Environmental Policy Negotiations, Transboundary Pollution and Lobby Groups in Small Open Economies

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Abstract

This paper analyzes the consequences of lobby group activity for policy outcomes in economies with transboundary pollution and international environmental policies. International environmental policies are characterized as pollution taxes determined in a negotiation between two countries and it is found, among other things, that the presence of local lobbying tends to reduce the level of pollution taxes. Furthermore, an increase in the environmental concern - here defined as an increase in the number of environmentalists - may reduce the pollution tax in both countries. It is also possible that increased environmental concern in one country reduces the pollution tax in the other country.

Keywords: transboundary pollution, lobbying, pollution tax, Nash bargain, international negotiations, environmental policy

JEL classification: D62, H21, H23, H70

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1 Introduction

When individuals are affected by political decisions, they have an incentive to try to influence the political outcome. One way of doing so is to participate in lobby groups, which exercise pressure on the incumbent governments. For example, 'green' lobby groups may exercise political pressure to increase pollution taxes, while industry lobby groups may try to reduce costs that are associated with pollution. The number of lobby groups and the extent to which they affect the political outcome may differ both between countries and over time.[1] Earlier literature on green lobbying and environmental policy has mainly focused on policies decided upon at the national level. Therefore, this paper analyzes consequences of lobby group activity for policy outcomes in economies with transboundary environmental problems and international environmental policies are analyzed.

Previous studies suggest that green lobbying leads to a stricter environmental policy at the national level. For example, Fredriksson (1997) and Aidt (1998) show that more green lobbying may lead to higher pollution taxes in small open economies with local pollution.[2] Furthermore, Conconi (2003) introduces interactions between countries, such as trade and transboundary pollution, and examines how green lobbying affects policy outcomes. She shows that the impact of green lobbying depends crucially on the trade regime and on how lobby groups act together. A specific result is that one country's increase in pollution taxes, triggered by lobbying, improves the terms of trade in favor of the other country, which leads to an increase in that country's production and emissions. However, it is worth noting that Conconi (2003) does not consider consequences of environmental policies that are determined in a negotiation between countries, which will be the case in this paper. Moreover, Aidt (2005) finds that an increase in the influence from environmental lobby-groups may lead to lower pollution taxes. This result rests on the assumption that pollution is immobile and environmentalists care sufficiently about pollution that arises abroad. Specifically, when environmentalists are very concerned with pollution abroad, the lobby group is willing to accept more domestic pollution in return for less

[1] See e.g. Conconi (2003) for a discussion on the importance of lobbying in real world politics.

[2] Fredriksson (1997) uses a lobby group model to study how a pollution tax is affected by movements in prices and lobbying.

pollution abroad. Accordingly, these two studies show that the standard intuition, where stronger environmental lobby groups improve the environmental quality, may not necessarily be correct.

In this paper, the standard lobby group model in Fredriksson (1997) is extended to include a negotiation between countries with respect to environmental policy, here defined as pollution taxes.[3] Hence, the present paper does not focus on trade policies but instead on international environmental agreements. The present paper considers a global economy consisting of many small countries but, to simplify the analysis as much as possible, it is assumed that only two of them generate, and are affected by, transboundary pollution. These two countries coordinate their environmental policies (taxes) via a cooperative Nash bargain, while treating the world market prices as exogenous. Although the focus on a two-country agreement is a simplification and motivated by convenience, the model is interpretable in terms of the literature on 'bottom-up' agreements; see e.g. Buchner and Carraro (2005).[4]

The purpose of this paper is to bring together lobbying, transboundary environmental problems and international environmental policy. It follows earlier literature on lobbying and employs a standard menu auction model first applied in Grossman and Helpman (1994).[5] The menu auction model is a suitable tool for analyzing situations where different lobby groups offer an incumbent government a menu of campaign contributions in return for a particular choice of policy. It should perhaps be emphasized that lobby activities are assumed to

[3] It can perhaps be argued that a negotiation over national policy instruments directly is an unrealistic assumption. However, this can - for example - be seen in economic federations such as the European Union. In such federations carbon dioxide targets are determined at the federal level although each member country choses how to implement the targets. As for the present paper, the negotiation over national pollution taxes becomes equivalent to a negotiation over national target levels.

