized stakes the equilibrium outcome is independent of the number and composition of individual special interest groups, this does not hold for equilibrium contributions and payoffs. In fact, we presume that lobbies with the same interests exert a positive externality on each other. Then, a higher fragmentation of such lobbies would effectively reduce equilibrium contributions which the government is able to collect. However, the investigation of this issue is left to future research.

In addition, our analysis has focussed on international climate policy by non-cooperative countries. There are, however, some notable exceptions to the extreme case of non-cooperation, one of them being the European Union which introduced a permit trading system in 2005. Thus, another promising agenda for future research is the investigation of cooperative international climate policies under political pressure from special interest groups.

Appendix

Proof of Proposition 1

In the following, we show existence and uniqueness of the Nash equilibrium in the no-trade case.

(i) Existence: The maximization problem of country i is strictly concave, as

$$G_i^{NT''}(e_i) = B_i''(e_i) - D_i''(E) + \theta_i \left[\sum_{j=1}^{M_i} [\beta_{ij} B_i''(e_i) - \delta_{ij} D_i''(E)] \right] < 0 \; . \tag{A.1}$$

Thus, for all countries $i = 1, 2$, the reaction function yields a unique best response for any given choice e_{-i} of the other country. This guarantees the *existence* of a Nash equilibrium.

(ii) Uniqueness: Solving the best response functions (8) for e_i and summing up over both countries yields the following equation for the aggregate emissions E:[10]

$$E = \sum_{i=1}^{2} B_i'^{-1} \left(\frac{1 + \theta_i d_i}{1 + \theta_i b_i} D_i'(E) \right) \; . \tag{A.2}$$

As the left-hand side is strictly increasing and the right-hand side is strictly decreasing in E, there exists a unique level of total emissions E^{NT} in the Nash equilibrium. Substituting back into the reaction functions yields the unique Nash equilibrium (e_1^{NT}, e_2^{NT}).

□

Proof of Corollary 1

Introducing the abbreviation

$$\begin{aligned} \Gamma = {} & (1 + \theta_i b_i)(1 + \theta_{-i} d_{-i}) B_i''(e_i) D_{-i}''(E) + (1 + \theta_{-i} b_{-i})(1 + \theta_i d_i) B_{-i}''(e_{-i}) D_i''(E) \\ & - (1 + \theta_i b_i)(1 + \theta_{-i} b_{-i}) B_i''(e_i) B_{-i}''(e_{-i}) < 0 \; , \end{aligned} \tag{A.3}$$

and applying the implicit function theorem to the first-order conditions (8) for both countries, we derive

$$\frac{de_i}{db_i} = \frac{\theta_i B_i'(e_i) \left[(1 + \theta_{-i} b_{-i}) B_{-i}''(e_{-i}) - (1 + \theta_{-i} d_{-i}) D_{-i}''(E) \right]}{\Gamma} > 0 \; , \tag{A.4a}$$

[10] As all marginal benefit functions B_i' are strictly and monotonically decreasing, the inverse functions $B_i'^{-1}$ exist and are also strictly and monotonically decreasing.

$$\frac{de_{-i}}{db_i} = \frac{\theta_i B_i'(e_i)(1+\theta_{-i}d_{-i})D_{-i}''(E)}{\Gamma} < 0 \ , \tag{A.4b}$$

$$\frac{dE}{db_i} = \frac{de_i}{db_i} + \frac{de_{-i}}{db_i} = \frac{\theta_i B_i'(e_i)(1+\theta_{-i}b_{-i})B_{-i}''(e_{-i})}{\Gamma} > 0 \ , \tag{A.4c}$$

$$\frac{de_i}{dd_i} = \frac{-\theta_i D_i'(E)\left[(1+\theta_{-i}b_{-i})B_{-i}''(e_{-i}) - (1+\theta_{-i}d_{-i})D_{-i}''(E)\right]}{\Gamma} < 0 \ , \tag{A.5a}$$

$$\frac{de_{-i}}{dd_i} = \frac{-\theta_i D_i'(E)(1+\theta_{-i}d_{-i})D_{-i}''(E)}{\Gamma} > 0 \ , \tag{A.5b}$$

