Submission Number: PET11-11-00058

Political influence on non-cooperative international climate policy

Wolfgang Habla
University of Munich

Ralph Winkler
Oeschger Centre for Climate Change Research and Department of Economics, University of Bern

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 emissions permits market, which only forms if it is supported by all countries. In the second stage, countries non-cooperatively either set national emissions caps or decide on the amount of emissions allowances, depending on the regime. We find that both the choice of regime and the level of aggregate emissions only depends on the aggregate levels of organized stakes in all countries and not on their distribution among individual interest groups, as long as all lobby groups have strictly positive contribution schedules in the second stage and at least one lobby group contributes in the first stage. However, as these conditions are not necessarily met, lobby groups may benefit from joining forces.

Submitted: February 22, 2011.

Political influence on non-cooperative international climate policy

Wolfgang Habla[†] and Ralph Winkler[‡]

[†] Department of Economics, University of Munich and
Oeschger Centre for Climate Change Research, University of Bern
Ludwigstraße 28, DE-80539 Munich, Germany; wolfgang.habla@lrz.uni-muenchen.de

[‡] Department of Economics and
Oeschger Centre for Climate Change Research, University of Bern
Schanzeneckstrasse 1, CH-3001 Bern, Switzerland; mail@ralph-winkler.de

This version: February 2011

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 emissions permits market, which only forms if it is supported by all countries. In the second stage, countries non-cooperatively either set national emissions caps or decide on the amount of emissions allowances, depending on the regime. We find that both the choice of regime and the level of aggregate emissions only depends on the aggregate levels of organized stakes in all countries and not on their distribution among individual interest groups, as long as all lobby groups have strictly positive contribution schedules in the second stage and at least one lobby group contributes in the first stage. However, as these conditions are not necessarily met, lobby groups may benefit from joining forces.

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

JEL-Classification: D72, H23, H41,Q58

1 Introduction

For global stock pollutants, such as greenhouse gases, emissions trading has become the most popular policy tool in international climate policy for several reasons. First, trading of permits leads to cost-effective international emissions abatement. Second, it is often argued that a cap on emissions combined with an international permit market is politically more viable than an equivalent carbon tax since this system entails the possibility of issuing permits to polluting firms at no cost. Third, efficiency gains from trading can provide an incentive for countries to accept less emission allowances. On the downside, however, a cap and trade system can induce low-damage countries to produce "hot air", i.e. issue more permits than they actually emit, because they can sell excess permits on the international market. As a consequence, global emissions may be higher in an international cap and trade system compared to a regime of unilateral climate policies (Helm 2003).

As international climate policy is lacking a supranational authority that can enforce cap and trade, many governments have shown themselves highly reluctant to agree to binding emissions reductions. Nevertheless, national climate policy initiatives and legislation to either enact or oppose to stricter environmental policies can be observed in nearly all countries, very often due to increasing pressure by organized special interest groups in the national policy arena.

We analyze the political economy of international climate policy in a framework with n non-cooperative countries whose governments can be swayed by national pressure groups. The endogenous choice of tradable or non-tradable emissions allowances is modelled as a two- respectively three-stage game. In the first stage, governments in each country decide whether to join an international permit market or not, given political influence by lobby groups. If all countries unanimously agree to form a permit market, the decision on the number of permits takes place in the second stage. In this case, there is a third stage in which an equilibrium on the international permit market is reached. If no permit market has been established in the first stage, governments decide upon national emission targets in the second stage. Also in the second stage, governments are subject to political influence by national interest groups.

In our model, governments are assumed to maximize a weighted sum of total welfare and lobby contributions, whereas special interest groups, differing in size and interests, maximize their utility net of lobbying contributions. 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 that captures the revenues from permit sales or the costs associated with permit purchases. In our setting, two non-cooperative games coincide: (i) Organized interest groups act non-cooperatively in choosing their contribution schedules to influence the respective government's policy, i.e. they take as given the contribution schedules of their competitors on the domestic political stage as well as the contribution schedules of foreign lobby groups. (ii) Countries decide non-cooperatively, as well, taking as given the lobbies' contribution schedules and all other countries' policies.

We find that the level of national emissions caps or the amount of emissions permits issued, depending on the type of regime, is determined by the aggregate level of organized stakes in all countries, as long as all lobby groups exhibit strictly positive contribution schedules. This implies that the distribution of organized interest groups does not matter for national and international emissions levels. Moreover, if countries decide to form an international permit market, it depends on the marginal contribution that environmental damages exert on the government's payoff function compared to a weighted average of the marginal contributions from environmental damages over all countries whether a country is a net buyer or seller of permits.

Also the choice 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 there are positive lobbying contributions in the first stage. However, the redistribution of organized stakes among interest groups may render the contribution schedules of some lobby groups negative. As these lobby groups will not take part in the political competition, this is equivalent to a reduction of aggregate organized stakes. As a consequence, both emissions levels and the decision whether to form an international permit market may be influenced. A numerical example illustrates that it may be beneficial for lobby groups with similar interests to join forces and act as one special interest group.

This paper combines two strands of literature. It adds to the literature on non-cooperative climate policy, mostly developed by 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. They analyze the discrete decision whether to take part in such an agreement under political influence. In contrast to their setting, our model comprises a second stage where the policy variable, the number of tradable or non-tradable allowances, is continuous. Consequently, aggregate welfare in our model does not remain unchanged.

There is another strand of literature (Lai 2007, 2008) 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. Unlike Lai we are interested in the political determination of climate policy in a multi-country setting as opposed to his analysis of permit allocation in a single country. Therefore, our analysis completely abstains from the issue of permit allocation.

The remainder of the paper is organized as follows: The next section introduces the basic economic model and the agents involved in the political process. Section 3.1 is concerned with the second and third stage of the game where the number of tradable or non-tradable allowances is chosen. The first stage is analyzed in Section 4 before a numerical illustration of the decision whether to participate in a trading system or not is carried out in Section 5. Section 6 concludes.

2 The Model

We consider a model of a global economy with pollutive emissions consisting of n countries indexed by $i = 1, \ldots, n$, $n \geq 2$. The political and economic landscape in each country is described below.

2.1 The economy

In each country i, emissions e_i imply country-specific benefits from productive activities $B_i(e_i)$. We assume that this function satisfies $B_i(0) = 0$, $B_i' > 0$ and $B_i'' < 0$. Global emissions, which are the sum of the emissions of all countries, are denoted by E:

$$E = \sum_{i=1}^{n} e_i \ . \tag{1}$$

Global emissions cause strictly increasing and convex country-specific damages $D_i(E)$, which satisfy $D_i(0) = 0$ and $D_i' > 0$, $D_i'' \geq 0$ for all $E > 0$ and $i = 1, \dots, n$.