[4] With a bottom-up approach, each country has the freedom to sign agreements with other countries, bilaterally or multilaterally, without being constrained by a 'global' convention (by 'global' it is referred to e.g. the Kyoto protocol and other international agreements). The bottom-up approach most likely lead to more regional coalitions with stronger incentives to participate (see Buchner and Carraro (2005) for a more rigorous discussion of this topic). If some countries do not take part in the agreement but are affected by the transboundary pollution, the approach does not completely internalize the external effects. However, an assumption of all countries taking part in the agreement is not sufficient to guarantee a complete internalization.

[5] The model in Grossman and Helpman (1994) originates from a paper by Bernheim and Whinston (1986).

be strictly national, meaning that campaign contributions are offered to the domestic government[6], and depend on domestic government policies[7]. Hence, the possibility of 'cross-national' lobbying is disregarded in this paper. Furthermore, each government is assumed to care only about the probability of re-election, which depends on a weighted sum of aggregate campaign contributions and domestic social welfare.

The negotiation between the countries is characterized as a Nash bargain with two possible outcomes facing each government. The preferred outcome to both governments is a signed contract that, by definition, renders a higher level of welfare than the no-contract outcome. If no contract is signed, each government obtains the 'fall-back' welfare level, which represents a non-cooperative Nash equilibrium, where each government treats the policy instruments of the other country as exogenous. Since each country benefits from signing a contract, the Nash bargain approach may be interpreted in terms of a 'self-enforcing' agreement.[8] Moreover, it is also worth noting that, if the political process is considered as a repeated game, the bottom-up approach may increase the credibility of the contract because a country could face a punishment in the next round of negotiations.

The paper is organized as follows. Section 2 describes the model and its characteristics. Section 3 defines and explains the political process. The main results are presented in section 4, while section 5 summarizes and discusses the results.

2 The Model

Consider a global economy consisting of many small countries. Two of these countries, denoted by superindices 1 and 2, respectively, are identical in all important respects. Pollution in each of these two countries is assumed to affect

[6] There are studies where lobby groups in one country may offer contributions to the government in the other country; see e.g. Prat and Rustichini (2003) for the multiple agent - multiple principle approach. This approach is adopted by Fredriksson and Millimet (2007) who study pollution taxation, and by Aidt and Hwang (2008) who study internalization of 'cross national' externalities via labour standards.

[7] Grossman and Helpman (1995) extend their previous paper to allow for contribution schedules that are contingent on tax policies in both countries.

[8] There is an existing body of literature that deals with game theoretic aspects of policy cooperation, see e.g. Mäler (1989), Barrett (1994) and Carraro (2003).

not only the domestic residents, but also residents in the other country. Notice, however, that pollution is assumed to be transboundary only in a restricted way, as no other country is affected by the environmental damage generated by these two particular countries.[9]

Production in country i, $i = 1, 2$, takes place in two sectors; one produces a non-polluting good, c^i, that serves as a numeraire, while the other produces a polluting good, x^i. Both countries produce both types of goods. The numeraire good is produced with a linear technology that uses labor as the only input, whereas good x^i is produced with a constant returns to scale technology that uses labor and a sector-specific input in the production. The sector-specific input is assumed to be immobile and non-tradable. Furthermore, all markets are assumed to be competitive and the wage rate is normalized to one in both countries.

The government in country i has the possibility to levy a tax on the pollution associated with the production of good x^i. Free trade and the assumption of small open economies define the producer price of good x^i as $p^i = p^* - t^i$, where p^* is the world market consumer price on good x^i and t^i the corresponding pollution tax paid by the producers. The assumption of price taking economies implies that p^* is exogenous to each country/government. The revenue from the pollution tax in country i is given by $\tau^i = t^i x^i$ and is redistributed uniformly to all individuals.[10] Profit maximization defines a profit function, $\Pi^i(p^i)$, and a supply function[11], $x_s^i(p^i)$, where the latter satisfies $\partial x_s^i / \partial p^i > 0$ and $\partial^2 x_s^i / \partial \left(p^i\right)^2 = 0$. Hotelling's lemma defines the supply of good x^i as

$$x_s^i(p^i) = \partial \Pi^i / \partial p^i \tag{1}$$

Each country consists of N^i citizens who receive labor income, l^i, and, for notational convenience, N^i is normalized to one. Some citizens are assumed to have a special interest in the environmental quality, while others receive profit

[9] It is, of course, possible to generalize the model to include more than two countries that are affected by environmental damage. However, given the objective of this paper it would complicate the analysis without providing any valuable insights (at least in the symmetric equilibrium, which is the main focus of the paper).

