Impact of international lobby groups on international environmental agreements

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Abstract

Economists have long argued over the political economy of tradable emission permits, especially the political pressure of lobby groups on international environmental agreements. However, little attention has been paid to the effects of cross-national lobbying on this market. Here, we examine how an international lobby group can affect national and international climate policies concerning international market for emission permits. It extends the common agency model of policy-making to multiple-agency relationships in the context of international environment agreements. The main questions are (1) to what extent are governments' rent-seeking incentives affected through international lobbying? (2) how do domestic and global emissions change in the presence of an international lobby group? We present a three-stage non-cooperative game in which international and national lobbies try to influence governments both when the governments decide on the formation of the international market and when each country chooses the number of permits. We find the condition under which the formation of an international lobby group can raise the contributions of national lobbies which support an international market and hence bring more benefits to the government. We also show that domestic and total emission levels not only depend on the aggregate levels of organized stakes in all countries but also on the distribution of stakes among individual lobby groups that form an international lobby group.

Keywords International environmental agreements · An international lobby group · Political economy · Emissions trading

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Abbreviations
GHG   Green house gas
IEA   International environmental agreements

1 Introduction

According to the Stern (2007) review on the economics of climate change, the global average temperature is estimated to increase over 2 °C by 2030 if greenhouse gas (GHG) emissions continue to rise at the present rate. Then, in the longer term, there will be a high chance of 5 °C increase in the average temperature. It will have dangerous effects on both the environment and human societies. This unavoidable global issue needs serious attention. A significant reduction of emissions of GHGs can be achieved only through international cooperation and participation of all countries. The historic Paris climate agreement is a serious step in international cooperation to reduce global emissions and restores hope for a global low-carbon economy.

The idea of designing an international environmental agreement and using environmental policies such as pollution permits for solving global warming is not new in the economics literature; however, the role of multilateral relationships between politicians and international lobby groups which are trying to take part in policy and decision-making process through communicating informally has not been seriously described in this context.

In general, achieving a sustainable international cooperation is extremely difficult for the following reasons; first, most of the sovereign countries act according to their self-interest since there is no supranational institution or third party at the global level to induce the countries to cooperate. Second, in the case of public goods (e.g. greenhouse gas emissions) each country's benefits are shared by all countries, while each one carries the costs individually. Therefore, free-riding seems to be more attractive than cooperation. Furthermore, sometimes property rights (i.e., emission rights for transboundary pollutants and resources) are not well defined in the detail which is usually referred to as 'environmental anarchy'. Hence, the international environmental agreements (IEAs) should clarify the property rights and establish institutions that have the authority to overcome environmental anarchy. Accordingly, IEAs to tackle climate change must consider the benefits of all parties to increase the motivation of the countries in such a way as to promote cooperation.

When we began to look more carefully at an IEA, the position of governments at the international negotiations tables became the central focus of the analysis. Since governments are mostly influenced by national and international political actors such as ministries, political pressure groups (lobbies) and the general electorate, the study of these relationships plays an important role in the success of a global warming treaty (i.e. the level of reduction of GHG emissions).

The most noteworthy study of the impact of national lobbies on IEAs is the paper by Habla and Winkler (2013). They introduce a model of the political economy

of permit markets and present a three-stage game including the government and national lobbies. In the first stage, the governments decide on the formation of the international market. In the second stage, each country chooses the number of permits and in the third stage, the permits are traded. They demonstrate that governments' decisions about participation in the IEA and the number of emission permits depend on economic and political parameters related to national lobby groups. Moreover, they show that lobbying may backfire. A political change by a lobby group in a given country has a direct effect on that country and an indirect effect on both countries. This indirect effect may contradict the direct effect and be strong enough to change the regime towards the lobby group's less preferred one.

This paper extends the work of Habla and Winkler (2013) and focuses on the role of an international lobby group in the determination of environmental policy and participation in IEA to form an international market for emission permits. Indeed, by introducing international lobbying in a multi-agency setting, we not only provide new and richer answers to previous issues, but also aim to address new questions, such as what the implications of lobbying at the international level for rent-seeking incentives of governments are and how governments' perception of the environmental damages changes in the presence of international lobbying. To our knowledge, this is the first paper that studies the role of international lobbies on the formation of international emission permit markets. We try to illustrate how international lobbies can help to solve the aforementioned international environmental agreement problems.

To address this issue, we assume that both national and international lobby groups try to sway the government in their favor. Here, an international lobby group is an alliance of several national lobbies in different countries. National lobby groups only care about domestic objectives; however, each nation is affected by the emissions of other countries, hence, impacted by the collective decisions of foreign governments. As a result, they have the incentive to form an international lobby group to join forces and convince other governments to take the desired action. The international lobby group may offer contributions to a government by means of national groups affiliated to it. Media and social networks are other tools available for international lobbies to affect political actors. An example of such international lobbies is the World Coal Association that organizes both companies and not-for-profit associations across the globe to shape the coal industry and influence the policy environment at the international level. In a study, Sapinski (2019) uncovers the presence of a network of policy groups working together to promote the climate capitalism agenda across the globe. The events organized by activists such as Greta Thunberg that influence policymakers in different countries can also be considered an act of international lobbying. Considering the results of Habla and Winkler (2013) as a benchmark, we show that the issuance of emission permits is a function not only of the aggregate levels of organized stakes in both countries but is also determined by the composition of the international lobby group. We also find that under the absence of the international market for emission permits, the presence of an international lobby group with a positive stake in environmental damages can decrease both domestic and global emission levels. However, under

an international market for emission permits, the formation of an international lobby group can reduce emissions only under a certain condition. This study also finds that the formation of international lobby group which opposes IEA increases the costs of national lobbies that support the international market in the country that it contributes. Hence, these national lobbies should contribute more to influence the government's decision and this, in turn, increases the government's revenue.

This work belongs to three main strands of literature. The first one is related to the game-theoretic literature on IEA which examines the motivational structure of countries signing an agreement. These studies are dedicated to the analysis of the conditions under which an international agreement is reached (Barrett 1994, 1999, 2002; Carraro and Siniscalco 1992, 1993; Tulkens 2006) or abatement targets on which countries would agree (Hoel 1992; Endres 1997; Eyckmans 1999). They also examine the number and types of countries needed for achieving an IEA (Carraro and Siniscalco 1993; Barrett 2002; Endres and Finus 2002; Finus and Rundshagen 1998; McGinty 2007; Hannesson 2010).

The second strand of literature relies on the political economy of environmental policy. Many studies of the political economy are dedicated to environmental policies and the formation of IEAs. They concentrate on political processes within a country (Congleton 2001; Böhringer and Vogt 2004) and investigate political economy approaches for IEA design and stability (see Haffoudhi 2005; Altamirano-Cabrera et al. 2007; Roelfsema 2007). Marchiori et al (2017) and Habla and Winkler (2013) pursued the common agency framework instituted by Bernheim and Whinston (1986) to build a model in which the process of policy formation is viewed as a game between a government and national lobby groups. Aidt and Hwang (2008) and Cole and Fredriksson (2009) used a multi-principal multi-agent lobby group model (developed by Prat and Rustichini 2003) to analyze foreign effects on environmental policies. Most of these studies suggest the strong influence lobbying activities have on different subjects such as the determination of environmental tax policies.

The third strand includes studies of international emission trading which is considered as a pivotal instrument to tackle environmental problems. Helm (2003) expands a consecutive game of international trading of emission permits and finds that international emission trading does not necessarily decrease the total emissions. Carbone et al. (2009), by applying Helm's (2003) framework, show that under certain conditions international permit markets can reduce emissions. Gersbach and Winkler (2011) suggest an emissions-trading scheme to increase the incentives for the reduction target in which a part of the permits are auctioned and the revenues are distributed to all participants.

The remainder of the paper is organized as follows. Section 2 presents the model environment and describes its key aspects. Section 3 examines firms' decisions in the third stage. Section 4 characterizes political equilibrium in the second stage and then derives governments' policy choices in domestic and international permit markets, respectively. Section 5 analyses conditions under which an international permit market is formed. Finally, concluding remarks are offered in Sect. 6.

2 The model

The model used in this paper, as mentioned above, is an extension of Habla and Winkler (2013) which aims to examine the effects of an international lobby group. Their model is based mainly on Grossman and Helpman (1994) for the model of endogenous policy determination and on Helm (2003) for the concept of non-cooperative international permit markets. Similar to Habla and Winkler (2013), a three-stage game is considered. In the first stage, the governments decide on the formation of the international market. In the second stage, each country chooses the number of permits and in the third stage, the permits are traded.