Countries may agree upon introducing an international emissions 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 all countries need (at least) emission permits amounting to emissions e_i. Permits of all countries are traded on a perfectly competitive international permit market at price p. As a consequence, national social welfare is given by:

$$W_i^T(\omega_i, E) = B_i(e_i(E)) - D_i(E) - p(E)\left[e_i(E) - \omega_i\right] \ . \tag{2}$$

We assume that an international permit market is only introduced if all countries are willing to participate. If this is not the case all countries set emissions e_i non-cooperatively such as to maximize own social welfare:

$$W_i^{NT}(e_i, E) = B_i(e_i) - D_i(E) \ . \tag{3}$$

2.2 Stakeholders and interest groups

In each country i, we think of the political agents as M_i stakeholders. These agents have stakes in the elements of the social welfare function W_i. The degree to which stakeholder j benefits from emissions is defined as $\beta_{ij} \geq 0$, with $\sum_{j=1}^{M_i} \beta_{ij} = 1$, whereas she suffers from damages caused by emissions to the degree $\delta_{ij} \geq 0$, with $\sum_{j=1}^{M_i} \delta_{ij} = 1$. If an international permit market is set up, social welfare contains a third component (see equation (2)), the net revenues from permit trade, which is positive if a country has lower emissions than emissions permits issued. The agents' stakes in these revenues are denoted by $\pi_{ij} \geq 0$, $\sum_{j=1}^{M_i} \pi_{ij} = 1$. An agent can have stakes in one or several components of national welfare. We first derive fairly general equilibrium conditions of the political process before we proceed to identify distinct special interest groups such as green or producer lobbies.

We assume that some stakeholders are able to overcome the collective action problem described by Olson (1971) and organize themselves as lobby groups (special interest groups). We further assume that contribution schedules cannot be observed by other governments (nor lobby groups from abroad).[1] The governments in all countries are assumed to care about the weighted sum of national social welfare and lobbying contributions.

2.3 Structure of the game

As already mentioned in the introduction, two separate non-cooperative games coincide in our model setup: On the one hand, organized interest groups act non-cooperatively in choosing their contribution schedules to influence the respective government's policy variable. They take as given the contribution schedules of their competitors on the political stage as well as the lobby contributions and policies in all other countries. On the other hand, countries decide non-cooperatively upon their emissions caps. Governments take as given the political contribution schedules and other countries' policies.

The timing of the game is as follows: In the first stage, governments choose simultaneously whether to establish an international permit market or not by comparing the value of their objective functions for the two cases. Lobbies influence this decision so as to maximize their respective welfare, i.e. interest groups that gain from a permit market will lobby in favor of such a market whereas interest groups that lose from the introduction of the market will oppose to trading. Basically, interest groups will only contribute in favor of the regime where the policy variable is closer to their ideal point. In the second stage, the government either sets an emissions cap or issues allowances that can be traded on an international permit market, depending on the decision in the first stage. In the latter case, there is a third stage of the game where allowance trading takes place and the equilibrium permit price is determined.

3 National Emissions Levels

We solve the game by backward induction, starting with the second or third stage, depending on whether an international permit market has been established or not in the

[1] In principle, the observability of the lobbies' efforts could have two effects: First, lobby groups could strategically choose their contribution schedules in order to manipulate foreign governments in their policy responses. Second, even if interest groups could announce their intention publicly, a foreign government could never know if there exist other agreements besides those that have been made public. Furthermore, it might be very problematic for lobby groups to announce public contribution schedules in democracies as well as in states governed by dictators.

first stage.

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, all countries set national emissions caps non-cooperatively in the second stage.

The government in country i seeks to maximize

$$G_i^{NT}(e_i, E) = B_i(e_i) - D_i(E) + \theta_i \sum_{j=1}^{M_i} I_{ij} C_{ij}^{NT}(e_i, E), \tag{4}$$

subject to equation (1) and for given emissions e_k of all other countries $k \neq i$, where θ_i denotes the weight the government of country i assigns to lobbying contributions, $\theta_i \in [0, \infty[$. Lobby group j's contribution in country i is given by C_{ij}. I_{ij} is an indicator variable which equals one if a group of stakeholders is able to overcome the free-riding problem and form a lobby group, and zero otherwise. Lobby group j maximizes its utility net of contributions:

$$U_{ij}^{NT}(e_i, E) - C_{ij}^{NT}(e_i, E) = \beta_{ij} B_i(e_i) - \delta_{ij} D_i(E) - C_{ij}^{NT}(e_i, E). \tag{5}$$

We seek the Nash equilibrium of this non-cooperative game for truthful contribution schedules (Grossman and Helpman 1994) for all interest groups. Truthful contribution schedules are differentiable and continuous and express a lobby's true marginal willingness-to-contribute.[2] The equilibrium outcome of this principal-agent game can either be found by maximizing (4) taking into account that lobbies are willing to contribute at the margin according to their marginal change in utility. Another way of determining the optimality conditions without trading is as follows: Since the policymaker's welfare is a function of aggregate welfare and the sum of campaign contributions and since contributions enter the government's and the interest groups' welfare functions linearly, the equilibrium policy maximizes a weighted sum of the welfare of the interest groups and the general public (Grossman and Helpman 2002). Using this property of joint efficiency

[2] 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.

as a shortcut, the first-order condition for country i's government reads as follows:

$$G_i^{NT\prime}(e_i) = B_i'(e_i) - D_i'(E) + \theta_i \left[\sum_{j=1}^{M_i} I_{ij}[\beta_{ij} B_i'(e_i) - \delta_{ij} D_i'(E)] \right] = 0 \ , \tag{6}$$

which implies:

$$(1 + \theta_i b_i) B_i'(e_i) = (1 + \theta_i d_i) D_i'(E) \ , \tag{7}$$

where $b_i = \sum_{j=1}^{M_i} I_{ij}\beta_{ij} \leq 1$ and $d_i = \sum_{j=1}^{M_i} I_{ij}\delta_{ij} \leq 1$.

Aggregate emissions are derived by summing up equation (7) over all countries yielding the following condition:

$$\sum_{j=1}^{n} \frac{1 + \theta_j b_j}{1 + \theta_j d_j} B_j'(e_j) = \sum_{j=1}^{n} D_j'(E), \tag{8}$$

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 $i = 1, \ldots, n$ simultaneously set national emissions caps e_i such as to maximize (4) *subject to equation* (1) *and taking emissions e_j of all other countries $j \neq i$ as given.*

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 $i = 1, \ldots, n$. This either holds if governments assign no weight to lobbying contributions, i.e. $\theta_i = 0$, or if organized and participating lobby groups represent equally strong stakes in both components of national social welfare, i.e $b_i = d_i$. 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.

Applying the implicit function theorem to equation (8), we derive the following corollary stating how total emissions E in the Nash equilibrium change dependent on b_i, d_i and θ_i.