[10] The assumption of uniformly distributed revenues follows related literature, see e.g. Grossman and Helpman (1994) and Fredriksson (1997).

[11] A linear supply function is used for computational reasons and follows Fredriksson (1997). An example of a production technology that implies a linear supply function is a Cobb-Douglas production function with an input elasticity equal to 0.5.

income from the production of x^i. The remaining agents (i.e. those who are neither environmentalists nor owners of the firm that produces x^i) are called workers. In what follows, these groups are denoted environmentalists, industrialists and workers, respectively (superindex E, I and W). By assumption, all citizens share a common quasilinear utility function for c^i and x^i, whereas environmentalists also derive disutility from pollution associated with the production of good x^i.[12] Hence, workers and industrialists have their utility functions defined as

$$U^{W,i} = c^{W,i} + u(x^{W,i}) \tag{2}$$

$$U^{I,i} = c^{I,i} + u(x^{I,i}) \tag{3}$$

while an environmentalist's utility becomes

$$U^{E,i} = c^{E,i} + u(x^{E,i}) - X \tag{4}$$

where X is the disutility experienced from both domestic and foreign pollution, defined as $X = x^i + x^j$ for $i \neq j$. Notice that $x^{k,i}$, $k = E, I, W$, is the fraction of x^i associated with each group of individuals and that the marginal disutility of pollution is normalized to one. It is assumed that *all* citizens receive income from both labor and redistributed tax revenues, while industrialists also receive profit income from the polluting sector.

Citizens with interests in the polluting sector are assumed to organize themselves into lobby groups. Environmentalists join the environmental lobby group and industrialists join the industry lobby group, while workers do not take part in any lobbying. Lobby group membership is exogenous in the model, meaning that *all* environmentalists and *all* industrialists are assumed to be members in their respective groups.[13]

Citizens use their income to finance the consumption of c^i and x^i. However, environmentalists and industrialists also support their interests by campaign contributions to the incumbent government. Campaign contributions in each country are assumed to depend only on the domestic pollution tax rate, i.e. $\Lambda^{E,i}(t^i)$ and $\Lambda^{I,i}(t^i)$. Other characteristics of the contribution schedules are

[12] The quasilinear utility function is appealing because it implies a simple demand structure and there are no income effects to be considered. A quasilinear utility function is also in line with related literature as e.g. Grossman and Helpman (1994).

[13] For a more general discussion of incentives associated with lobbying, see e.g. Olson (1965).

discussed in more detail later in the paper. It is assumed that the environmentalists recognize that a higher tax on pollution reduces production in the polluting sector, while industrialists recognize that a higher tax on pollution reduces profits. Given these characteristics, each citizen chooses c^i and x^i to maximize his/her utility subject to the budget constraint. The optimization problem facing environmentalists and industrialists can be written as

$$\max_{c^{E,i},x^{E,i}} U^{E,i} = c^{E,i} + u^i(x^{E,i}) - \left[x^i + x^j\right] \tag{5}$$

$$s.t. \;\; l^i + \tau^i = c^{E,i} + p^* x^{E,i} + \Lambda^{E,i}/\alpha^{E,i}$$

and

$$\max_{c^{I,i},x^{I,i}} U^{I,i} = c^{I,i} + u^i(x^{I,i}) \tag{6}$$

$$s.t. \;\; l^i + \tau^i + \Pi^i/\alpha^{I,i} = c^{I,i} + p^* x^{I,i} + \Lambda^{I,i}/\alpha^{I,i},$$

respectively, where $\alpha^{E,i}$ and $\alpha^{I,i}$ are the fractions of environmentalists and industrialists, respectively, in country i. As described above, workers are not lobby group members and do not give any campaign contributions. Hence, the optimization problem facing each worker is written as

$$\begin{aligned} \max_{c^{W,i},x^{W,i}} U^{W,i} &= c^{W,i} + u^i(x^{W,i}) \\ s.t. \;\; l^i + \tau^i &= c^i + p^* x^{W,i} \end{aligned} \tag{7}$$