$$\frac{dE}{dd_i} = \frac{de_i}{dd_i} + \frac{de_{-i}}{dd_i} = \frac{-\theta_i D_i'(E)(1+\theta_{-i}b_{-i})B_{-i}''(e_{-i})}{\Gamma} < 0 \ , \tag{A.5c}$$

and

$$\frac{de_i}{d\theta_i} = \frac{\left[b_i B_i'(e_i) - d_i D_i'(E)\right]\left[(1+\theta_{-i}b_{-i})B_{-i}''(e_{-i}) - (1+\theta_{-i}d_{-i})D_{-i}''(E)\right]}{\Gamma} \ , \tag{A.6a}$$

$$\frac{de_{-i}}{d\theta_i} = \frac{[b_i B_i'(e_i) - d_i D_i'(E)](1+\theta_{-i}d_{-i})D_{-i}''(E)}{\Gamma} \ , \tag{A.6b}$$

$$\frac{dE}{d\theta_i} = \frac{de_i}{d\theta_i} + \frac{de_{-i}}{d\theta_i} = \frac{[b_i B_i'(e_i) - d_i D_i'(E)](1+\theta_{-i}b_{-i})B_{-i}''(e_{-i})}{\Gamma} \ . \tag{A.6c}$$

For the signs of equations (A.17), we re-write the first-order condition of country i to yield:

$$B_i'(e_i) - D_i'(E) + \theta_i\left[b_i B_i'(e_i) - d_i D_i'(E)\right] = 0 \ . \tag{A.7}$$

Then,

$$b_i B_i'(e_i) - d_i D_i'(E) \gtreqless 0 \quad \Leftrightarrow \quad B_i'(e_i) - D_i'(E) \lesseqgtr 0 \quad \Leftrightarrow \quad b_i \gtreqless d_i \ . \tag{A.8}$$

□

Proof of Lemma 1

Condition (13) of the permit market equilibrium implies

$$E - \sum_{j=1}^{2} B_j'^{-1}(p) = 0 \tag{A.9}$$

Applying the implicit function theorem yields

$$p'(E) = \frac{dp(E)}{dE} = -\frac{1}{-\sum_{j=1}^{2} \frac{\partial B_j'^{-1}(p)}{\partial p}} = \frac{1}{\sum_{j=1}^{2} \frac{1}{B_j''\big(e_j(p)\big)}} < 0 \tag{A.10a}$$

We further obtain

$$e_i{}'(p) = \frac{de_i(p)}{dp} = \frac{1}{B_i''(e_i(p))} < 0 \ , \tag{A.10b}$$

$$e_i{}'(E) = \frac{de_i(E)}{dE} = \frac{de_i\big(p(E)\big)}{dp(E)} \frac{dp(E)}{dE} = \frac{\frac{1}{B_i''\big(e_i(p)\big)}}{\sum_{j=1}^{2} \frac{1}{B_j''\big(e_j(p)\big)}} \in [0,1] \ . \tag{A.10c}$$

Employing the abbreviations (14) yields the stated result. □

Proof of Proposition 2

In the following, we show existence and uniqueness of the Nash equilibrium in the trading scenario.

(i) Existence: The maximization problem of country i is strictly concave, as

$$\begin{aligned} &p'(E)\{(1+\theta_i r_i)[2 - e_i'(E)] + \theta_i(b_i - r_i)e_i'(E)\} - (1+\theta_i d_i)D_i''(E) \\ &\quad + p(E)\theta_i(b_i - r_i)e_i''(E) + (1+\theta_i r_i)p''(E)[\omega_i - e_i(E)] < 0 \ , \end{aligned} \tag{A.11}$$

if $e_i''(E)$ and $p''(E)$ are sufficiently small. Thus, for all countries $i = 1, 2$, the reaction function yields a unique best response for any given choice ω_{-i} of the other countries, which guarantees the *existence* of a Nash equilibrium.