Consider two identical countries ($i = 1, 2$), with a single firm in each country. In each firm, production causes emission. The level of actual polluting emissions generated by firm i is denoted by e_i. Pollution is assumed to be uniformly mixing and hence the global emissions are equal to $E = e_1 + e_2$. The damage to country i caused from uniformly mixed pollution is denoted by $D_i(E)$ where $D_i(0) = 0$, $D_i' > 0$ $D_i'' \geq 0$ for all $E > 0$. Benefits derived from the emission of each firm are denoted by $B_i(e_i)$ where $B_i(0) = 0$, $B_i' > 0$, $B_i'' < 0$ for all $i = 1, 2$.

2.1 The structure of the economy

We suppose that the pollutant or firm in each country is regulated in a way that each needs an emission permit. The permits are traded in domestic emission permit markets. In these markets, the emission permits ω_i are chosen non-cooperatively by each country. The sum of emission permits in the two countries equals to the global emissions $E = \omega_1 + \omega_2$. Gross profits of each firm and permit revenues in country i respectively are

$$\pi_i^R(\omega_1, \omega_2) = B_i(e_i^R) - p^R e_i^R, \quad T_i^R(\omega_1, \omega_2) = p^R \omega_i, \tag{1}$$

where p^R is the competitive emission permits price. The index $R = \{I, D\}$ stands for then regime that prevails. The regime in which an international emission permit market is formed is indexed by I; otherwise, it is indexed by D. It should be noted that IEA forms only if both governments agree to join their domestic permit markets and form an international permit market. The permit revenues can be redistributed to the firms or the general public.

Social welfare in each country is defined as the sum of the gross profits of the representative firm, the environmental damage and the permit revenues:

$$\begin{aligned} W_i^R(\omega_1, \omega_2) &= \pi_i^R(\omega_1, \omega_2) - D_i(E) + T_i^R(\omega_1, \omega_2) \\ &= B_i(e_i^R) - D_i(E) + p^R[\omega_i - e_i^R]. \end{aligned} \tag{2}$$

2.2 The lobbying framework

Lobby groups offer contributions to influence government decisions. The government in each country seeks to maximize social welfare and its own political revenues given

the pressure from lobbies. Lobbying can be separated into two forms, direct and indirect. Direct lobbying activities are direct communications between interest group representatives and government officials to influence policy outcome; indirect lobbying is indirect communications through the media and constituents to heighten the politics and the pressure around the issue. Hence, we consider lobby pressure as contributions that reflect the lobby groups' willingness to pay to affect the government's decisions in their favor.

Assume that there are M_i national lobby groups in each country i. The gross utility of lobby group $j = 1, \ldots, M_i$ is defined by the size of their stake in the elements of the social welfare function:

$$U_{ij}^R(\omega_1, \omega_2) = \gamma_{ij}\pi_i^R(\omega_1, \omega_2) - \delta_{ij}D_i(E) + \rho_{ij}T_i^R(\omega_1, \omega_2), \tag{3}$$

where ρ_{ij}, γ_{ij} and δ_{ij} are, respectively, the lobby group's stakes in the revenues from permit issuance, in the domestic firm's profits and in damages caused by emissions. These coefficients are all in the unit interval and represent the degree of importance of each aspect of the social welfare for national lobby groups. The national aggregates of stakes from firms' profit, environmental damages and emission permit revenues in country i are defined by $b_i = \sum_{j=1}^{M_i} \gamma_{ij}$, $d_i = \sum_{j=1}^{M_i} \delta_{ij}$, $r_i = \sum_{j=1}^{M_i} \rho_{ij}$. This suggests that there are two primary lobby groups: one that concerns for environmental damages and tries to exert pressure through the permit market to maintain and enhance environmental quality called green lobbies; the other lobby group seeks to increase firms' profit by contributing to the relaxation of environmental regulations, which we designate a firm lobby group.

Here, we assume that green lobbies or firm lobbies in the two countries, respectively, may arrange an international lobby group through which they can offer contributions to each of the two governments. In fact, lobby groups in different countries can join forces through international organizations. The international lobby here thus is the outcome of merger between national lobby group M_i in country 1 and country 2 with assumption that both are included a particular type of lobbying (green or firms lobbies). Then the utility of the international lobby is simply the sum of the utilities of the national lobbies:

$$U_I^R(\omega_1, \omega_2) = \sum_{i=1}^{2} \gamma_{iM_i}\pi_i^R(\omega_1, \omega_2) - \sum_{i=1}^{2} \delta_{iM_i}D_i(E) + \sum_{i=1}^{2} \rho_{iM_i}T_i^R(\omega_1, \omega_2). \tag{4}$$

National and international lobby groups have preferences over the regime and the number of permits and try to influence governments by contributing, conditional on the regime and the number of permits they choose. The objective functions of the national and international lobby groups, respectively, are

$$U_{ij}^R(\omega_1, \omega_2) - \left[C_{ij}^{1.R} + C_{ij}^{2.R}(\omega_1, \omega_2) \right], \tag{5a}$$

$$U_I^R(\omega_1, \omega_2) - \left[C_{I1}^{1.R} + C_{I2}^{1.R} + C_{I1}^{2.R}(\omega_1, \omega_2) + C_{I2}^{2.R}(\omega_1, \omega_2) \right], \tag{5b}$$

where $C_{ij}^{1.R}$ and $C_{ij}^{2.R}(\omega_1, \omega_2)$, respectively, are contributions of national lobby group j in country i in the first and the second stages, and $C_{Ii}^{1.R}$ and $C_{Ii}^{2.R}(\omega_1, \omega_2)$ are contributions of international lobby group offered to government i in the first and second stages, respectively.

Similar to Grossman and Helpman (1994), a government cares about the national social welfare and lobbying contributions. The incumbent government evaluates contributions because it can use them to finance campaign spending or private consumption. It may be concerned about social welfare for ethical reasons or for increasing its reelection chance in subsequent elections since voters reelect a government that has brought a high standard of living. Hence, the government's objective function is determined as follows:

$$
\begin{aligned}
G_i^R(\omega_1, \omega_2) = & \theta_i W_i^R(\omega_1, \omega_2) \\
& + \sum_{j=1}^{M_i-1} \left[C_{ij}^{1.R} + C_{ij}^{2.R}(\omega_1, \omega_2) \right] + \left[C_{Ii}^{1.R} + C_{Ii}^{2.R}(\omega_1, \omega_2) \right],
\end{aligned}
\tag{6}
$$

where θ_i is the measure of the government's benevolence or the relative weight that each government gives to national social welfare compared to lobbying contributions.

Our results depend on the following assumption which is explained below:

Assumption 1 For the second-order conditions to be satisfied, the following conditions are assumed to hold:

1. For both countries, the benefit functions are almost quadratic: $B_i''' \approx 0$.
2. The aggregate organized stakes of national and international lobbies in the permit revenues must be large compared to the aggregate organized stakes of national lobbies in the firm's profits: $r_i > \frac{1}{2}(b_i - \theta_i - \gamma_{-iM_{-i}})$, $i = 1, 2$.

2.3 The game

We use the sequential Stackelberg game through which lobby groups select their contribution first and the government's strategy will be a function that maps lobby groups' choice into a contribution level for the government. A three-stage game is considered. The first and the second stages, in turn, consist of three sub-stages to model lobbying.

At stage 1, in the first sub-stage, national and international lobbies simultaneously propose their contributions to governments conditional on the regime they choose. In the second sub-stage, governments choose a regime, whether to form an international permit market. In the third sub-stage, lobbies pay contributions depending on the regime choice.

At stage 2, in the first sub-stage, national and international lobbies simultaneously propose their contributions to the governments' conditional on the number of permits they choose. In the second sub-stage, governments choose the number of

permits. In the third sub-stage, lobbies pay contributions depending on the number of permits chosen by the governments.

At stage 3, permits are traded on national or international permit markets, depending on the regime that emerged in the first stage.

3 The third stage

We look for a subgame perfect Nash equilibrium of this game and solve it backward. First, we are looking at the firm's decision, then the government's decisions for a number of emission permits and then their participation in the IEA. In the second and the third stages, we take the first-stage decision as given.