Corollary 1 (Comparative statics of national emissions caps)
For the level of total emissions E in the Nash equilibrium the following conditions hold:

$$\frac{dE}{db_i} = -\frac{\theta_i B_i'(e_i)}{\sum_{j=1}^{n}\Big[(1+\theta_j b_j)B_j''(e_j) - (1+\theta_j d_j)D_j''(E)\Big]} > 0 \; , \tag{9a}$$

$$\frac{dE}{dd_i} = -\frac{\theta_i D_i'(e_i)}{\sum_{j=1}^{n}\Big[(1+\theta_j b_j)B_j''(e_j) - (1+\theta_j d_j)D_j''(E)\Big]} < 0 \; , \tag{9b}$$

$$\begin{aligned}\frac{dE}{d\theta_i} &= -\frac{b_i B_i'(e_i) - d_i D_i'(E)}{\sum_{j=1}^{n}\Big[(1+\theta_j b_j)B_j''(e_j) - (1+\theta_j d_j)D_j''(E)\Big]} \gtreqless 0 \\ &\Leftrightarrow \big[b_i B_i'(e_i) - d_i D_i'(E)\big] \gtreqless 0 \; .\end{aligned} \tag{9c}$$

Corollary 1 states that global emissions will rise if the organized stakes in the benefits in one country i increase or the organized stakes in the environmental damages in that country decrease. Furthermore, if the government of country i assigns a higher value to lobbying contributions the effect on total emissions depends on the difference between marginal benefits and damages in that country, weighted by the respective influence of the lobby groups. If the marginal willingness-to-contribute (MWTC) of all lobbies for an additional unit of emissions is greater than zero, global emissions will rise, and vice versa. In other words, if there is only one benefit and one damage lobby, whether global emissions will increase or decrease if θ_i is increased marginally, depends on the difference between the MWTCs of the two lobby groups. If the benefit lobby has a higher MWTC than the damage lobby in the equilibrium, then national and global emissions will rise.

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 all countries non-cooperatively decide on the amount of emission permits ω_i they will issue in the second stage. In the third stage, all permits are 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 third stage, profit maximization in each country implies that marginal benefits equal the permit price:[3]

$$p = B_i'(e_i) \ , \quad i = 1, \ldots, n \ . \tag{10}$$

This implies the well-known equimarginal 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

$$e_i(p) = B'^{-1}(p) \ , \quad i = 1, \ldots, n \ . \tag{11}$$

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

$$\sum_{i=1}^{n} \omega_i = \sum_{i=1}^{n} B_i'^{-1}(p) = \sum_{i=1}^{n} e_i(p) = E \ . \tag{12}$$

Equation (12) 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.

Introducing the abbreviations,

$$\phi_i(p) \equiv -\frac{1}{B_i''(e_i(p))} \ , \qquad \Phi(p) \equiv \sum_{i=1}^{n} \phi_i(p) \ , \quad i = 1, \ldots, n \ , \tag{13}$$

the following lemma states some important relationships for later use:

Lemma 1
Defining $e_i(E) \equiv e_i\big(p(E)\big)$, the following relationships hold:

$$\begin{aligned} p'(E) &= -\frac{1}{\Phi(p)} < 0 \ , \qquad & p''(E) &= -\frac{\Phi'(p)}{\Phi(p)^2} \\ e_i{}'(E) &= \frac{\phi_i(p)}{\Phi(p)} \in [0,1] \ , \qquad & e_i''(E) &= -\frac{\phi_i'(p)\Phi(p) - \phi_i(p)\Phi'(p)}{\Phi(p)^3} \ . \end{aligned} \tag{14}$$

[3] We assume the absence of lobbying in the third stage. This assumption is driven by the fact that permit market transactions are governed by individual decentralized firms and not by a central government.

The proof of Lemma 1 is given in the Appendix.

3.2.2 Issuance of emissions permits

In the second stage, all countries simultaneously choose the level of emission permits ω_i, taking the actions ω_j of all other countries as given. Thus, the government in country i chooses ω_i such as to maximize its payoff function

$$G_i^T = B_i(e_i(E)) - D_i(E) - p(E)\,[e_i(E) - \omega_i] + \theta_i \sum_{j=1}^{M_i} I_{ij} C_{ij}^T(\omega_i, E), \tag{15}$$

subject to equations (11), (12) and given $\omega_k,\ k = 1, \ldots, n\,,\ k \neq i$. In each country $i = 1, \ldots, n$, all lobby groups $j = 1, \ldots, M_i$ choose strictly positive contribution schedules such as to maximize their utility net of contributions:

$$U_{ij}^T(\omega_i, E) - C_{ij}^T(\omega_i, E) = \beta_{ij} B_i(e_i(E)) - \delta_{ij} D_i(E) - \pi_{ij} p(E)\,[e_i(E) - \omega_i] - C_{ij}^T(\omega_i, E). \tag{16}$$

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

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

where $r_i = \sum_{j=1}^{M_i} I_{ij}\pi_{ij} \leq 1$ denotes the share of the net profits (or losses) associated with the permit market transaction which is represented by organized lobby groups.[4] Dividing by $(1+\theta_i r_i)$ and summing up equation (17) over all countries yields the following condition, which holds in the Nash equilibrium:

$$F(E) \equiv p(E) \left\{ n + \sum_{j=1}^{n} \frac{\theta_j(b_j - r_j)e_j'(E)}{1+\theta_j r_j} \right\} - \sum_{j=1}^{n} \frac{1+\theta_j d_j}{1+\theta_j r_j} D_j'(E) = 0\ . \tag{18}$$

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

[4] Who benefits or loses from permit market transactions crucially depends on the allocation method: If permits are grandfathered, polluting industries bear the costs or gains from revenues. In the case of an auction, the state generates additional income in any case, i.e. not only if hot air is produced. The proceeds from the auction could be distributed to green projects or be used to finance tax cuts. In this scenario, the lobbies that benefit from permit market revenues are either the green lobby or a lobby constituted of tax-payers.

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 $i = 1, \ldots, n$, there exists a unique Nash equilibrium of the game in which all countries $i = 1, \ldots, n$ simultaneously set the level of emission permits ω_i such as to maximize (15) *subject to equations* (11), (12) *and taking permit levels ω_k of all other countries $k \neq i$ 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 all countries $i = 1, \ldots, n$ are *almost quadratic*. For the remainder of the paper we assume that $\phi_i'(p)$ is so small for all countries $i = 1, \ldots, n$ 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.

In order to derive comparative statics results, we employ the implicit function theorem on equation (18). Defining

$$\begin{aligned}\Gamma(E) = \frac{\partial F(E)}{\partial E} = p'(E)\left\{n + \sum_{j=1}^{n} \frac{\theta_j(b_j - r_j)e_j'(E)}{1+\theta_j r_j}\right\} + \\ + p(E)\sum_{j=1}^{n}\frac{\theta_j(b_j - r_j)e_j''(E)}{1+\theta_j r_j} - \sum_{j=1}^{n}\frac{1+\theta_j d_j}{1+\theta_j r_j}D_j''(E) < 0 \ ,\end{aligned} \tag{19}$$

the following corollary summarizes the results.