By defining $Y^{k,i}$ as each individual's net income after redistributed tax revenues (τ^i), profits (Π^i) and expenses for lobbying ($\Lambda^{k,i}$), the indirect utility functions for each type of individual can be written as

$$\begin{aligned} V^{E,i}(p^*, t^i, Y^{E,i}) &= Y^{E,i} + u(x_d^{E,i}(p^*)) - p^* x_d^{E,i}(p^*) - X \\ V^{I,i}(p^*, t^i, Y^{I,i}) &= Y^{I,i} + u(x_d^{I,i}(p^*)) - p^* x_d^{I,i}(p^*) \\ V^{W,i}(p^*, t^i, Y^{W,i}) &= Y^{W,i} + u(x_d^{W,i}(p^*)) - p^* x_d^{W,i}(p^*) \end{aligned} \tag{8}$$

where the demand for the polluting good, associated with each type of individual, $x_d^{k,i}(p^*)$, is the inverse of $\partial u(x^{k,i})/\partial x^{k,i} = p^*$ and the difference $u(x_d^{k,i}(p^*)) - p^* x_d^{k,i}(p^*)$ is the consumer surplus derived from the two goods.

Each lobby group's utility is defined as the sum of its members' utilities. Hence, when omitting constant terms and in the absence of campaign contributions, the utilities of the environmental and industrial lobby groups become, respectively,

$$\begin{aligned} \Omega^{E,i}(t^i, t^j) &= \alpha^{E,i}\left[\tau^i(t^i) - \left[x^i(p^i) + x^j(p^j)\right]\right] \qquad (9) \\ \Omega^{I,i}(t^i) &= \alpha^{I,i}\tau^i(t^i) + \Pi^i(p^i) \end{aligned}$$

By adding all indirect utilities, the aggregate social welfare function in country i is defined as

$$\Omega^i(t^i, t^j) = \tau^i(t^i) + \Pi^i(p^i) - \alpha^{E,i}\left[x^i(p^i) + x^j(p^j)\right] \qquad (10)$$

3 The Political Game

As mentioned in the introduction, the political process to determine the level of pollution taxes can be described as a two stage game. The first takes place at the national level between the government and the lobby groups, where each lobby group offers the incumbent government a contribution schedule that depends on the pollution tax rate, i.e. $\Lambda^{k,i}(t^i)$, $k = E, I$. The contribution schedule from each lobby group is assumed to be continuously differentiable and each lobby group treats the other lobby group's contribution schedule as exogenous. Following earlier literature (e.g. Grossman and Helpman (1994)), possible effects of direct political competition (political parties) and lobby groups that do not recognize that their contributions affect the likelihood of re-election of the incumbent government are disregarded.

In line with earlier comparable literature, it is assumed that the incumbent government uses contributions to finance campaign spending. The incumbent government realizes the relationship between campaign spending and the probability of re-election, and that the probability of re-election also depends on the aggregate welfare of society. Therefore, given that re-election is the single goal of the government, the incumbent government in each country maximizes a weighted sum of aggregate campaign contributions and aggregate social welfare. Hence, the government's objective function is defined as

$$W^i(t^i, t^j) = \sum_{k=E,I} \Lambda^{k,i}(t^i) + \lambda^i \Omega^i(t^i, t^j) \qquad (11)$$

where $\lambda^i \geq 0$ is an exogenous weight attached to aggregate social welfare relative to campaign contributions.[14]

In the second stage, where the bargain between the two governments takes place, each government takes the contribution schedules into consideration and negotiates with the other country's government about the policy. Let $W^i = W^i(t^i, t^j)$ be the welfare each government obtains if it signs a contract, and $\overline{W}^i$ the welfare obtained if no contract is signed (denoted 'fall-back'). The fall-back outcome is derived by assuming that each government behaves as a Nash competitor by choosing its policy conditional on the other country's policy, i.e. the outcome will be a non-cooperative Nash equilibrium. By defining $\Psi^i = W^i - \overline{W}^i$ and $\Psi^j = W^j - \overline{W}^j$ to be the rents from bargaining, the Nash bargain maximizes the product

$$\Gamma = \Psi^i \Psi^j \tag{12}$$

with respect to t^i and t^j (where both governments are assumed to have equal bargaining power). Given these characteristics, the first order condition for t^i becomes

$$\frac{\partial \Gamma}{\partial t^i} = \frac{\partial \Psi^i}{\partial t^i} \Psi^j + \frac{\partial \Psi^j}{\partial t^i} \Psi^i = 0 \tag{13}$$