Let p_i denote the equilibrium price for permits in country i. Each firm in each country chooses emission levels to maximize profit. In case that permit markets are kept domestic, market clearing and the equilibrium conditions of profit maximization, respectively, are

$$
\begin{aligned}
\omega_i &= e_i, \\
p_i(\omega_i) &= B'_i(e_i).
\end{aligned}
\tag{7}
$$

When an international permit market is formed and countries have agreed to an international permit market, both countries trade permits at a price p on a perfectly competitive international permit market. Given p, each firm chooses emission to maximize its profit. Accordingly, the equilibrium conditions of profit maximization and market clearing are

$$
p(E) = B'_1(e_1(E)) = B'_2(e_2(E)),
\tag{8}
$$

$$
\omega_1 + \omega_2 = B'^{-1}_1(p(E)) + B'^{-1}_2(p(E)) = e_1(E) + e_2(E) = E.
\tag{9}
$$

Then from Eq. (8) and $e_i(E) = B'^{-1}_i(p(E))$, we obtain

$$
p'(E) < 0, \quad e'_i(E) \in [0, 1].
\tag{10}
$$

4 Political equilibrium in the second stage

In the second stage, when all lobby groups correctly predict the governments' best responses, the contribution schedule of each lobby group is the best response to the set of schedules of other groups. In our game, the contribution offered by an international lobby group to a particular government may rely indirectly on the policy actions taken by the other government. This makes the equilibrium characterization complex.

Following Aidt and Hwang (2008), in the presence of national lobbies which try to affect their own governments separately and an international lobby group which offers contributions to each of the two governments, the characterization of a pure strategy

equilibrium is adopted from Bernheim and Whinston (1986), Grossman and Helpman (1995) and Prat and Rustichini (2003). A set of feasible contribution functions $\left\{ \hat{C}_{Ii}^{2.R}, \hat{C}_{ij}^{2.R} \right\}_{j=1,\dots,M_i-1}$ for $i = 1,2$ and pollution permit $\{\hat{\omega}_i\}_{i=1,2}$ constitute an equilibrium response to the pollution permit ω_{-i} by the other country, if the following three conditions are all satisfied:

(C1) For each government $i = 1,2$ and for all ω_i,

$$
\theta_i W_i^R \left(\hat{\omega}_i, \hat{\omega}_{-i} \right) + \sum_{j=1}^{M_i-1} \left[C_{ij}^{1.R} + \hat{C}_{ij}^{2.R} \left(\hat{\omega}_i, \hat{\omega}_{-i} \right) \right] + \left[C_{Ii}^{1.R} + \hat{C}_{Ii}^{2.R} \left(\hat{\omega}_i, \hat{\omega}_{-i} \right) \right]
$$

$$
\geq \theta_i W_i^R \left(\omega_i, \hat{\omega}_{-i} \right) + \sum_{j=1}^{M_i-1} \left[C_{ij}^{1.R} + \hat{C}_{ij}^{2.R} \left(\omega_i, \hat{\omega}_{-i} \right) \right] + \left[C_{Ii}^{1.R} + \hat{C}_{Ii}^{2.R} \left(\omega_i, \hat{\omega}_{-i} \right) \right].
$$

(11)

(C2) For the international and every national lobby group k in each country i, there cannot be a feasible contribution $C_{Ii}^{2.R} \left(\omega_i, \omega_{-i} \right)$ and $C_{ik}^{2.R} \left(\omega_i, \omega_{-ui} \right)$ and a set of emission permits (ω_i^I, ω_i^k) such that

$$
\omega_i^I = \arg \max_{\omega_i} \theta_i W_i^R \left(\omega_i, \omega_{-i} \right) + \sum_{j=1}^{M_i-1} \left[C_{ij}^{1.R} + \hat{C}_{ij}^{2.R} \left(\omega_i, \omega_{-i} \right) \right] + \left[C_{Ii}^{1.R} + \hat{C}_{Ii}^{2.R} \left(\omega_i, \omega_{-i} \right) \right],
$$

(12a)

$$
U_I^R \left(\omega_i^I, \omega_{-i} \right) - \sum_{i=1}^{2} C_{Ii}^{1.R} - \sum_{i=1}^{2} C_{Ii}^{2.R} \left(\omega_i^I, \omega_{-i} \right)
$$

$$
> U_I^R \left(\hat{\omega}_i, \omega_{-i} \right) - \sum_{i=1}^{2} C_{Ii}^{1.R} - \sum_{i=1}^{2} \hat{C}_{Ii}^{2.R} \left(\hat{\omega}_i, \omega_{-i} \right),
$$

(12b)

and

$$
\omega_i^k = \arg \max_{\omega_i} \theta_i W_i^R \left(\omega_i, \omega_{-i} \right)
$$

$$
+ \sum_{j=1}^{M_i-1} \left[C_{ij}^{1.R} + C_{ij}^{2.R} \left(\omega_i, \omega_{-i} \right) \right] + \left[C_{Ii}^{1.R} + \hat{C}_{Ii}^{2.R} \left(\omega_i, \omega_{-i} \right) \right],
$$

(13a)

$$
U_{ik}^R \left(\omega_i^k, \omega_{-i} \right) - C_{ik}^{1.R} - C_{ik}^{2.R} \left(\omega_i^k, \omega_{-i} \right) > U_{ik}^R \left(\hat{\omega}_i, \omega_{-i} \right) - C_{ik}^{1.R} - \hat{C}_{ik}^{2.R} \left(\hat{\omega}_i, \omega_{-i} \right),
$$

(13b)

where U_{ik}^R and $C_{ik}^{2.R}$ indicate utility and contribution of national lobby group k contingent on the policy choice of the local government i.

(C3) For the international lobby group, for all feasible ω_i,

$$\theta_i W_i^R(\hat{\omega}_i, \omega_{-i}) + \sum_{j=1}^{M_i-1} \left[C_{ij}^{1.R} + \hat{C}_{ij}^{2.R}(\hat{\omega}_i, \omega_{-i}) \right] + \left[C_{Ii}^{1.R} + \hat{C}_{Ii}^{2.R}(\hat{\omega}_i, \omega_{-i}) \right]$$

$$= \max_{\omega_i} \theta_i W_i^R(\omega_i, \omega_{-i}) + \sum_{j=1}^{M_i-1} \left[C_{ij}^{1.R} + \hat{C}_{ij}^{2.R}(\omega_i, \omega_{-i}) \right]. \tag{14}$$

All above inequalities must hold for all $\hat{\omega}_i$, $i = 1,2$. The first condition or agent maximization suggests that each government chooses the amounts of emission permits that maximize its payoff, given the contribution offered by lobby groups. The second condition is incentive compatibility which ensures that there is no other contribution schedule that both national and international lobby groups can use to gain better payoff than its equilibrium schedule. Thus, in the equilibrium, not only must the joint welfare of an international lobby group and the collective of two governments be maximized by the amounts of permits, but also must the joint welfare of national lobby groups and its government be maximized. Hence, from conditions (12) and (13) it is possible to obtain the following functions:

$$\hat{\omega}_i = \arg\max_{\omega_i} \theta_i W_i^R(\omega_i, \omega_{-i}) + \theta_{-i} W_{-i}^R(\omega_{-i}, \omega_i) + \sum_{j=1}^{M_i-1} \left[C_{ij}^{1.R} + \hat{C}_{ij}^{2.R}(\omega_i, \omega_{-i}) \right]$$

$$+ \sum_{j=1}^{M_{-i}-1} \left[C_{-ij}^{1.R} + \hat{C}_{-ij}^{2.R}(\omega_{-i}, \omega_i) \right] + U_I^R(\omega_i, \omega_{-i}), \tag{15a}$$

$$\hat{\omega}_i = \arg\max_{\omega_i} \theta_i W_i^R(\omega_i, \omega_{-i}) + \sum_{j=1}^{M_i-1} \left[C_{ij}^{1.R} + \hat{C}_{ij}^{2.R}(\omega_i, \omega_{-i}) \right]$$

$$+ \left[C_{Ii}^{1.R} + \hat{C}_{Ii}^{2.R}(\omega_i, \omega_{-i}) \right] + U_{ik}^R(\omega_i, \omega_{-i}) - C_{ik}^{1.R} - \hat{C}_{ik}^{2.R}(\omega_i, \omega_{-i}). \tag{15b}$$