Corollary 2 (Comparative statics of permit issuance)
For the level of total emissions E in the Nash equilibrium the following conditions hold:

$$\frac{dE}{db_i} = -\frac{\theta_i p(E)e_i'(E)}{\Gamma(E)(1+\theta_i r_i)} > 0 \ , \tag{20a}$$

$$\frac{dE}{dd_i} = \frac{\theta_i}{\Gamma(E)(1+\theta_i r_i)}D_i'(E) < 0 \ , \tag{20b}$$

$$\begin{aligned}\frac{dE}{dr_i} &= -\frac{\theta_i\left\{(1+\theta_i)D_i'(E) - p(E)e_i'(E) - \theta_i(b_i - r_i)e_i'(E)\right\}}{\Gamma(E)(1+\theta_i r_i)^2} \\ &= -\frac{\theta_i\left\{p(E)[1-e_i'(E)] - p'(E)[e_i(E) - \omega_i]\right\}}{\Gamma(E)(1+\theta_i r_i)} \ ,\end{aligned} \tag{20c}$$

$$\frac{dE}{d\theta_i} = -\frac{[(b_i - r_i)p(E)e_i(E)e_i'(E) - (d_i - r_i)D_i'(E)]}{\Gamma(E)(1+\theta r_i)^2} \ . \tag{20d}$$

The first two equations yield the same result as in the case where no international permit market is set up: For a marginal increase in b_i (d_i) global emissions rise (fall). The third and fourth equation cannot be signed unambiguously. In the third equation, we plugged in the first-order condition (17) for an individual country. We see that there are two effects that determine the sign of this equation. The term in brackets gives the marginal revenue from an increase in national allowances. On the one hand, an additional unit of domestic allowances is beneficial for both permit-buying and permit-selling countries, since emissions in this country will rise by less than this marginal unit (first-order effect). The remainder of this marginal unit can be sold or need not be bought on the permit market. On the other hand, an additional unit of allowances decreases the permit price on the world market for all infra-marginal units. This is, of course, beneficial for permit buyers, but not for permit sellers. Therefore, the sign of this equation is unambiguously positive for permit buyers but can turn negative for permit sellers depending on which effect is stronger (the first-order effect from selling an additional unit or the second-order effect from a decreasing world market price for all infra-marginal units). For the sign of the fourth equation, we obtain for $d_i, b_i > r_i$:

$$\frac{dE}{d\theta_i} \lesseqqgtr 0 \Leftrightarrow (b_i - r_i)p(E)e_i(E)e_i'(E) \lesseqqgtr (d_i - r_i)D_i'(E). \tag{21}$$

For $d_i, b_i > r_i$, the interpretation is as follows: A marginal increase in government i's weight for lobby contributions increases global emissions if the MWTC of the lobby with stakes in benefits is higher than the MWTC of the lobby interested in damages, adjusted for the influence of the permit market revenue lobby.

Without lobbying, which is equivalent to $\theta_i = 0$ for all $i = 1, ..., n$, or if all three different components of the welfare function are equally represented by lobby groups in all countries, i.e. $b_i = d_i = r_i$ for all $i = 1, \ldots, n$, we reproduce Helm (2003)'s result that a country is a net permit buyer (seller) of emissions permits if it exhibits above (below) average marginal environmental damages. In case of lobbying, we obtain a corresponding condition by solving equation (18) for the permit price $p(E)$ and inserting into the reaction function (17):

$$\begin{aligned} e_i(E) - \omega_i = & \\ & -\frac{1}{p'(E)}\left\{\frac{1+\theta_i d_i}{1+\theta_i r_i}D_i'(E) - \frac{1+\frac{\theta_i(b_i-r_i)e_i'(E)}{1+\theta_i r_i}}{n+\sum_{j=1}^{n}\frac{\theta_j(b_j-r_j)e_j'(E)}{1+\theta_j r_j}}\sum_{j=1}^{n}\frac{1+\theta_j d_j}{1+\theta_j r_j}D_j'(E)\right\}. \end{aligned} \tag{22}$$

Again, whether a country is a permit buyer depends on the marginal contribution that environmental damages exert on the payoff function of the government in country i

compared to a weighted average of the contribution of marginal environmental damages over all countries.

If all countries were politically alike, that is $\theta_i = \theta_j = \theta$, $b_i = b_j = b$, $d_i = d_j = d$ and $r_i = r_j = r$ for all $i, j = 1, \ldots, n$, then equation (22) collapses to

$$e_i(E) - \omega_i = -\frac{1}{p'(E)} \frac{1+\theta d}{1+\theta r} \left\{ D_i'(E) - \frac{1}{n} \sum_{j=1}^{n} D_j'(E) \right\} , \tag{23a}$$

implying that, again, a country i is a net buyer (seller) of permits if it exhibits above (below) average marginal environmental damages. Considering the other polar case that countries are economically identical with respect to environmental damages, i.e. $D_i(E) = D_j(E) = D(E)$ for all $i, j = 1, \ldots, n$, we obtain:

$$e_i(E) - \omega_i = \\ -\frac{D'(E)}{p'(E)} \left\{ \frac{1+\theta_i d_i}{1+\theta_i r_i} - \frac{1 + \frac{\theta_i (b_i - r_i) e_i'(E)}{1+\theta_i r_i}}{n + \sum_{j=1}^{n} \frac{\theta_j (b_j - r_j) e_j'(E)}{1+\theta_j r_j}} \sum_{j=1}^{n} \frac{1+\theta_j d_j}{1+\theta_j r_j} \right\} . \tag{23b}$$

Then, whether a country is a net buyer or seller of permits depends on its political parameters relative to the political parameters of all other countries. Note that without lobbying an international permit market yields a degenerate solution if all countries exhibit identical environmental damages, as all countries would issue permits equal to their emissions.

3.3 Emissions levels with and without trading

Even without lobbying it is not an easy task to assess emissions levels in the Nash equilibrium with and without trading, as Helm (2003) pointed out. Not surprisingly, when political competition by lobby groups is introduced it is even more demanding and no clear-cut conditions can be stated.