3.1 The equilibrium

It is assumed that the environmental policy and the campaign contributions are determined as a subgame perfect Nash equilibrium of the game presented above. The characteristics of this subgame perfect Nash equilibrium is that each contribution schedule is feasible, that the chosen pollution taxes maximize the government's objective function and, given the contribution schedules of each lobby group, no other lobby group has an alternative strategy that yields a greater payoff than the equilibrium payoff. These characteristics follow the equilibrium properties derived in Grossman and Helpman (1994), Dixit (1996) and Fredriksson (1997), which are all based on the characterization of a subgame perfect Nash equilibrium in a menu auction model developed in Bernheim and

[14] Following the model as defined above, the government's problem should be introduced as a maximization of $\widehat{W}^i = \nu_1^i \sum_{k=E,I} \Lambda^{k,i} + \nu_2^i \left[\Omega^i - \sum_{k=E,I} \Lambda^{k,i}\right]$. However, this is equivalent to maximizing W^i (equation (11)) with $\lambda^i = \nu_2^i / \left(\nu_1^i - \nu_2^i\right)$, given that the government values a dollar in their campaign budget higher than a dollar in the hands of the public, i.e. given that $\nu_1^i > \nu_2^i$. This assumption is in line with related literature and must hold when lobbying exists.

Whinston (1986). These equilibrium properties imply, among other things, that

$$\partial\Lambda^{k,i}(t^i)/\partial t^i = \partial\Omega^{k,i}(t^i,t^j)/\partial t^i \text{ for } k = E, I \tag{14}$$

The intuition behind this property is that each lobby group sets its contribution schedule so that the change in the contributions, caused by a marginal change in the tax rate, is equal to the corresponding change in the lobby group's welfare. Hence, the property corresponds to the marginal willingness to pay for a change in the tax rate. The contribution schedules are said to be locally truthful around the equilibrium pollution tax rate.[15] Throughout the paper, this equilibrium property is assumed to hold, meaning that equation (14) will be interpreted as a constraint in the optimization process.

4 The Environmental Policy Outcome

The main purpose of this section is to derive optimal pollution taxes and to study how exogenous changes in the number of lobby group members, as well as changes in the relative weight the government attaches to social welfare, affect the policy outcome. To simplify the analysis, the section begins with a benchmark case in which the policy is determined without any influence of lobbying. It then continues by incorporating lobbying into a symmetric framework where the countries are identical in all important respects, and changes are symmetric between the countries. Finally, the pollution taxes are derived and analyzed with differences between the two countries, meaning that the assumption of identical countries is relaxed.

Within the lobby group framework, a standard result when all individuals have their interests represented by lobby groups is that the policy outcome becomes socially efficient and replicates the first best. This result is a direct implication of an efficient equilibrium as presented in Bernheim and Winston (1986). The intuition is simply that the externality becomes completely internalized in this case. However given the specific setup of this paper, the externality is not completely internalized - even though all individuals have their interests represented by lobby groups (this is explained in more detail below). Accordingly, to simplify the analysis as much as possible, most of the results

[15] See e.g. Grossman and Helpman (1994) for a more rigorous discussion about this property.

are presented with the assumption that all citizens are lobby group members (i.e. either environmentalists or industrialists).

4.1 The benchmark case

In the absence of lobbying, the objective of each national government reduces to the measure of aggregate social welfare. By using $W^i = \lambda^i \Omega^i$, in equation (12), the optimal solution defines the pollution tax in country i as

$$t^i = \alpha^{E,i} + \alpha^{E,j} \tag{15}$$

where it is used that $\Psi^i = \Psi^j$ in a symmetric equilibrium with identical countries[16].

This result is standard and implies that the optimal pollution tax in each country equals the sum of marginal social damage that this country generates. Given the model specification, the sum of marginal social damage is defined as the proportion of environmentalists in both countries.[17]

4.2 The symmetric equilibrium

The introduction of lobbying implies that each government maximizes the objective function defined by equation (11). Consider the case where all citizens are either environmentalists or industrialists, i.e. $\alpha^{E,i} + \alpha^{I,i} = 1$.

Proposition 1 *Within the given framework, a subgame perfect Nash equilibrium with symmetric countries implies that the pollution taxes are defined as*

$$t^i = \alpha^{E,i} + \alpha^{E,j} \frac{\lambda^j}{\left(1 + \lambda^i\right)}$$

where $\alpha^{E,i} = \alpha^{E,j}$, $\lambda^i = \lambda^j$ *and* $i \neq j$.