The first-order conditions are given by

$$\theta_i \frac{\partial W_i^R}{\partial \hat{\omega}_i} + \theta_{-i} \frac{\partial W_{-i}^R}{\partial \hat{\omega}_i} + \frac{\partial \sum_{j=1}^{M_i-1} \hat{C}_{ij}^{2.R}}{\partial \hat{\omega}_i} + \frac{\partial \sum_{j=1}^{M_{-i}-1} \hat{C}_{-ij}^{2.R}}{\partial \hat{\omega}_i} + \frac{\partial U_I^R}{\partial \hat{\omega}_i} = 0, \tag{16a}$$

$$\theta_i \frac{\partial W_i^R}{\partial \hat{\omega}_i} + \frac{\partial \sum_{j=1}^{M_i-1} \hat{C}_{ij}^{2.R}}{\partial \hat{\omega}_i} + \frac{\partial \hat{C}_{Ii}^{2.R}}{\partial \hat{\omega}_i} + \frac{\partial U_{ik}^R}{\partial \hat{\omega}_i} - \frac{\partial \hat{C}_{ik}^{2.R}}{\partial \hat{\omega}_i} = 0. \tag{16b}$$

From the third condition or cost minimization condition, it is seen that an international lobby group minimizes its cost when it tries to influence a government in its favor. Since in equilibrium an international lobby group can deviate by reducing its contribution to the one government, the best response of an international lobby group to the given contribution of national lobby groups must satisfy

$$
\begin{aligned}
C_{Ii}^{1.R} &+ \hat{C}_{Ii}^{2.R}\left(\hat{\omega}_i, \omega_{-i}\right) \\
&= \left\{ \max_{\omega_i} \theta_i W_i^R\left(\omega_i, \omega_{-i}\right) + \sum_{j=1}^{M_i-1}\left[C_{ij}^{1.R} + \hat{C}_{ij}^{2.R}\left(\omega_i, \omega_{-i}\right)\right] \right\} \\
&\quad - \left\{ \theta_i W_i^R\left(\hat{\omega}_i, \omega_{-i}\right) + \sum_{j=1}^{M_i-1}\left[C_{ij}^{1.R} + \hat{C}_{ij}^{2.R}\left(\hat{\omega}_i, \omega_{-i}\right)\right] \right\}.
\end{aligned}
\tag{17}
$$

The first term on the right-hand side of the above equation is independent of $\hat{\omega}_i$; hence, the following condition should be satisfied:

$$
\frac{\partial \hat{C}_{Ii}^{2.R}}{\partial \hat{\omega}_i} = -\theta_i \frac{\partial W_i^R}{\partial \hat{\omega}_i} - \frac{\partial \sum_{j=1}^{M_i-1} \hat{C}_{ij}^{2.R}}{\partial \hat{\omega}_i},
\tag{18a}
$$

$$
\frac{\partial \hat{C}_{I-i}^{2.R}}{\partial \hat{\omega}_i} = -\theta_i \frac{\partial W_{-i}^R}{\partial \hat{\omega}_i} - \frac{\partial \sum_{j=1}^{M_i-1} \hat{C}_{-ij}^{2.R}}{\partial \hat{\omega}_i},
\tag{18b}
$$

by substituting Eq. (18) into Eq. (16), we get

$$
\frac{\partial U_I^R}{\partial \hat{\omega}_i} = \frac{\partial \hat{C}_{Ii}^{2.R}}{\partial \hat{\omega}_i} + \frac{\partial \hat{C}_{I-i}^{2.R}}{\partial \hat{\omega}_i},
\tag{19a}
$$

$$
\frac{\partial U_{ik}^R}{\partial \hat{\omega}_i} = \frac{\partial \hat{C}_{ik}^{2.R}}{\partial \hat{\omega}_i},
\tag{19b}
$$

which imply that the international lobby group and each national lobby group arrange their contributions such that the marginal utility resulting from a policy change are reflected by their marginal contribution (truthful contribution).

4.1 The political equilibrium in domestic permit markets

In the case of the failure to adopt an international permit market in the first stage, each government chooses ω_i to maximize its objective function by taking the permit choice of the other country as given

$$
\begin{aligned}
G_i^D\left(\omega_1, \omega_2\right) &= \theta_i W_i^D\left(\omega_1, \omega_2\right) + \sum_{j=1}^{M_i-1}\left[C_{ij}^{1.D} + C_{ij}^{2.D}\left(\omega_1, \omega_2\right)\right] \\
&\quad + \left[C_{Ii}^{1.D} + C_{Ii}^{2.D}\left(\omega_1, \omega_2\right)\right], \quad i = 1, 2,
\end{aligned}
\tag{20}
$$

subject to Eq. (7) and Eq. (19). Using condition (19), national and international lobby groups' contributions are obtained by Eq. (3) and Eq. (4), respectively, then by setting $p_i(\omega_i) = B_i'(e_i)$, from Eq. (7), we have

$$
\begin{aligned}
G_i^D(\omega_1, \omega_2) = {} & \theta_i B_i(e_i) - \theta_i D_i(E) + b_i B_i(e_i) \\
& - b_i B_i'(e_i) e_i - d_i D_i(E) + r_i B_i'(e_i) \omega_i \\
& + \gamma_{-iM_{-i}} B_{-i}(e_{-i}) - \gamma_{-iM_{-i}} B_{-i}'(e_{-i}) e_{-i} \\
& - \delta_{-iM_{-i}} D_{-i}(E) + \rho_{-iM_{-i}} B_{-i}'(e_{-i}) \omega_{-i}, i = 1, 2.
\end{aligned}
\tag{21}
$$

The first-order condition for country i becomes

$$
B_i'(\hat{e}_i) = \frac{(\theta_i + d_i)}{(\theta_i + r_i)} D_i'(\hat{E}) + \frac{(b_i - r_i)}{(\theta_i + r_i)} B_i''(\hat{e}_i) \omega_i + \frac{\delta_{-iM_{-i}}}{(\theta_i + r_i)} D_{-i}'(\hat{E}), i = 1, 2.
\tag{22}
$$

which is an implicit function that yields the optimal emission level, $\hat{e}_i$. Equation (22) implicitly defines the best response function for country i and shows how an international lobby group through its stake in environmental damages affects the strategic interaction between the countries.

The following proposition characterizes each country's policy choice:

Proposition 1 *There exists a unique Nash equilibrium of the non-cooperative emission game under domestic permit markets.*

Proof See the Appendix.

Compared to the situation that there is no international lobby group (Habla and Winkler's (2013) work), the third term is added on the right side of Eq. (22). It shows that domestic emission permits not only depend on the national levels of organized stakes in the three components of social welfare, but also on the stakes of the international lobby group in the other country's environmental damages. Then the emission level decrease as long as environmental damages matter for the international lobby group. This allows us to derive the proposition that follows.

Proposition 2 *The formation of an international lobby group decreases both domestic and global emission levels under domestic permit markets if this group has any stake in environmental damages.*

Proof See the Appendix.

The intuition behind this proposition is as follows. Lobby groups, in general, have an important role in conveying public preferences to governments. Hence, national lobbying can only modify the governments' perception about the three different components of social welfare, while the presence of the international lobby group under domestic markets can influence the governments' perception about the environmental damages in both countries. Thus, this can increase the influence of a special lobby group (green lobbies) to alter policy in their interests. An implication of this is that even when national environmental lobbies do not offer any contributions to the local government, domestic emissions can decrease

with strong international green lobbies or in general environmental awareness of the countries.

As a consequence of Proposition 1, we have the following corollary:

Corollary 1 *(Comparative statics of domestic permit market) For $r_i = b_i$ and $r_i = d_i$,*

$$\frac{d\hat{e}_i}{db_i} > 0, \quad \frac{d\hat{e}_{-i}}{db_i} < 0, \quad \frac{d\hat{E}}{db_i} > 0, \tag{23a}$$

$$\frac{d\hat{e}_i}{dd_i} < 0, \quad \frac{d\hat{e}_{-i}}{dd_i} > 0, \quad \frac{d\hat{E}}{dd_i} < 0, \tag{23b}$$

$$\frac{d\hat{e}_i}{d\theta_i} > 0 \quad \text{if } b_i < d_i, \quad \frac{d\hat{e}_{-i}}{d\theta_i} < 0 \quad \text{if } b_i < d_i, \quad \frac{d\hat{E}}{d\theta_i} > 0 \quad \text{if } b_i < d_i. \tag{23c}$$

Proof See the Appendix.