Denote E^T and E^{NT} the global emissions in the Nash equilibrium with and without trading. From equation (18) we know that for the Nash equilibrium with trade the following condition holds:

$$p(E^T) \left\{ n + \sum_{j=1}^{n} \frac{\theta_j (b_j - r_j) e_j'(E^T)}{1+\theta_j r_j} \right\} = \sum_{j=1}^{n} \frac{1+\theta_j d_j}{1+\theta_j r_j} D_j'(E^T) , \tag{24}$$

where the right-hand side gives global marginal damages and the left-hand side equals global marginal benefits from emissions. As the right-hand side of equation (24) is increasing and the left-hand side is decreasing in the global emissions level, the following corollary holds:

Corollary 3 (Emissions levels with and without trading)
Comparing the global emissions levels in the Nash equilibrium with and without trading, the following condition holds:

$$E^T \gtreqless E^{NT} \Leftrightarrow p(E^{NT}) \left\{ n + \sum_{j=1}^{n} \frac{\theta_j (b_j - r_j) e_j'(E^{NT})}{1+\theta_j r_j} \right\} \gtreqless \sum_{j=1}^{n} \left[\frac{1+\theta_j d_j}{1+\theta_j r_j} D_j'(E^{NT}) \right]. \quad (25)$$

4 The first stage: To trade or not to trade

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 all 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 contribution schedules

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 has a pressured and when it has 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 saying that the government must be at least equally well off if the lobby is active compared to the case when it is not active. Depending on whether a permit market is formed in the second stage, the following conditions hold:

$$\begin{aligned} & W_i^{NT}(e_i^\star, E^{NT}) + \theta_i \sum_{j=1}^{M_i} I_{ij} C_{ij}^{NT}(e_i^\star, E^{NT}) = \\ & \qquad W_i^{NT}(e_i^{-k}, E^{-k}) + \theta_i \sum_{\substack{j=1 \\ j \neq k}}^{M_i} I_{ij} C_{ij}^{NT}(e_i^{-k}, E^{-k}) \ , \end{aligned} \tag{26a}$$

$$\begin{aligned} & W_i^{T}(\omega_i^\star, E^{T}) + \theta_i \sum_{j=1}^{M_i} I_{ij} C_{ij}^{T}(\omega_i^\star, E^{T}) \\ & \qquad = W_i^{T}(\omega_i^{-k}, E^{-k}) + \theta_i \sum_{\substack{j=1 \\ j \neq k}}^{M_i} I_{ij} C_{ij}^{T}(\omega_i^{-k}, E^{-k}) \ , \end{aligned} \tag{26b}$$

where equilibrium emissions and permit choices are denoted by a superscript star when all lobbies are active, and ω_i^{-k}, e^{-k} and E^{-k} indicate permits and emissions levels that would arise if lobby group k did not offer any contributions.

Then, the following proposition holds for the contribution schedules of all lobbying groups.

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

$$\begin{aligned} C_{ik}^{NT}(e_i^\star, E^{NT}) = {} & \frac{1}{\theta_i}\left[W_i^{NT}(e_i^{-k}, E^{-k}) - W_i^{NT}(e_i^\star, E^{NT})\right] \\ & + (b_i - \beta_{ik})\left[B_i(e_i^{-k}) - B_i(e_i^*)\right] - (d_i - \delta_{ik})\left[D_i(E^{-k}) - D_i(E^{NT})\right] \ , \end{aligned} \tag{27a}$$

$$\begin{aligned} C_{ik}^{T}(\omega_i^\star, E^{T}) = {} & \frac{1}{\theta_i}\left[W_i^{T}(\omega_i^{-k}, E^{-k}) - W_i^{T}(\omega_i^\star, E^{T})\right] \\ & + (b_i - \beta_{ik})\left[B_i(e_i(E^{-k})) - B_i(e_i(E^T))\right] - (d_i - \delta_{ik})\left[D_i(E^{-k}) - D_i(E^{T})\right] \\ & - (r_i - \pi_{ik})\left[p(E^{-k})(e_i(E^{-k}) - \omega_i^{-k}) - p(E^T)(e_i(E^T) - \omega_i^\star)\right] \ . \end{aligned} \tag{27b}$$

The proof of Proposition 3 is given in the Appendix.

Proposition 3 says that a particular lobby group k has to compensate the government twofold: On the one hand, it has to compensate proportionally for the loss (gain) in national welfare attributable to the change in emissions or issued permits levels due to the lobby's influence. 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 as a consequence of the lobby's influence.

Inserting the contribution schedules in the governments' payoff functions, yields the following corollary:

Corollary 4 (Government's payoff in the second stage)
For truthful and strictly positive contribution schedules of all lobby groups, the government's payoff in country i dependent on the choice of regime yields:

$$G_i^{NT}(e_i^\star, E^{NT}) = \left(1 - \sum_{j=1}^{M_i} I_{ij}\right) \left\{W_i^{NT}(e_i^\star, E^{NT}) + \theta_i \left[b_i B_i(e_i^\star) - d_i D_i(E^{NT})\right]\right\} \tag{28a}$$

$$+ \sum_{j=1}^{M_i} I_{ij} \left\{W_i^{NT}(e_i^{-j}, E^{-j}) + \theta_i \left[(b_i - \beta_{ij}) B_i(e_i^{-j}) - (d_i - \delta_{ij}) D_i(E^{-j})\right]\right\} \ ,$$

$$G_i^{T}(\omega_i^\star, E^{T}) = \left(1 - \sum_{j=1}^{M_i} I_{ij}\right) \left\{W_i^{T}(\omega_i^\star, E^{T}) + \theta_i \left[b_i B_i(e_i^\star) - d_i D_i(E^{T})\right.\right. \tag{28b}$$

$$\left.\left. - r_i p(E^T)(e_i(E^T) - \omega_i^\star)\right]\right\} + \sum_{j=1}^{M_i} I_{ij} \left\{W_i^{T}(\omega_i^{-j}, E^{-j}) + \theta_i \left[(b_i - \beta_{ij}) B_i(e_i^{-j})\right.\right.$$

$$\left.\left. - (d_i - \delta_{ij}) D_i(E^{-j}) - (r_i - \pi_{ij}) p(E^T)(e_i(E^T) - \omega_i^\star)\right]\right\} \ .$$

Proposition 3 and Corollary 4 yield 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 contribution schedules of individual lobbying groups and, thus, also the aggregate lobbying contributions the government receives depend on the composition of lobbying groups within each country.

4.2 Unilateral stances

Knowing the contribution schedules 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^1, which is given by the sum of the equilibrium payoff in the second stage G_i^R plus lobbying contributions C_{ij}^1 in the first stage:

$$G_i^1(R) = G_i^R + \theta_i \sum_{j=1}^{M_i} I_{ij} C_{ij}^1(R) \ . \tag{29}$$

Obviously, if there were no lobbying in the first stage, country i's government would oppose the formation of an international emissions permits market if and only if its second stage equilibrium payoff in case of no trading exceeds the one in case of trading, i.e. $G_i^{NT}(e_i^\star, E^{NT}) > G_i^T(\omega_i^\star, E^T)$.