Proof. See the Appendix. ■

Compared with equation (15), the pollution tax in country i is lower than in the benchmark case. The intuition is that a government only receives contributions from domestic lobby groups and, therefore, attaches no weight to

[16] Without the assumption of identical countries, the pollution tax in country i equals $t^i = \alpha^{E,i} + \alpha^{E,j} \frac{\lambda^j}{\lambda^i} \frac{\Psi^i}{\Psi^j}$.

[17] This result corresponds to a tax rate equal to the sum of marginal willingness to pay to avoid the pollution, i.e. $t^i = \sum_i MWP^i$, in related literature. A Benthamite approach, where a global planner determines the pollution taxes in both countries, also gives the same result.

the other country's environmentalists. The pollution tax reflects the weight the other country's government attaches to social welfare. The interpretation must be that the marginal social damage from pollution in country j has less impact on the pollution tax in country i. Accordingly, the introduction of lobbying implies that the pollution tax in country i is defined as a weighted sum of the marginal social damage in each country, and pollution taxes become lower with lobbying than without (i.e., the benchmark case). This result implies that although all citizens have their interests represented by lobby groups, the pollution tax does not replicate first best; the policy outcome does not completely internalize the externality.

4.2.1 Comparative statics in a symmetric equilibrium

It is reasonable to assume that the environmental concern and industrial lobbying may change within countries. It is also reasonable to assume that the weight the government attaches to lobbying may change. It is, for example, possible that a government's motive may change over time, which is interpreted as a change in the weight attached to contributions. Therefore, a relevant question would be to ask how the equilibrium pollution taxes are affected by changes in $\alpha^{E,i}$ and λ^i?

Given that all citizens are either environmentalist or industrialists, it is sufficient to study changes in only one lobby group's member base, since the effect of the other lobby group becomes its mirror image. Moreover, to characterize a general change in either the environmental concern, or in the weight the governments attach to social welfare, in the two countries, it will be convenient to define $\alpha^E = \alpha^{E,i} + \alpha^{E,j}$ and $\lambda = \lambda^i + \lambda^j$. Consider the following proposition.

Proposition 2 *In a symmetric equilibrium, a general increase in the environmental concern or in the weight the governments attach to social welfare will lead to an increase in the pollution tax in both countries;*

$$\frac{dt^i}{d\alpha^E} = 1 + \frac{\lambda^j}{1+\lambda^i} > 0$$

$$\frac{dt^i}{d\lambda} = \frac{\alpha^{E,j}}{\left(1+\lambda^i\right)^2} > 0$$

for $\lambda^i = \lambda^j$ *and* $j \neq i$.

To prove Proposition 2, differentiate the pollution tax equation derived in Proposition 1 and solve for $dt^i/d\alpha^E$ and $dt^i/d\lambda$, respectively.

First, consider the general increase in the environmental concern (defined as more environmentalists in both countries). In Proposition 1, the pollution tax was defined as a weighted sum of marginal social damages in countries i and j. Hence, an increase in the number of environmentalists in both countries will undoubtedly increase this weighted sum. The reason is that more individuals in each country are negatively affected by pollution, and thus accept/want a higher tax on pollution.

To interpret the effect on t^i of increasing the weight attached to social welfare, note that a joint increase in λ^i and λ^j affects the pollution tax in country i via the preferences of country j's environmentalists. When differentiating the pollution tax in Proposition 1 with respect to both λ^i and λ^j, it becomes obvious that an increase in λ^i tends to decrease the weight attached to the preferences in country j, while an increase in λ^j tends to increase this weight. Hence, the joint increase in λ^i and λ^j has both a positive and negative effect on the tax rate in country i. However, since the government in country i now attaches relatively less weight on lobbying contributions compared to social welfare, the net effect becomes positive. The government in country i attaches relatively more weight on the preferences of the environmentalists in country j. Notice that, as contributions become less important to the government, the pollution tax approaches the benchmark case. In the limit, when λ^i goes to infinity, the contributions becomes insignificant and aggregate social welfare is all that matters to the government.

4.3 Extensions

Although the assumption of symmetric countries gives intuitive results, it is partly motivated by analytical convenience. Allowing for asymmetries between the countries takes the analysis one step further. For example, the introduction of asymmetries makes it possible to analyze pollution taxes when countries differ with respect to their environmental concern (number of environmentalists), which certainly is a realistic scenario. As for the symmetric equilibrium, consider the case where all citizens are lobby group members, i.e. $\alpha^{E,i} + \alpha^{I,i} = 1$.