(ii) Uniqueness: Dividing the reaction function (17) by $(1 + \theta_i r_i)$ and summing up over both countries yields the following condition, which holds in the Nash equilibrium:

$$p(E)\left\{2 + \sum_{j=1}^{2} \frac{\theta_j(b_j - r_j)e_j'(E)}{1+\theta_j r_j}\right\} = \sum_{j=1}^{2} \frac{1+\theta_j d_j}{1+\theta_j r_j} D_j'(E) \ . \tag{A.12}$$

For $e_i''(E)$ sufficiently small, the left-hand side is strictly decreasing (note that the term in brackets is always positive as $e_i'(E) \in [0, 1]$), while the right-hand side is increasing in E. Thus, there exists a unique level of total emission allowances E^T in the Nash equilibrium. Inserting E^T back into the reaction function (17) yields the unique equilibrium allowance choices $(\omega_i^T, \omega_{-i}^T)$. □

Proof of Corollary 2

For $r_i = b_i$ the reaction function (18) of country i reduces to:

$$p(E) + p'(E)[\omega_i - e_i(E)] - \tilde{D}_i'(E) = 0 \; , \tag{A.13}$$

where $\tilde{D}_i$ denotes the politically adjusted damage function (9). Introducing the abbreviations

$$\Lambda = p'(E)\left[2p'(E) - \tilde{D}_i''(E) - \tilde{D}_{-i}''(E)\right] > 0 \; , \tag{A.14a}$$

$$\Omega = p'(E)[1 - e_{-i}'(E)] - \tilde{D}_{-i}''(E) + p''(E)[\omega_i - e_{-i}(E)] < 0 \; , \tag{A.14b}$$

and applying the implicit function theorem to the first-order conditions (A.13) for both countries, we derive

$$\frac{d\omega_i}{db_i} = -\frac{\theta_i \tilde{D}_i''(E)[\Omega + p'(E)]}{(1+\theta_i b_i)^2 \Lambda} > 0 \; , \tag{A.15a}$$

$$\frac{d\omega_{-i}}{db_i} = \frac{\theta_i \tilde{D}_i''(E)\Omega}{(1+\theta_i b_i)^2 \Lambda} < 0 \; , \tag{A.15b}$$

$$\frac{dE}{db_i} = \frac{d\omega_i}{db_i} + \frac{d\omega_{-i}}{db_i} = -\frac{\theta_i \tilde{D}_i''(E)p'(E)}{(1+\theta_i b_i)^2 \Lambda} > 0 \; , \tag{A.15c}$$

$$\frac{d\omega_i}{dd_i} = \frac{\theta_i \tilde{D}_i''(E)[\Omega + p'(E)]}{(1+\theta_i b_i)\Lambda} < 0 \; , \tag{A.16a}$$

$$\frac{d\omega_{-i}}{dd_i} = -\frac{\theta_i \tilde{D}_i''(E)\Omega}{(1+\theta_i b_i)\Lambda} > 0 \; , \tag{A.16b}$$

$$\frac{dE}{dd_i} = \frac{d\omega_i}{dd_i} + \frac{d\omega_{-i}}{dd_i} = \frac{\theta_i \tilde{D}_i''(E)p'(E)}{(1+\theta_i b_i)\Lambda} < 0 \; , \tag{A.16c}$$

and

$$\frac{d\omega_i}{d\theta_i} = -\frac{(b_i - d_i)\tilde{D}_i''(E)[\Omega + p'(E)]}{(1+\theta_i b_i)^2 \Lambda} \gtreqless 0 \qquad \Leftrightarrow \qquad b_i \gtreqless d_i \; , \tag{A.17a}$$

$$\frac{d\omega_{-i}}{d\theta_i} = \frac{(b_i - d_i)\tilde{D}_i''(E)\Omega}{(1+\theta_i b_i)^2 \Lambda} \lesseqgtr 0 \qquad \Leftrightarrow \qquad b_i \gtreqless d_i \; , \tag{A.17b}$$

$$\frac{dE}{d\theta_i} = \frac{d\omega_i}{d\theta_i} + \frac{d\omega_{-i}}{d\theta_i} = -\frac{(b_i - d_i)\tilde{D}_i''(E)p'(E)}{(1+\theta_i b_i)^2 \Lambda} \gtreqless 0 \qquad \Leftrightarrow \qquad b_i \gtreqless d_i \; . \tag{A.17c}$$