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. Given regime R prevails in the second stage, the lobby group j's total net utility is given by the second stage's equilibrium net utility minus the lobbying contributions in the first stage:

$$NU_{ij}^1(R) = U_{ij}^R - C_{ij}^R - C_{ij}^1(R) \ . \tag{30}$$

This implies that 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 net utilities between both regimes. For later reference, we define

$$\Delta U_{ij}^{NT,T} = U_{ij}^{NT}(e_i^\star, E^{NT}) - C_{ij}^{NT}(e_i^\star, E^{NT}) - U_{ij}^T(\omega_i^\star, E^T) + C_{ij}^T(\omega_i^\star, E^T) \ , \tag{31a}$$

$$\Delta U_{ij}^{T,NT} = -\Delta U_{ij}^{NT,T} \ . \tag{31b}$$

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 the government in country i supports regime R, i.e. $G_i^R > G_i^{\bar{R}}$, 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

$$G_i^R - G_i^{\bar{R}} > \theta_i \Delta U_{ij}^{\bar{R},R} \ . \tag{32}$$

If inequality (32) 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 (32) 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 (32) *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.,

$$G_i^R + \theta_i \sum_{j=1}^{M_i} C_{ij}^1(R) = G_i^{\bar{R}} + \theta_i \sum_{j=1}^{M_i} C_{ij}^1(\bar{R}) \ , \tag{33}$$

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:

$$G_i^R + \theta_i \sum_{j \in S_R} \Delta U_{ij}^{R,\bar{R}} > G_i^{\bar{R}} + \theta_i \sum_{j \in S_{\bar{R}}} \Delta U_{ij}^{\bar{R},R} \ . \tag{34}$$

Note that condition (34) is necessary but not sufficient for a pressured stance in favor of regime R to exist. In addition we need that

$$G_i^R < G_i^{\bar{R}} + \theta_i \sum_{j \in S_{\bar{R}}} \Delta U_{ij}^{\bar{R},R} \ , \tag{35}$$

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 (34) *and* (35) *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 the 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.[5]

It may happen that both an unpressured and a pressured unilateral stance exist simultaneously. This holds if all three conditions (32), (34) and (35) hold simultaneously. Both stances select the same regime R, if

$$G_i^{\bar{R}} < G_i^R < G_i^{\bar{R}} + \theta_i \sum_{j \in S_{\bar{R}}} \Delta U_{ij}^{\bar{R},R} \ , \tag{36}$$

holds. 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 emissions levels 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 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

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

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 selected regime may change by redistributing organized stakes, the following proposition shows that pressured unilateral stances are immune.

Proposition 6 (Regime choice and distribution of organized stakes)
For truthful and strictly positive contribution schedules of all lobby groups in the second stage and constant aggregate organized stakes b_i, d_i and r_i, a redistribution of organized stakes β_{ij}, δ_{ij} and π_{ij} among lobby groups j in country i does not change the selected regime if a pressured stance exists before and after the redistribution.

The proof is given in the Appendix.

The intuition for this result is that the necessary condition (34) 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 it selects the same regime. However, a pressured stance may come into existence or, conversely, cease to exist by a redistribution of organized stakes, as this influences the second necessary condition (35) for a pressured stance. As also the necessary and sufficient condition (32) for an unpressured stance depends on the distribution of stakes, no general statement can be made if there is no unpressured stance either before and/or after the redistribution.

It is important to note that Proposition 6 only holds as long as all lobby groups exhibit strictly positive contribution schedules in the second stage before and after the redistribution of organized stakes. As we show in Section 5, a redistribution may result in negative contribution schedules for some lobby groups. These lobby groups will not contribute in the second stage, which is equivalent to a reduction of the aggregate organized stakes b_i, d_i and r_i.

4.3 International agreements

Having defined unilateral stances, we define an equilibrium agreement as one in which the regime is a unilateral stance in all countries. As we require the support of all countries for an emissions permit market to be adopted, emission trading in the second stage only occurs if the trading regime is a unilateral stance in all countries.

5 Numerical Illustration

In the following, we will analyze some interesting scenarios that can arise in the two country case and illustrate some of our above results. For ease of analysis, we assume that only one of the two countries (country 1) faces political pressure from lobby groups. The other country (country 2) is governed by purely benevolent politicians. Furthermore, we assume that permits would be grandfathered if a permit market is introduced. There are only two kinds of lobby groups in the economy: green lobbies that are affected by damages only and industry lobbies that have stakes both in the benfits of emissions and in the permit market revenues (costs).

5.1 Emission levels with and without trading

In order to make emission levels with and without trading comparable, we use specific functional forms for the benefit and damage functions:

$$
\begin{aligned}
B_i(e_i) &= \frac{1}{\phi_i} e_i (1 - \frac{1}{2} e_i), \quad B_i'(e_i) = \frac{1}{\phi_i}(1 - e_i), \quad B_i''(e_i) = -\frac{1}{\phi_i}, && (37) \\
D_i(E) &= \frac{\epsilon_i}{2} E^2, \quad D_i'(E) = \epsilon_i E; \quad D_i''(E) = \epsilon_i, && (38)
\end{aligned}
$$

where ϕ_i is a benefit and ϵ_i is a damage parameter. We assume that $e_i < 1$ for all $i = 1, \ldots, n$ so that marginal benefits do not turn negative.

Applying our parameterized functions to the first-order conditions for the regimes with and without trading, we get emission levels, number and price of permits:

$$E^{NT} = \frac{n}{1 + \sum_{j=1}^{n} \frac{1+\theta_j d_j}{1+\theta_j b_j} \phi_j \epsilon_j}, \tag{39}$$

$$e_i^{NT} = 1 - \phi_i \epsilon_i \frac{1 + \theta_i d_i}{1 + \theta_i b_i} E^{NT}, \tag{40}$$

$$E^T = \frac{n + \frac{1}{\Phi} \sum_{j=1}^{n} \frac{\theta_j (b_j - r_j)}{1+\theta_j r_j} \phi_j}{1 + \frac{1}{\Phi n} \sum_{j=1}^{n} \frac{\theta_j (b_j - r_j)}{1+\theta_j r_j} \phi_j + \frac{\Phi}{n} \sum_{j=1}^{n} \frac{1+\theta_j d_j}{1+\theta_j r_j} \epsilon_j}, \tag{41}$$

$$p = \frac{n - E^T}{\Phi}, \tag{42}$$

$$e_i^T = 1 + (E^T - n) \frac{\phi_i}{\Phi}, \tag{43}$$

$$\omega_i = e_i^T + (n - E^T) \left[1 + \frac{\theta_i (b_i - r_i)}{1 + \theta_i r_i} \frac{\phi_i}{\Phi} \right] - \frac{1 + \theta_i d_i}{1 + \theta_i r_i} \epsilon_i \Phi E^T. \tag{44}$$

5.2 Simulating different lobby distributions

In Section 4, we found that pressured stances are immune to a redistribution of stakes. Our simulations will show that this is only true for strictly positive contributions.

As we have seen in the previous section, lobbies' contributions in stage 1 and stage 2 vary with the number of competing lobbies. The less competition among lobby groups, the higher the payoff that the government can extract from the political process, and the higher each lobby's contribution. This can be seen in the following example where we assume that in country 1, there is only one environmental lobby whereas stakeholders in the benefits of emissions and in permit market revenues/costs have not been able to overcome the free-riding problem: $\theta_1 = 0.6, \delta_1 = 0.6, \epsilon_1 = 0.09, \phi_1 = 0.15$. In country 2, we have $\theta_2 = 0, \epsilon_2 = 0.05, \phi_2 = 0.5$. This parameter constellation results in an agreement between the two governments to establish a permit market. Without any contributions in the first stage, the government in country 1 would prefer the no trade regime. There is a pressured stance in favor of trade in country 1 since only one lobby group is active.