As a special case, two redistribution schemes are considered: $r_i = b_i$ and $r_i = d_i$. In the first scheme, permit revenues are redistributed to each firm and in the second scheme, the general public gains permit revenues through a lump-sum transfer. Corollary 1 illustrates that decreasing the organized stakes in firm's benefits or increasing the organized stakes in environmental damages in one country reduces the emission levels in the other country. The comparative statics also demonstrate that if the share of organized stakes for firms' profits is less than the share of organized stakes for environmental damages (i.e. $b_i < d_i$), an increase in θ_i or the relative weight that each government assigns to national social welfare enhances domestic emissions and the aggregate emissions.

To understand the strategic interdependence between the two governments in choosing their policies, we yield

$$FOC_{\omega_i}^{-i} = -(\theta_i + d_i)D_i''(\hat{E}) - \delta_{-iM_{-i}}D_{-i}''(\hat{E}) < 0, \tag{24}$$

which implies that the policy choices of the two countries are strategic substitutes in such circumstances. This means that the government in one country responds to increasing amounts of permits in the other country by reducing its own permits. However, the direct effect is greater than this indirect effect and total emissions pursue national emissions. As represented by the last term in Eq. (24), the strategic substitution effect becomes stronger in the presence of an international lobby group.

4.2 The political equilibrium in the international permit market

If an international permit market is established in the first stage, each government takes the permit choice of the other country as given and chooses ω_i to maximize its objective function

$$
\begin{aligned}
G_i^I(\omega_1, \omega_2) = {} & \theta_i W_i^I(\omega_1, \omega_2) + \sum_{j=1}^{M_i-1} \left[C_{ij}^{1,I} + C_{ij}^{2,I}(\omega_1, \omega_2) \right] \\
& + \left[C_{Ii}^{1,I} + C_{Ii}^{2,I}(\omega_1, \omega_2) \right], \quad i = 1, 2,
\end{aligned} \tag{25}
$$

subject to Eq. (8) and Eq. (19). Under these conditions similar to the above, the objective function becomes

$$
\begin{aligned}
G_i^I(\omega_1, \omega_2) = {} & \theta_i B_i(e_i) - \theta_i D_i(E) + \theta_i p(E)(\omega_i - e_i) \\
& + b_i B_i(e_i) - b_i p(E) e_i - d_i D_i(E) + r_i p(E)\omega_i \\
& + \gamma_{-iM_{-i}} B_{-i}(e_{-i}) - \gamma_{-iM_{-i}} p(E) e_{-i} - \delta_{-iM_{-i}} D_{-i}(E) \\
& + \rho_{-iM_{-i}} p(E)\omega_{-i}, i = 1, 2.
\end{aligned} \tag{26}
$$

The first-order condition for country i is

$$
\begin{aligned}
p(\hat{E}) + p'(E)(\omega_i - e_i(\hat{E})) = {} & \frac{1}{(\theta_i + r_i)} [(\theta_i + d_i) D_i'(\hat{E}) \\
& + (b_i - r_i) p'(\hat{E}) e_i(\hat{E}) + \delta_{-iM_{-i}} D_{-i}'(\hat{E}) \\
& + (\gamma_{-iM_{-i}} e_{-i}(\hat{E}) - \rho_{-iM_{-i}} \omega_{-i}) p'(\hat{E})].
\end{aligned} \tag{27}
$$

where the superscript" ^ " indicates the equilibrium value. Equation (27) implicitly defines the best-response function for each country and shows how the formation of an international lobby group affects the strategic interaction between the countries. These resulting reaction functions simultaneously determine equilibrium policy choices. We can, therefore, state the following proposition:

Proposition 3 *There exists a unique Nash equilibrium under international permit markets.*

Proof See the Appendix.

Equation (27) shows that both domestic emission levels and total emissions not only depend on the aggregate levels of organized stakes in the three components of social welfare in a country, but also on the composition of the international lobby group. In other words, the distribution of stakes among individual lobby groups that form an international lobby group is here the central focus of the analysis.

Proposition 4 *The formation of an international lobby group under international permit markets reduces emissions if the following condition holds:*

$$
\delta_{-iM_{-i}} D_{-i}'(\hat{E}) - \rho_{-iM_{-i}} \omega_{-i} p'(\hat{E}) > \gamma_{-iM_{-i}} e_{-i} p'(\hat{E}). \tag{28}
$$

Proof See the Appendix.

The above proposition indicates that if the international lobby group's stakes in the profits of the firms are small relative to its stakes in the environmental damages and the permit revenues in each country, the formation of an international lobby group reduces domestic emission levels and total emissions. Hence, not only environmental awareness of citizens but also preferences towards government redistribution in another country can change the government's damage perception and global emissions.

Put differently, the presence of the international lobby group under an international market extends the governments' perception about all three components of social welfare in the other country. Hence, compared to domestic permit markets, the incentives of firm lobbies to affect the emission policy would be higher if an international permit market is formed.

To determine whether the policy choices of the two countries are strategic complements or substitutes, we yield

$$
\begin{aligned}
\text{FOC}_{\omega_i}^{-i} = & \left(\theta_{-i} + r_{-i} - \left(\theta_{-i} + b_{-i}\right)e'_{-i}(E) - \gamma_{iM_i}e'_i(E) + \rho_{iM_i}\right)p'(E) \\
& - d_{-i}D''_{-i}(E) - \delta_{iM_i}D''_i(E), i = 1, 2.
\end{aligned}
\tag{29}
$$

If $\text{FOC}_{\omega_i}^{-i} < 0$, national emission levels are strategic substitutes implying that if country i enhances emissions in reaction to a change in the political parameters, country $-i$ reduces emissions. If $\text{FOC}_{\omega_i}^{-i} > 0$, national emission levels are strategic complements, so that the government in one country responds to increasing amounts of permits in the other country by raising its own permits.

4.3 Global emission under domestic and international permit market

Overall emissions in a regime with international permit market may exceed those in a regime with domestic permit market. We use the abbreviations $\frac{(b_i - r_i)}{(\theta_i + r_i)} = k_i$, $\frac{(\theta_i + d_i)}{(\theta_i + r_i)} = \sigma_i$, $\frac{\delta_{-iM_{-i}}}{(\theta_i + r_i)} = v_i$ and $\frac{\gamma_{-iM_{-i}}e_{-i} - \rho_{-iM_{-i}}\omega_{-i}}{(\theta_i + r_i)} = z_i$, and sum the best respond functions (22) and (27) for two countries to obtain

$$
\begin{aligned}
& B'_i\left(e_i^D\right) + B'_{-i}\left(e_{-i}^D\right) - k_i p'_i\left(e_i\right) - k_{-i}p'_{-i}\left(e_{-i}\right) \\
& = \left(v_i + \sigma_i\right)D'_i\left(E^D\right) + \left(v_{-i} + \sigma_{-i}\right)D'_{-i}\left(E^D\right),
\end{aligned}
\tag{30a}
$$

$$
\begin{aligned}
& B'_i\left(e_i^I(E^I)\right) + B'_{-i}\left(e_{-i}^I(E^I)\right) - k_i e_i(E^I)p'\left(E^I\right) - k_{-i}e_{-i}(E^I)p'\left(E^I\right) \\
& -z_i e_{-i}(E^I)p'\left(E^I\right) - z_{-i}e_i(E^I)p'\left(E^I\right) = \left(v_i + \sigma_i\right)D'_i\left(E^I\right) + \left(v_{-i} + \sigma_{-i}\right)D'_{-i}\left(E^I\right).
\end{aligned}
\tag{30b}
$$

Then, the following result for comparing global emission under domestic and international permit markets holds:

$$
\begin{aligned}
E^D \lesseqgtr E^I \Leftrightarrow & B'_i\left(e_i^D\right) + B'_{-i}\left(e_{-i}^D\right) - k_i p'_i\left(e_i\right) - k_{-i}p'_{-i}\left(e_{-i}\right) \lesseqgtr B'_i\left(e_i^I(E^I)\right) + B'_{-i}\left(e_{-i}^I(E^I)\right) \\
& -k_i e_i(E^I)p'\left(E^I\right) - k_{-i}e_{-i}(E^I)p'\left(E^I\right) - z_i e_{-i}(E^I)p'\left(E^I\right) - z_{-i}e_i(E^I)p'\left(E^I\right).
\end{aligned}
\tag{31}
$$

5 The first stage

As mentioned earlier, international and national lobbies also try to influence governments on the stage of the IEA formation which is itself divided into three sub-stages: first, national and international lobby groups offer their contribution schedules to the governments, then each government decides whether to form an international permit market and finally lobby groups pay contributions.