□

Proof of Proposition 3

Given the government's indifference conditions (25a) and (25b) (depending on whether a permit market is formed in the second stage), we know that for all participating lobby groups, contributions are either the difference between gross welfare and some reservation welfare $R_{ij}^{2,R}$ (which is simply a scalar) or zero:

$$C_{ij}^{2,NT}(e_i, E) = \max[0, U_{ij}^{NT}(e_i, E) - R_{ij}^{2,NT}] \ , \tag{A.18a}$$

$$C_{ij}^{2,T}(\omega_i, E) = \max[0, U_{ij}^{T}(\omega_i, E) - R_{ij}^{2,T}] \ . \tag{A.18b}$$

If we assume that $C_{ij}^{2,R} > 0$ for all $j = 1, \ldots, M_i$ and all R, we can re-write equations (25a) and (25b) by virtue of condition (A.18b) to yield:

$$\begin{aligned} W_i^{NT}(e_i^{NT}, E^{NT}) + \theta_i \sum_{\substack{j=1 \\ j\neq k}}^{M_i} U_{ij}^{NT}(e_i^{NT}, E^{NT}) + \theta_i \left[U_{ik}^{NT}(e_i^{NT}, E^{NT}) - R_{ik}^{2,NT}\right] \\ = W_i^{NT}(e_i^{-k}, E^{-k}) + \theta_i \sum_{\substack{j=1 \\ j\neq k}}^{M_i} U_{ij}^{NT}(e_i^{-k}, E^{-k}) \ , \end{aligned} \tag{A.19a}$$

$$\begin{aligned} W_i^{T}(\omega_i^{T}, E^{T}) + \theta_i \sum_{\substack{j=1 \\ j\neq k}}^{M_i} U_{ij}^{T}(\omega_i^{T}, E^{T}) + \theta_i \left[U_{ik}(\omega_i^{T}, E^{T}) - R_{ik}^{2,T}\right] \\ = W_i^{T}(\omega_i^{-k}, E^{-k}) + \theta_i \sum_{\substack{j=1 \\ j\neq k}}^{M_i} U_{ij}^{T}(\omega_i^{-k}, E^{-k}) \ . \end{aligned} \tag{A.19b}$$

Solving for R_i^k and inserting into conditions (A.18b), we obtain:

$$\begin{aligned} C_{ik}^{2,NT}(e_i^{NT}, E^{NT}) = \frac{1}{\theta_i}\left[W_i^{NT}(e_i^{-k}, E^{-k}) - W_i^{NT}(e_i^{NT}, E^{NT})\right] \\ + \sum_{\substack{j=1 \\ j\neq k}}^{M_i} \left(U_{ij}^{NT}(e_i^{-k}, E^{-k}) - U_{ij}^{NT}(e_i^{NT}, E^{NT})\right) \end{aligned} \tag{A.20a}$$

$$\begin{aligned} C_{ik}^{2,T}(\omega_i^{T}, E^{T}) = \frac{1}{\theta_i}\left[W_i^{T}(\omega_i^{-k}, E^{-k}) - W_i^{T}(\omega_i^{T}, E^{T})\right] \\ + \sum_{\substack{j=1 \\ j\neq k}}^{M_i} \left(U_{ij}^{T}(\omega_i^{-k}, E^{-k}) - U_{ij}^{T}(\omega_i^{T}, E^{T})\right). \end{aligned} \tag{A.20b}$$

Inserting the lobbies' utilities functions (4b) and (4a) yields equations (26a) and (26b).