Proposition 3 *Within the given framework, a subgame perfect Nash equilib-*

rium with asymmetric countries implies pollution taxes defined by

$$t^i = \alpha^{E,i} + \alpha^{E,j} \frac{\lambda^j}{(1+\lambda^i)} \frac{\Psi^i}{\Psi^j}$$

Proof. See the Appendix. ■

When the analysis is extended to allow for asymmetries, the tax rates change slightly. Compared with the symmetric equilibrium, the second part of the pollution tax equation is now multiplied by the quotient of rents (Ψ^i/Ψ^j). If the two countries are not identical, these rents may differ and the quotient may, therefore, deviate from unity. For example, countries may differ with respect to the proportion of environmentalists and/or industrialists as well as the weight that the government attaches to social welfare. Assume for a moment an exogenous change that only affects country i and increases the rent Ψ^i. In such a case (cet. par.), the quotient of rents becomes larger than one and thus works in the direction of increasing the pollution tax in country i. The interpretation is that country i becomes more eager to reach an agreement (has more to lose from a no-contract outcome or, alternatively, puts less pressure on country j) and, therefore, accepts a higher tax on pollution.

To conclude, the introduction of asymmetries between the two countries may either increase or decrease the pollution taxes, compared to the symmetric case, depending on the relative rents.

4.3.1 Symmetric changes in an asymmetric equilibrium

From Proposition 3 it is obvious that, to analyze changes in the number of environmentalists and the weight attached to social welfare, effects via the rents, Ψ^i, need to be considered. This, however, implies a slightly more complicated analysis since changes in exogenous variables in one country affect the other country's policy decision via the quotient of rents. Recall that, the assumption of symmetric countries actually implies that symmetric changes in both countries have equal effects on the rents - the rent effects become insignificant. Accordingly, the comparative statics in an asymmetric equilibrium must be solved as a simultaneous system of equations (tax equations), where exogenous changes may also affect the fall-back outcome.

Given an asymmetric equilibrium, the total effect on the pollution taxes from an increase in the fraction of environmentalists in both countries becomes ambiguous. To see this, take as a starting point the pollution taxes defined in Proposition 3. By inspection, there are now effects via the quotient of rents, in addition to the positive effects derived in Proposition 2. These rent effects capture how a change in the number of environmentalists affects a country's incentives in the bargaining process (as described above). The total effect becomes ambiguous since the rents in each country, Ψ^i and Ψ^j, are affected so that they tend to increase, as well as decrease, the pollution tax. For instance, one of the rent effects (via Ψ^j) captures how an increase in the number of environmentalists in country j tends to decrease the pollution tax in country i since the rent Ψ^j increases. The interpretation of this particular effect is that country j becomes more eager to reach an agreement when $\alpha^{E,j}$ increases, and relaxes the pressure on country i in the bargaining process.

To conclude, given symmetric countries a general increase in the environmental concern increases the pollution tax. However, when allowing for asymmetries, the possibility that a general increase in environmental concern actually reduces the pollution tax cannot be excluded.

4.3.2 Asymmetric changes in a symmetric equilibrium

To develop the analysis further, it would be interesting to study the effects on the pollution taxes when the number of environmentalists changes in only one country. Therefore, consider the following proposition.

Proposition 4 *Starting with identical countries, an increase in the number of environmentalists in country i ($\alpha^{E,i}$) increases the pollution tax in that country (t^i), while it has an ambiguous effect on the other country's pollution tax (t^j).*

Proof. See the Appendix. ■

When the environmental concern increases in one country, it is natural that it affects the domestic pollution tax, but, through the bargaining, it must also be taken into account that it affects the pollution tax in the other country. Besides the positive effects derived in the case with symmetric changes, there is now an effect via the rent in country i. Since $\partial\Psi^i/\partial\alpha^{E,i} > 0$, this accentuates the positive impact on the tax rate. The intuition follows the previously discussed rent effects, which implies that country i becomes more eager to reach an agreement and hence increases its pollution tax.

The total 'cross-country' effect from an increase in $\alpha^{E,i}$ is indeterminate because, in addition to the effects that tend to increase t^j (corresponding to the effects in Proposition 2), there is a negative effect that tends to decrease the pollution tax t^j. The intuition behind this negative effect is that the increase in $\alpha^{E,i}$, and the corresponding reduction of pressure that country i puts on country j in the bargaining process, implies that country j tends to reduce its pollution tax. The government in country i becomes more eager to reach an agreement when the number of environmentalists increases, and therefore reduces its pressure on the other country. Therefore, if this effect is large enough an increase in the environmental concern in country i may actually reduce the pollution tax in country j.