When splitting up the environmental lobby group into two groups of equal size, i.e. $\delta_{11} = \delta_{12} = 0.3$, the sum of the two groups' contributions is lower than the contribution if the two were organized in one lobby. Consequently, net utilities between the trade and no trade regime differ and so do lobby contributions in stage 1. As it turns out, however, the government's payoff is the same, independently of the amount of contributions it can collect in the second stage. The intuition is as follows. The government can extract lower aggregate contributions from the political competition if more lobbies are present in the second stage, leaving a higher net utility for the lobby groups. As lobby groups pay contributions in the first stage up to the difference in net utility between the two regimes, the government can, in turn, extract higher payments in the first stage so that the difference in the government's objective function between the two regimes remains the same. This confirms the result of Proposition 6 that pressured unilateral stances are immune to a redistribution of constant aggregate organized stakes.

Although the final outcome does not depend on the number of lobby groups for strictly positive contributions for all lobbies and all distributions of lobbies, more competition among lobby groups can lead to a situation where lobbies prefer to be inactive. Consider the following scenario: Again, we assume lobbying activities in country 1 while country 2 is governed by purely benevolent politicians. We construct a situation where both countries gain from the introduction of a permit market initially. Particularly, we assume: $\theta_1 = 1.5, \beta_1 = \pi_1 = 0.6, \delta_{11} = \delta_{12} = 0.3, \epsilon_1 = 0.35$ and $\phi_1 = 0.01$ for country 1;

$\theta_2 = 0, \epsilon_2 = 0.06$ and $\phi_2 = 0.03$ for country 2. We get positive contributions for the industrial and the green lobbies in country 1 under both regimes. There exist both an unpressured stance and a pressured stance in favor of trading.

Now suppose that the organized industry group splits up into two equal parts that do not cooperate, i.e. $\beta_{11} = \pi_{11} = \beta_{12} = \pi_{12} = 0.3$. As a consequence, these two lobbies' contributions in the trading regime turn negative because it has become more costly for each of the two industry lobbies to compensate the government for the loss in all other lobbies' welfare relative to the gain (which is now a loss) in social welfare associated with its non-participation. Under these assumptions, the difference in the government's total payoff in stage 1 between trading and non-trading turns negative, indicating that a pressured stance in favour of the no trade regime exists after redistribution. This implies that the government finally prefers not to participate in a trading system if two industrial lobby groups of equal size are present instead of one. The industry lobby "crowds" itself "out" from the political competition in the trading regime when splitting up.[6] However, no unpressured stance exists after redistribution because one industry lobby alone would be able to "convince" the government by means of its contributions not to participate in trading. An agreement between the two governments on establishing a permit market fails.

6 Conclusion

We have analyzed the non-cooperative formation of an international emissions permit market in a setting of political competition by national interest groups. We found that whether total emissions are higher or lower for the trade regime depends on economic and political parameters. The same is true for the countries' welfare levels that are achieved in equilibrium. However, only the aggregate level of organized stakes in each country matter and not their distribution among individual interest groups, as long as the contribution schedules of all lobby groups are strictly positive. Also, the decision whether an international permit market is formed does not depend on the distribution of organized stakes, as long as at least one lobby groups exhibits positive payments in each country. However, these conditions are not necessarily met. Redistribution may result in negative contribution schedules for at least one lobby group. As these crowded out lobby groups do not take part in the political competition, this is equivalent to a

[6] This crowding out of the industry lobbies in the trade case occurs, no matter whether the green stakeholders are organized in one or two groups.

reduction of the aggregate organized stakes in the respective country. As a consequence, both the choice of regime and the level of aggregate emissions may change.

Our analysis has been 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. It is worth exploring cooperative international climate policy under political pressure from special interest groups in future research.

Appendix

Proof of Proposition 1

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

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

$$D_i''(E) - e_i'(E) + 2p'(E)\left[e_i'(E) - 1\right] + p''(E)\left[e_i(E) - \omega_i\right] > 0 \ , \tag{A.1}$$

if $p''(E)$ is sufficiently small. Thus, for all countries $i = 1, \ldots, n$, the reaction function yields a unique best response for any given choices ω_j of all other countries $j \neq i$, which guarantees the *existence* of a Nash equilibrium.

(ii) Uniqueness: In the Nash equilibrium equation (8) holds, which we can re-write to yield:

$$\sum_{j=1}^{n} \frac{1 + \theta_j b_j}{1 + \theta_j d_j} B_j' \left(E - \sum_{k \neq j} e_k \right) = \sum_{j=1}^{n} D_j'(E) \ . \tag{A.2}$$

As the left-hand side is strictly decreasing and the right-hand side is strictly increasing in E, there exists a unique level of total emissions allowances E. Substituting E back into the reaction function (7) yields the unique national emissions levels e_i. □

Proof of Lemma 1

Condition (12) of the permit market equilibrium implies

$$E - \sum_{j=1}^{n} B_j'^{-1}(p) = 0 \tag{A.3}$$

Applying the implicit function theorem yields

$$p'(E) = \frac{dp(E)}{dE} = -\frac{1}{-\sum_{j=1}^{n} \frac{\partial B_j'^{-1}(p)}{\partial p}} = \frac{1}{\sum_{j=1}^{n} \frac{1}{B_j''\left(e_j(p)\right)}} < 0 \tag{A.4a}$$

We further obtain

$$p''(E) = \frac{d^2p(E)}{dE^2} = \frac{\sum_{j=1}^{n} \frac{B_j'''(e_j(p))}{B_j''(e_j(p))^3}}{\left[\sum_{j=1}^{n} \frac{1}{B_j''(e_j(p))}\right]^3} \ , \tag{A.4b}$$

$$e_i{}'(p) = \frac{de_i(p)}{dp} = \frac{1}{B_i''(e_i(p))} < 0 \ , \tag{A.4c}$$

$$e_i{}'(E) = \frac{de_i(E)}{dE} = \frac{de_i\big(p(E)\big)}{dp(E)} \frac{dp(E)}{dE} = \frac{\frac{1}{B_i''\left(e_i(p)\right)}}{\sum_{j=1}^{n} \frac{1}{B_j''\left(e_j(p)\right)}} \in [0,1] \ . \tag{A.4d}$$

Employing the abbreviations (13) yields the stated result. □

Proof of Proposition 2

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

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

$$G_i^{NT\prime\prime}(e_i) = B_i''(e_i) - D_i''(E) + \theta_i \left[\sum_{j=1}^{M_i} I_{ij}[\beta_{ij} B_i''(e_i) - \delta_{ij} D_i''(E)]\right] < 0 \ . \tag{A.5}$$

Thus, for all countries $i = 1, \ldots, n$, the reaction function yields a unique best response for any given choices ω_j of all other countries $j \neq i$, which guarantees the *existence* of a Nash equilibrium.