□

Proof of Proposition 6

Condition (30) is a necessary condition for a pressured stance. We can re-write this condition to yield

$$G_i^R + \theta_i \sum_{j \in S_R} \Delta U_{ij}^{R,\bar{R}} > G_i^{\bar{R}} + \theta_i \sum_{j \in S_{\bar{R}}} \Delta U_{ij}^{\bar{R},R} \ , \tag{A.21a}$$

$$\Leftrightarrow \quad W_i^R + \theta_i \sum_{j=1}^{M_i} C_{ij}^{2,R} + \theta_i \sum_{j \in S_R} \left[U_{ij}^R - C_{ij}^{2,R} - U_{ij}^{\bar{R}} + C_{ij}^{2,\bar{R}} \right]$$

$$> W_i^{\bar{R}} + \theta_i \sum_{j=1}^{M_i} C_{ij}^{2,\bar{R}} + \theta_i \sum_{j \in S_{\bar{R}}} \left[U_{ij}^{\bar{R}} - C_{ij}^{2,\bar{R}} - U_{ij}^R + C_{ij}^{2,R} \right] \tag{A.21b}$$

$$\Leftrightarrow \quad W_i^R + \theta_i \sum_{j=1}^{M_i} C_{ij}^{2,R} + \theta_i \sum_{j=1}^{M_i} \left[U_{ij}^R - C_{ij}^{2,R} \right]$$

$$> W_i^{\bar{R}} + \theta_i \sum_{j=1}^{M_i} C_{ij}^{2,\bar{R}} + \theta_i \sum_{j=1}^{M_i} \left[U_{ij}^{\bar{R}} - C_{ij}^{2,\bar{R}} \right] \tag{A.21c}$$

$$\Leftrightarrow \quad W_i^R + \theta_i \sum_{j=1}^{M_i} U_{ij}^R > W_i^{\bar{R}} + \theta_i \sum_{j=1}^{M_i} U_{ij}^{\bar{R}} \ . \tag{A.21d}$$

Obviously, this condition does not depend on the distribution of organized stakes, as welfare and the sum of the lobby groups' (gross) utilities are determined by the aggregate level of organized stakes b_i and d_i. This implies that whenever there exists a pressured stance – no matter what the distribution of organized stakes among the individual lobby groups – the pressured stance supports regime R. However, whether a pressured stance exists or not may well depend on the distribution, as condition (31), which also has to hold for the existence of a pressured stance, is not immune to change in the distribution of organized stakes. □

Proof of Proposition 7

To prove the proposition, we introduce the special case of quadratic benefit functions and linear environmental damages:

$$B_i(e_i) = \frac{1}{\phi_i} e_i (1 - \frac{1}{2} e_i), \qquad B_i'(e_i) = \frac{1}{\phi_i}(1 - e_i), \qquad B_i''(e_i) = -\frac{1}{\phi_i}, \tag{A.22a}$$

$$D_i(E) = \epsilon_i E, \qquad D_i'(E) = \epsilon_i, \qquad D_i''(E) = 0, \tag{A.22b}$$

where $\phi_i > 0$ denotes the country-specific benefit parameter, as defined in Lemma 1 and

$\epsilon_i > 0$ are the country-specific but constant marginal damages. We define the following shortcut for politically adjusted marginal damages:

$$\psi_i = \tilde{D}_i'(E) = \alpha_i \epsilon_i = \frac{1+\theta_i d_i}{1+\theta_i b_i}\epsilon_i \ , \tag{A.23}$$

and introduce the following abbreviations for the average benefit parameter and the average politically adjusted marginal damages:

$$\bar{\phi} = \frac{1}{2}(\phi_i + \phi_{-i}) \ , \qquad \bar{\psi} = \frac{1}{2}(\psi_i + \psi_{-i}) \ . \tag{A.24}$$