As defined by Grossman and Helpman (1995), a unilateral stance is the policy position adopted by a government to determine the fate of an agreement. Then, the consequence of an agreement would be contingent on the unilateral stance of both countries. There are two kinds of unilateral stances; unpressured stance and pressured stance. In an unpressured stance, there is no lobbying contribution that can influence a government's choice, while in a pressured stance a government's decision is influenced by lobby groups' contribution. Following Bernheim and Whinston (1986) and Grossman and Helpman (1995), the pressured stance prevails when both unpressured and pressured stances exist and support different regimes.

Each government selects the regime that maximizes its objective function by taking into account the lobbies' contribution schemes. The maximum amount each lobby group is willing to pay to the government for setting up regime R in the first stage is the amount that it gains in the second stage from changing regime $\overline{R}$ (the alternative regime) to R which is called the net of lobbying contribution in the second stage:

$$\Delta U_{ij}^{R,\overline{R}} = U_{ij}^{R}\left(\omega_1^R, \omega_2^R\right) - C_{ij}^{2,R}\left(\omega_1^R, \omega_2^R\right) - U_{ij}^{\overline{R}}\left(\omega_1^{\overline{R}}, \omega_2^{\overline{R}}\right) + C_{ij}^{2,\overline{R}}\left(\omega_1^{\overline{R}}, \omega_2^{\overline{R}}\right), \quad (32a)$$

$$\Delta U_{I}^{R,\overline{R}} = U_{I}^{R}\left(\omega_1^R, \omega_2^R\right) - C_{I1}^{2,R}\left(\omega_1^R, \omega_2^R\right) - C_{I2}^{2,R}\left(\omega_1^R, \omega_2^R\right) - U_{I}^{\overline{R}}\left(\omega_1^{\overline{R}}, \omega_2^{\overline{R}}\right)$$
$$+ C_{I1}^{2,\overline{R}}\left(\omega_1^{\overline{R}}, \omega_2^{\overline{R}}\right) + C_{I2}^{2,\overline{R}}\left(\omega_1^{\overline{R}}, \omega_2^{\overline{R}}\right). \quad (32b)$$

The national lobby group j and the international lobby group support regime R if and only if the value of $\Delta U_{ij}^{R,R}$ and $\Delta U_{I}^{R,R}$ are positive. Then

$$C_{ij}^{1,R} \in \left[0, \Delta U_{ij}^{R,\overline{R}}\right], C_{ij}^{1,\overline{R}} = 0, \quad (33a)$$

$$C_{Ii}^{1,R} \in \left[0, \Delta U_{I}^{R,\overline{R}}\right], C_{Ii}^{1,\overline{R}} = 0. \quad (33b)$$

5.1 International permit markets

In this section, we characterize only conditions under which an international permit market is formed. As aforementioned, an international permit market is established only if signing the agreement $(R = I)$ is the unilateral stance in both

countries. Depending on the type of unilateral stances in each country, the following cases are considered for the formation of an international agreement:

Case 1: unpressured unilateral stance in both countries

In this case, the two countries have an unpressured unilateral stance in favor of regime I. It means that without lobbying contributions the international permit market is the favorable regime for both governments, i.e. $G_{i0}^I > G_{i0}^D$, because not contributing is the best response for all lobby groups. G_{i0}^R indicates government i's payoff at the first stage in the absence of any lobbying contribution under regime R.

In other words, an unpressured stance in favor of regime I could exist only if the following inequalities hold for each national lobby group and the international lobby group in the both countries.

$$G_{i0}^I - G_{i0}^D > \Delta U_{ij}^{D,I}, \tag{34a}$$

$$G_{i0}^I - G_{i0}^D > \Delta U_I^{D,I}, \tag{34b}$$

This means that no lobby group alone is able to change the regime by its own contribution.

Case 2: unpressured unilateral stance in one country and pressured unilateral stance in the other

In this case, the government in one country (country 1) has an unpressured unilateral stance in support of regime I and then no lobby group is able to affect the government's decision:

$$G_{10}^I - G_{10}^D > \Delta U_{1j}^{D,I}, \tag{35a}$$

$$G_{10}^I - G_{10}^D > \Delta U_I^{D,I}, \tag{35b}$$

while the government in the other country (country 2) has a pressured unilateral stance in support of regime I. Due to positive contributions for at least one lobby group, the government should be indifferent concerning the choice of the regime since otherwise lobby groups in the winning side (advocates of regime I) could lessen their contributions without affecting the government's decisions. Also, lobby groups in the losing side (opponents of regime I) bid the full amount of what they gain under their preferred regime, otherwise advocates of regime D could influence the government to adopt their preferred regime by increasing their contribution. So if the international lobby group supports regime I, the following must hold:

$$G_{20}^I + \sum_{j \in S_2^I} C_{2j}^{1,I} + C_{I2}^{1,I} = G_{20}^D + \sum_{j \in S_2^D} C_{2j}^{1,D}, \tag{36a}$$

where S_i^R is the set of national lobbies in country i which support regime $R = \{I, D\}$. If the international lobby group supports regime D, we have

$$G_{20}^I + \sum_{j \in S_2^I} C_{2j}^{1,I} = G_{20}^D + \sum_{j \in S_2^D} C_{2j}^{1,D} + C_{I2}^{1,D}. \tag{36b}$$

In a pressured stance, the necessary condition is that the potential payoff of the government under regime I be higher than under the alternative regime. Then, if the international lobby group supports regime I, the following inequality must hold:

$$G_{20}^I + \sum_{j \in S_2^I} \Delta U_{2j}^{I,D} + \Delta U_I^{I,D} > G_{20}^D + \sum_{j \in S_2^D} \Delta U_{2j}^{D,I} \tag{37a}$$

and if the international lobby group support regime D, the following inequality must hold:

$$G_{20}^I + \sum_{j \in S_2^I} \Delta U_{2j}^{I,D} > G_{20}^D + \sum_{j \in S_2^D} \Delta U_{2j}^{D,I} + \Delta U_I^{D,I}. \tag{37b}$$

Moreover, a sufficient condition is required for a pressured stance in favor of regime I as it follows when the international lobby group supports regime I

$$G_{20}^I < G_{20}^D + \sum_{j \in S_2^D} \Delta U_{2j}^{D,I}, \tag{38a}$$

and if the international lobby group supports regime D:

$$G_{20}^I < G_{20}^D + \sum_{j \in S_2^D} \Delta U_{2j}^{D,I} + \Delta U_I^{D,I}. \tag{38b}$$

Otherwise, advocates of regime I can desist from offering any contributions with the certainty that the government will select their preferred regime.

Case 3: pressured unilateral stance for both countries

In this case, both governments should have a pressured unilateral stance in support of regime I to form IEA. Our interesting finding suggests that because of the presence of an international lobby group, a government is not necessarily indifferent in the pressured stance. In fact, when the international lobby group supports regime D, the policy makers are not indifferent anymore between being lobbied and not being lobbied. As IEA forms only if both governments agree to join their domestic permit markets, it is sufficient for the international lobby group to contribute to one of the governments while policy-makers at both countries strictly gain from being lobbied. They are not indifferent because the contribution that an international lobby group offers to a government imposes externalities on the relationships between another government and its national lobbies. Hence, the offer made in equilibrium by an international lobby group to each government increases the reservation utility of the other agent above the corresponding level.

If both the governments oppose regime I $(G_{i0}^I < G_{i0}^D)$ and the international lobby group supports regime D, in equilibrium the governments cannot be indifferent between the two regimes. In this case, the international lobby group can offer only to one of the governments to convince it not to join the international

market. Accordingly, to prevent this, national lobbies that support regime I in that country should increase their contribution so that at least it equals to the sum of the aggregate contribution of opponents of regime I, including the total amount the international lobby is willing to contribute, ie. $\Delta U_I^{D,I}$. In fact, in this situation, the presence of an international lobby group increases the contributions of national lobbies that support the international market in both countries and the governments' benefits go up as well. In equilibrium the following equation holds for country $i = 1,2$:

$$G_{i0}^I + \sum_{j \in S_i^I} C_{ij}^{1,I} = G_{i0}^D + \sum_{j \in S_i^D} C_{ij}^{1,D} + \left(C_{I1}^{1,D} + C_{I2}^{1,D} \right). \tag{39}$$

Note that $C_{I1}^{1,D} + C_{I2}^{1,D} = \Delta U_I^{D,I}$ is in equilibrium, but there is no other restriction on how much the international lobby would contribute to any of the governments. The necessary and sufficient conditions for a pressured stance in favor of regime I for country i are

$$G_{i0}^I + \sum_{j \in S_i^I} \Delta U_{ij}^{I,D} > G_{i0}^D + \sum_{j \in S_i^D} \Delta U_{ij}^{D,I} + \Delta U_I^{D,I}, \tag{40a}$$

$$G_{i0}^I < G_{i0}^D + \sum_{j \in S_i^D} \Delta U_{ij}^{D,I} + \Delta U_I^{D,I}. \tag{40b}$$

A similar explanation is applied for the cases that an international lobby group supports regime D, but two governments support regime I $(G_{i0}^D < G_{i0}^I)$ or one country supports regime I $(G_{i0}^D < G_{i0}^I)$ and another one opposes regime I $(G_{i0}^D > G_{i0}^I)$.