(ii) Uniqueness: In the Nash equilibrium equation (18) holds. As the first term on the left-hand side is strictly decreasing and the second term on the left-hand side is strictly increasing in E, there exists a unique level of total emissions allowances $\hat{E}$. Substituting back into the reaction function yields the unique Nash equilibrium (17). □

Proof of Proposition 3

Given the government's indifference conditions (26a) and (26b) (depending on whether a permits 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} (which is simply a scalar) or zero:

$$C_{ij}^{NT}(e_i, E) = \max[0, U_{ij}^{NT}(e_i, E) - R_{ij}] \ , \quad \text{or} \quad C_{ij}^{T}(\omega_i, E) = \max[0, U_{ij}^{T}(\omega_i, E) - R_{ij}] \ ,$$

(A.6)

If we assume that $C_{ij} > 0$ for all $j = 1, \dots, M_i$, we can re-write equations (26a) and (26b) by virtue of condition (A.6) to yield:

$$\begin{aligned} W_i^{NT}(e_i^\star, E^{NT}) + \theta_i \sum_{\substack{j=1 \\ j\neq k}}^{M_i} U_{ij}^{NT}(e_i^\star, E^{NT}) + \theta_i \left[U_{ik}^{NT}(e_i^\star, E^{NT}) - R_{ik}\right] \\ = W_i^{NT}(e_i^{-k}, E^{-k}) + \theta_i \sum_{\substack{j=1 \\ j\neq k}}^{M_i} U_{ij}^{NT}(e_i^{-k}, E^{-k}) \ , \end{aligned} \tag{A.7a}$$

$$\begin{aligned} W_i^{T}(\omega_i^\star, E^{T}) + \theta_i \sum_{\substack{j=1 \\ j\neq k}}^{M_i} U_{ij}^{T}(\omega_i^\star, E^{T}) + \theta_i \left[U_{ik}(\omega_i^\star, E^{T}) - R_{ik}\right] \\ = W_i^{T}(\omega_i^{-k}, E^{-k}) + \theta_i \sum_{\substack{j=1 \\ j\neq k}}^{M_i} U_{ij}^{T}(\omega_i^{-k}, E^{-k}) \ . \end{aligned} \tag{A.7b}$$

Solving for R_i^k and inserting into conditions (A.6), we obtain:

$$\begin{aligned} C_{ik}^{NT}(e_i^\star, E^{NT}) = \frac{1}{\theta_i}\left[W_i^{NT}(e_i^{-k}, E^{-k}) - W_i^{NT}(e_i^\star, E^{NT})\right] \\ + \sum_{\substack{j=1 \\ j\neq k}}^{M_i} \left(U_{ij}^{NT}(e_i^{-k}, E^{-k}) - U_{ij}^{NT}(e_i^\star, E^{NT})\right) \end{aligned} \tag{A.8a}$$

$$\begin{aligned} C_{ik}^{T}(\omega_i^\star, E^{T}) = \frac{1}{\theta_i}\left[W_i^{T}(\omega_i^{-k}, E^{-k}) - W_i^{T}(\omega_i^\star, E^{T})\right] \\ + \sum_{\substack{j=1 \\ j\neq k}}^{M_i} \left(U_{ij}^{T}(\omega_i^{-k}, E^{-k}) - U_{ij}^{T}(\omega_i^\star, E^{T})\right). \end{aligned} \tag{A.8b}$$

Inserting the lobbies' utilities functions (5) and (16) yields equations (27a) and (27b). □

Proof of Proposition 6

Condition 34 is a necessary condition for a pressured stance. We can re-write this condition to yield

$$G_i^R + \theta_i \sum_{j\in S_R} \Delta U_{ij}^{R,\bar{R}} > G_i^{\bar{R}} + \theta_i \sum_{j\in S_{\bar{R}}} \Delta U_{ij}^{\bar{R},R} \ , \tag{A.9a}$$

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

$$> W_i^{\bar{R}} + \theta_i \sum_{j=1}^{M_i} I_{ij} C_{ij}^{\bar{R}} + \theta_i \sum_{j \in S_{\bar{R}}} \left[U_{ij}^{\bar{R}} - C_{ij}^{\bar{R}} - U_{ij}^R + C_{ij}^R \right] \tag{A.9b}$$

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

$$> W_i^{\bar{R}} + \theta_i \sum_{j=1}^{M_i} I_{ij} C_{ij}^{\bar{R}} + \theta_i \sum_{j=1}^{M_i} I_{ij} \left[U_{ij}^{\bar{R}} - C_{ij}^{\bar{R}} \right] \tag{A.9c}$$

$$\Leftrightarrow \quad W_i^R + \theta_i \sum_{j=1}^{M_i} I_{ij} U_{ij}^R > W_i^{\bar{R}} + \theta_i \sum_{j=1}^{M_i} I_{ij} U_{ij}^{\bar{R}} \ . \tag{A.9d}$$

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, d_i and r_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 35, which also has to hold for the existence of a pressured stance, is not immune to change in the distribution of organized stakes. □

References

B.D. Bernheim and M.D. Whinston. Menu auctions, resource allocation, and economic influence. *The Quarterly Journal of Economics*, 101(1):1–31, February 1986.

B.D. Bernheim, B. Peleg, and M.D. Whinston. Coalition-proof nash equilibria i. concepts. *Journal of Economic Theory*, 42(1):1 – 12, 1987.

J.C. Carbone, C. Helm, and T.F. Rutherford. The case for international emission trade in the absence of cooperative climate policy. *Journal of Environmental Economics and Management*, 58(3):266–280, November 2009.

G.M. Grossman and E. Helpman. Protection for sale. *The American Economic Review*, 84(4): 833–850, 1994.

G.M. Grossman and E. Helpman. The politics of free-trade agreements. *The American Economic Review*, 85(4):667–690, 1995a.

G.M. Grossman and E. Helpman. Trade wars and trade talks. *Journal of Political Economy*, 103(4):675–708, August 1995b.

G.M. Grossman and E. Helpman. *Special Interest Politics*. The MIT Press, June 2002.

C. Helm. International emissions trading with endogenous allowance choices. *Journal of Public Economics*, 87(12):2737 – 2747, 2003.

Y.-B. Lai. The optimal distribution of pollution rights in the presence of political distortions. *Environmental & Resource Economics*, 36(3):367–388, March 2007.

Y.-B. Lai. Auctions or grandfathering: the political economy of tradable emission permits. *Public Choice*, 136(1):181–200, July 2008.

M. Olson. *The Logic of Collective Action: Public Goods and the Theory of Groups*. Harvard economic studies, v. 124. Harvard University Press, revised edition, January 1971.