Then, we obtain for the national allowance choices and the global emissions in the two regimes:

$$E^T = 2 - \bar{\phi}(\psi_i - \psi_{-i}) \ , \qquad E^{NT} = 2 - \phi_i\psi_i - \phi_{-i}\psi_{-i} \ , \tag{A.25a}$$

$$e_i^T = 1 - \phi\bar{\psi} \ , \qquad e_i^{NT} = 1 - \phi_i\psi_i \ , \tag{A.25b}$$

$$\omega_i^T = 1 + \phi_{-i}\bar{\psi} - 2\bar{\phi}\psi_i \ . \tag{A.25c}$$

Global emissions are lower in the trade regime compared to the no-trade regime if the country with the higher ϕ_i exhibits the lower politically adjusted marginal damages ψ_i:

$$E^T \gtreqless E^{NT} \qquad \Leftrightarrow \qquad \phi_{-i}(\psi_{-i} - \psi_i) \gtreqless \phi_i(\psi_{-i} - \psi_i) \ , \tag{A.26}$$

Applying these specific functional forms to Corollary 3, we derive

$$\begin{aligned} \frac{d\Delta G_i}{d\Box_i} &= \frac{d\alpha_i}{d\Box_i}\left[E^{NT} - E^T\right] - \frac{1}{2}\frac{d\alpha_i}{d\Box_i}\phi_i\bar{\psi} \qquad \text{(A.27a)} \\ &= \frac{d\alpha_i}{d\Box_i}\left[(\bar{\phi} - \phi_i)\psi_i + (\bar{\phi} - \phi_{-i})\psi_{-i}\right] - \frac{1}{2}\frac{d\alpha_i}{d\Box_i}\phi_i\bar{\psi} \ , \\ \frac{d\Delta G_{-i}}{d\Box_i} &= \frac{d\alpha_i}{d\Box_i}\left[e_{-i}^{NT} - \omega_{-i}^T + \frac{1}{2}\phi_{-i}\bar{\psi}\right] \qquad \text{(A.27b)} \\ &= \frac{d\alpha_i}{d\Box_i}\left[\phi_i(\psi_{-i} - \bar{\psi}) + \frac{1}{2}\phi_{-i}\bar{\psi}\right] \ , \end{aligned}$$

where

$$\frac{d\alpha_i}{db_i} = \frac{\theta_i}{1+\theta_i b_i} > 0 \ , \tag{A.28a}$$

$$\frac{d\alpha_i}{dd_i} = -\frac{\theta_i(1+\theta_i d_i)}{(1+\theta_i b_i)^2} < 0 \ , \tag{A.28b}$$

$$\frac{d\alpha_i}{d\theta_i} = \frac{d_i - b_i}{(1+\theta_i b_i)^2} \gtreqless 0 \Leftrightarrow d_i \gtreqless b_i \ . \tag{A.28c}$$

We immediately observe that the indirect effect for country i may have the opposite direction compared to the direct effect (first term in (A.27a)) and the total effect of country i may go in the opposite direction of the total effect of country $-i$. Consider the situation that $E^{NT} > E^T$. In this case the direct effect and the indirect effect for country i have opposing signs. If ϕ_i and ϕ_{-i} are similar, the direct effect is small and the indirect effect may outweigh the direct effect. If, however, ϕ_i is sufficiently small compared to ϕ_{-i} the direct effect outweighs the indirect effect. If ψ_{-i} exceeds ψ_i (implying that country $-i$ is a permit-buyer) then the total effect of country $-i$ goes in the same direction as the direct effect of country i. Otherwise, if ψ_{-i} is small compared to ψ_i (country $-i$ is a permit-seller), the total effect of country $-i$ may go in the opposite direction. If the total effect of one or both countries goes in the opposite direction of the direct effect of country i, then there may be a change of regime towards the regime which is less favored by the interest group that gained influence.

For example, assume that in country i the green lobby gains momentum (i.e. d_i increases). Then the direct effect goes into the direction of the regime with lower emissions, say the trade regime. However, the indirect effect of country i goes in favor of the no-trade regime and may even outweigh the direct effect. As a consequence, the government in country i is less in favor of the trade regime than before the gain in influence. Also the indirect effect in country $-i$ may induce the government of country $-i$ to more strongly oppose the trading regime than before. If the initial regime was the trading regime, the gain in influence of the green lobby in country i may now have caused the support for the trading regime to cease in one or both of the countries. As a consequence, the regime changes towards the no-trade regime. If the no-trading regime exhibits higher total emissions than the trading regime (as assumed), then global emissions rise. □

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