If both governments oppose regime I $(G_{i0}^I < G_{i0}^D)$ and an international lobby group supports regime I, the governments would be indifferent to the choice of the regime. In this case, the international lobby group should allocate its contributions between two countries in such a way that both countries choose regime I,

$$G_{i0}^I + \sum_{j \in S_i^I} C_{ij}^{1,I} + C_{Ii}^{1,I} = G_{i0}^D + \sum_{j \in S_i^D} C_{ij}^{1,D}. \tag{41}$$

Let α_i be the share of the international lobby group's contribution to country i so that $\alpha_1 + \alpha_2 = 1$. A pressured stance in favor of regime I exists if the following necessary and sufficient conditions are satisfied for some α_i:

$$G_{i0}^I + \sum_{j \in S_i^I} \Delta U_{ij}^{I,D} + \alpha_i \Delta U_I^{I,D} > G_{i0}^D + \sum_{j \in S_i^D} \Delta U_{ij}^{D,I}, \tag{42a}$$

$$G_{i0}^I < G_{i0}^D + \sum_{j \in S_i^D} \Delta U_{ij}^{D,I}. \tag{42b}$$

Also, similar explanation is valid for the two following cases in which the international lobby group supports regime I; first, when the two governments

support regime I $(G_{i0}^D < G_{i0}^I)$ and second, when one country supports regime I $(G_{i0}^D < G_{i0}^I)$ and another one opposes regime I $(G_{i0}^D > G_{i0}^I)$.

In this section, we derived the conditions required to determine the government's decision on the international permit market. These conditions illustrate the impact of internationalization of national lobby groups in the different circumstances. We find that depending on the type of international lobby group when both countries have pressured unilateral stance, the presence of international lobby group can have a positive impact on the establishment of IEA. If an international lobby supports the international market, the establishment of IEA could be facilitated by giving power to national lobbies which support the international market to change the regime in their favor. But if an international lobby group opposes the international permit market, the presence of the international lobby group promotes competition between lobby groups in the country that it offers. As a matter of fact, it leads to a significant increase in national lobbies' contributions that support the international market in that country.

6 Conclusion

Lobby groups always take part in public debate and voice the interests of their members in political negotiations. It is, therefore, crucial to understand the functioning of political processes in the analysis of international environmental agreements. By growing international institutional relationships, new potential channels of influence have emerged in the political economy of environmental policy-making. This paper provides a theoretical framework to address the role of an international lobby group on international permit markets and answers the following questions: how political competition on the national and international levels affects a particular international climate policy? Under what circumstances will the policymaker be better off, through international lobbying? And then how do domestic and global emissions react to a change of the political environment and the presence of an international lobby group?

In seeking answers to these questions, we present a three-stage non-cooperative game in which international and national lobbies try to influence governments in deciding about the formation of the international market and subsequently the number of issued permits contingent on whether an international permit market is formed. Our results show that when the international lobby group supports the international market, the formation of IEA could be facilitated by giving power to national lobbies that support IEA to change the regime in their favor. However, when the international lobby group opposes IEA, it is sufficient for the international lobby group to contribute only to one of the governments to convince it not to join the international market. Therefore, the presence of the international lobby group promotes competition between lobby groups in the country that it offers. It increases the costs of national lobbies that support the international market and this, in turn, bring more benefits to the government. This would be consistent with the findings of Peterson (1995) who showed that contributions or bribes paid by lobby groups increase as the number of political units involved in the policy-making grows.

We have also shown that even in the absence of the international market for emission permits, the presence of an international lobby group with a positive stake in environmental damages decreases both domestic and global emission levels. Indeed, it can extend governments' perception about the environmental damages in two countries. This can grow the influence of green lobbies to change a policy in their favor. An implication of this is that even if national environmental lobbies do not offer any contributions to the local government, domestic emissions can decrease with strong national environmental lobby groups in other country or in general environmental awareness of another country. However, under an international market for emission permits, the governments are more sensitive to international firm lobbies and as a result, they obtain more bargaining power with respect to emission policy. Specifically, the aggregate emissions are reduced if and only if the international lobby group's stakes in benefits from emission are small relative to its stakes in the environmental damages and the permit revenues.

As discussed by Prat and Rustichini (2003), every cooperative game is similar to this multiple-principals multiple-agents model which national and international lobby groups compete to influence governments. The value of a coalition of countries in the cooperative game becomes the payoff of the lobby group that influences the governments in that coalition.

Consequently, the role of international lobby groups merits serious attention by planners to include in international environmental agreements. However, we have limited our attention to a model with two countries. Hence, extending the current model to a context with more than two countries would be theoretically interesting, as well as potentially insightful, for the understanding of lobby group behavior. It would be also interesting to test the model empirically or develop our model for other agreements and political economy issue.

Appendix

Proof of Proposition 1

Given Assumption 1, the existence of a Nash equilibrium is assured by

$$
\begin{aligned}
SOC_i : \; & (\theta_i + r_i)B_i''(\hat{e}_i) - (\theta_i + d_i)D_i''(\hat{E}) \\
& - \delta_{-iM_{-i}}D_{-i}''(\hat{E}) + (r_i - b_i)B_i''(\hat{e}_i) < 0, i = 1, 2,
\end{aligned}
\tag{A1}
$$

which implies that the problem defined in Eq. (20) is strictly concave.

The uniqueness of the solution to Eq. (22) is assured by the aggregate emissions

$$\hat{E} = \sum_{i=1}^{2} B_i'^{-1} \left[\frac{(\theta_i + d_i)}{(\theta_i + r_i)} D_i'(\hat{E}) + \frac{(b_i - r_i)}{(\theta_i + r_i)} B_i''(\hat{e}_i)\omega_i + \frac{\delta_{-iM_{-i}}}{(\theta_i + r_i)} D_{-i}'(\hat{E}) \right], \quad i = 1, 2,$$

(A2)

which is obtained by summing $\hat{e}_i$ over the both countries. As can be seen, the left-hand side of the above equation is strictly increasing in E, while the right-hand side, the inverse function $B_i'^{-1}$ is strictly and monotonically decreasing in E. Thus, the equilibrium is unique and by replacing this unique level of $\hat{E}$ into Eq. (22), we obtain the unique Nash equilibrium.

Proof of Proposition 2

The comparison of equilibrium emission functions under the presence and absence of an international lobby group is more straightforward. In the presence of an international lobby, as indicated by Eq. (22), we have

$$B_i'(\hat{e}_i) = \frac{(\theta_i + d_i)}{(\theta_i + r_i)} D_i'(\hat{E}) + \frac{(b_i - r_i)}{(\theta_i + r_i)} B_i''(\hat{e}_i)\omega_i + \frac{\delta_{-iM_{-i}}}{(\theta_i + r_i)} D_{-i}'(\hat{E}), \forall i \quad \text{(A3)}$$

$$\hat{E} = \hat{e}_1 + \hat{e}_2, i = 1,2.$$

$$\omega_i = \hat{e}_i.$$

In contrast, in the absence of an international lobby group we have

$$B_i'(\hat{e}_i^{NL}) = \frac{(\theta_i + d_i)}{(\theta_i + r_i)} D_i'(\hat{E}^{NL}) + \frac{(b_i - r_i)}{(\theta_i + r_i)} B_i''(\hat{e}_i^{NL})\omega_i, \forall i \quad \text{(A4)}$$

$$\hat{E}^{NL} = \hat{e}_i^{NL} + \hat{e}_{-i}^{NL}, i = 1,2.$$

$$\omega_i^{NL} = \hat{e}_i^{NL},$$

where the superscript "NL" refers to the presence of only national lobbying. It implies that $\hat{e}_i^{NL} < \hat{e}_i \forall i$.

Proof of Corollary 1

Using the following abbreviation:

$$\tau_i = SOC_i \times SOC_{-i} + \left((\theta_i + d_i)D_i''(E) + \delta_{-iM_{-i}} D_{-i}''(E) \right)^2 > 0 \quad \text{(A5)}$$

We derive

$$\frac{d\omega_i}{dx_i} = -\frac{\text{SOC}_{-i}}{\tau_i} \cdot \frac{\partial \text{FOC}_i}{\partial x_i}, \tag{A6a}$$

$$\frac{d\omega_{-i}}{dx_i} = -\frac{\left(\theta_{-i} + d_{-i}\right)D''_{-i}\left(\hat{E}\right) + \delta_{iM_i}D''_i\left(\hat{E}\right)}{\tau_i} \cdot \frac{\partial \text{FOC}_i}{\partial x_i}, \tag{A6b}$$

$$\frac{dE}{dx_i} = -\frac{\text{SOC}_{-i} + \left(\theta_{-i} + d_{-i}\right)D''_{-i}\left(\hat{E}\right) + \delta_{iM_i}D''_i\left(\hat{E}\right)}{\tau_i} \cdot \frac{\partial \text{FOC}_i}{\partial x_i}, \tag{A6c}$$

$$\frac{d\omega_i}{dx_{-i}} = -\frac{\left(\theta_i + d_i\right)D''_i\left(\hat{E}\right) + \delta_{-iM_{-i}}D''_{-i}\left(\hat{E}\right)}{\tau_{-i}} \cdot \frac{\partial \text{FOC}_{-i}}{\partial x_{-i}}, \tag{A6d}$$

$$\frac{d\omega_{-i}}{dx_{-i}} = -\frac{\text{SOC}_i}{\tau_{-i}} \cdot \frac{\partial \text{FOC}_{-i}}{\partial x_{-i}}, \tag{A6e}$$

$$\frac{dE}{dx_{-i}} = -\frac{\text{SOC}_i + \left(\theta_i + d_i\right)D''_i\left(\hat{E}\right) + \delta_{-iM_{-i}}D''_{-i}\left(\hat{E}\right)}{\tau_{-i}} \cdot \frac{\partial \text{FOC}_{-i}}{\partial x_{-i}}, \tag{A6f}$$

where $x \epsilon \{\theta, b, d\}$. Then, $\left(\frac{\partial \text{FOC}_i}{\partial x_i}\right)$ in the two cases $r_i = b_i$ and $r_i = d_i$ are

$$\frac{\partial \text{FOC}_i^{r_i=b_i, r_i=d_i}}{\partial \theta_i} = B'_i\left(e_i\right) - D'_i(E), \tag{A7a}$$

$$\frac{\partial \text{FOC}_i^{r_i=b_i}}{\partial b_i} = B'_i\left(e_i\right), \quad \frac{\partial \text{FOC}_i^{r_i=d_i}}{\partial b_i} = -B''_i\left(e_i\right)\omega_i, \tag{A7b}$$

$$\frac{\partial \text{FOC}_i^{r_i=b_i}}{\partial d_i} = -D'_i(E),$$
$$\frac{\partial \text{FOC}_i^{r_i=d_i}}{\partial d_i} = B'_i\left(e_i\right) - D'_i(E) + B''_i\left(e_i\right)\omega_i, \tag{A7c}$$

$$\frac{\partial \text{FOC}_i^{r_i=b_i, r_i=d_i}}{\partial \delta_{-iM_{-i}}} = -D'_{-i}(E). \tag{A7d}$$

For determining the signs of (A7c), we applied the first-order condition when $r_i = d_i$:

$$\left[B'_i(e_i) - D'_i(E)\right] = \frac{(b_i - d_i)}{(\theta_i + d_i)}\omega_i B''_i(\omega_i) + \frac{\delta_{-iM_{-i}}}{(\theta_i + d_i)}D'_{-i}(E), \qquad \text{(A8)}$$

which implies that $B'_i(e_i) - D'_i(E) > 0 \Longleftrightarrow d_i > b_i$.
By re-writing again the first-order condition, we have

$$B''_i(e_i)\omega_i = \frac{b_i}{d_i}B''_i(e_i)\omega_i - \left(\frac{\theta_i}{d_i} + 1\right)(B'_i(e_i) - D'_i(E)) + \frac{\delta_{-iM_{-i}}}{d_i}D'_{-i}(E), \quad \text{(A9)}$$

which enables us immediately to evaluate the sign of $\frac{\partial \text{FOC}_i^{r_i = d_i}}{\partial d_i}$. Hence, even if $B'_i(e_i) - D'_i(E) > 0$, we yield

$$B''_i(e_i)\omega_i < -(B'_i(e_i) - D'_i(E)) \Rightarrow \frac{\partial \text{FOC}_i^{r_i = d_i}}{\partial d_i} < 0, \qquad \text{(A10)}$$

Proof of Proposition 3

Given assumption 1, the existence of a Nash equilibrium is assured by

$$\begin{aligned} SOC_i : &\; p'(\hat{E})\left[2\theta_i + 2r_i - (\theta_i + b_i)e'_i(\hat{E}) - \gamma_{-iM_{-i}}e'_{-i}(\hat{E})\right] \\ &- (\theta_i + d_i)D''_i(\hat{E}) - \delta_{-iM_{-i}}D''_{-i}(E) < 0, i = 1, 2, \end{aligned} \qquad \text{(A11)}$$

which implies that the problem defined in Eq. (25) is strictly concave.
The uniqueness of the solution to Eq. (27) is assured by the aggregate emissions

$$2p(E) = \sum_{i=1}^{2} \frac{(\theta_i + d_i)}{(\theta_i + r_i)}D'_i(\hat{E}) + p'(E)\sum_{i=1}^{2} \frac{\delta_{-iM_{-i}}}{(\theta_i + r_i)}D'_i(\hat{E}), \qquad \text{(A12)}$$

which is obtained by summing $\hat{e}_i$ over the both countries. As can be seen, the left-hand side of the above equation is strictly increasing in E, while the right-hand side is strictly and monotonically decreasing in E. Thus, the equilibrium is unique. When we replace this unique level of $\hat{E}$ into equation Eq. (27), we obtain the unique Nash equilibrium.

Proof of Proposition 4

The determination of how the presence of an international lobby group affects the policy choices can be illustrated by comparisons of the best response functions. In the presence of an international lobby, as indicated by Eq. (27), we have

$$p(\hat{E}^I) + p'(\hat{E}^I)(\omega_i - e_i(\hat{E}))$$
$$= \frac{1}{(\theta_i + r_i)} \left[(\theta_i + d_i)D_i'(\hat{E}^I) + (b_i - r_i)p'(\hat{E}^I)e_i(\hat{E}^I) \right. \tag{A13}$$
$$\left. + \delta_{-iM_{-i}}D_{-i}'(\hat{E}^I) + (\gamma_{-iM_{-i}}e_{-i} - \rho_{-iM_{-i}}\omega_{-i})p'(\hat{E}^I) \right], \forall i$$

$$\hat{E}^I = e_1(\hat{E}^I) + e_2(\hat{E}^I) = \omega_1 + \omega_2.$$

Conversely, in the absence of an international lobby group, we have

$$p(\hat{E}^I_{NL}) + p'(\hat{E}^I_{NL})(\omega_i - e_i(\hat{E}^I_{NL}))$$
$$= \frac{1}{(\theta_i + r_i)} \left[(\theta_i + d_i)D_i'(\hat{E}^I_{NL}) + (b_i - r_i)p'(\hat{E}^I_{NL})e_i(\hat{E}^I_{NL}) \right], \forall i \tag{A14}$$

$$\hat{E}^I_{NL} = e_1(\hat{E}^I_{NL}) + e_2(\hat{E}^I_{NL}) = \omega_1 + \omega_2,$$

where the subscript "NL" refers to the presence of only national lobbying. This implies that

$$\delta_{-iM_{-i}}D_{-i}'(\hat{E}^I) + (\gamma_{-iM_{-i}}e_{-i} - \rho_{-iM_{-i}}\omega_{-i})p'(\hat{E}^I) \lesseqqgtr 0 \iff \hat{E}^I \lesseqqgtr \hat{E}^I_{NL}.$$

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