The exogenous change in the fraction of environmentalists affects the welfare in both the bargaining outcome and the fall-back outcome. This implies that the assumption of the fall-back welfare is crucial for Proposition 4. So far in the paper, it has been assumed that the fall-back welfare may be affected by exogenous changes in country characteristics. However, let us change the setup for a moment and make an assumption of a fixed fall-back welfare. This could, for example, be the case if a supranational organization decides the environmental policy if no contract is signed. In such a case, $\partial\Psi^i/\partial\alpha^{E,i}$ becomes negative and turns the rent effects discussed in Proposition 4 in the opposite direction. The intuition is that, since more individuals are negatively affected by pollution, the increased number of environmentalists decreases the aggregate social welfare cet.par. which decreases the rent. Recall the case of a 'flexible' fall-back welfare in which more environmentalists reduced the aggregate social welfare to a larger extent in the fall-back case, implying a positive effect on the rent. Hence, an increase in one country's environmental concern has a corresponding impact on the tax rates as in the flexible 'fall-back' case, yet with completely opposite 'rent effects'. These opposite rent effects imply that the 'cross country' effect is now unambiguously positive, while the 'home country' effect is ambiguous. The intuition behind these results is analogous to Proposition 4.

4.4 Pollution taxes with workers included

Although the assumption of $\alpha^{E,i} + \alpha^{I,i} = 1$ implies pollution taxes that differ from the first best, it is reasonable to assume that some citizens are not lobby group members. In this section, the pollution taxes are derived given the assumption that $\left(\alpha^{E,i}+\alpha^{I,i}\right)<1$ (as defined in section 2.1).[18] However, note that differences between countries are still allowed for, i.e. an asymmetric equilibrium. Define that

$$\beta^{i}=\frac{\left(1+\lambda^{i}\right)\delta^{i}}{\left[\alpha^{E,i}+\alpha^{I,i}+\lambda^{i}\right]\left(1+\delta^{i}\right)-\left(1+\lambda^{i}\right)} \tag{16}$$

where $\delta^{i}=\left[dx^{i}/dt^{i}\right]\left[t^{i}/x^{i}\right]$ is the tax elasticity of total pollution in country i. By inspection, it can be found that $\beta^{i}>0$ if total pollution is decreasing in the tax rate, i.e. if $\delta^{i}<0$, and if $\alpha^{E,i}+\alpha^{I,i}<1$. This shows that, given an asymmetric equilibrium where lobby groups employ campaign contributions that fulfil the criterion for a subgame perfect Nash equilibrium, and if pollution taxes are determined in a Nash bargain between two countries, the outcome will be tax rates defined as

$$t^{i}=\left[\alpha^{E,i}+\alpha^{E,j}\frac{\lambda^{j}}{\left(1+\lambda^{i}\right)}\frac{\Psi^{i}}{\Psi^{j}}\right]\beta^{i} \tag{17}$$

Therefore, the pollution tax in country i depends on lobby group membership, the governments' weights attached to aggregate social welfare and the tax elasticity of pollution in country i. Moreover, the pollution taxes are unambiguously positive in equilibrium, given that total pollution is decreasing in the tax rate, i.e. the tax elasticity of pollution is negative. When compared to the pollution tax derived in Proposition 3, it becomes obvious that the previously derived tax formula now is multiplied by β^{i}. Hence, an increase in β^{i} tends to increase the tax rates and vice versa. This means that the pollution tax now depends on the tax elasticity of pollution, δ^{i}. Differentiation of equation (16) gives that β^{i} is decreasing in δ^{i}, which implies that the tax rate tends to increase (via β^{i}) the more sensitive pollution is to changes in the tax rate (δ^{i} more negative). The intuition behind this result is that, although the positive welfare effect to environmentalists increases, the negative tax revenue effect through the lost tax base dominates and hence tends to decrease the tax rate.

Finally, it is worth noting that the only difference compared with the tax rates derived in Proposition 3 is that not all citizens are lobby group members. Accordingly, when the number of lobby group members increases, the pollution tax approaches that in Proposition 3. If all citizens are lobby group members, Proposition 3 becomes completely replicated ($\beta^{i}=1$).

[18] This result is referred to as the 'general case' in the Appendix.

5 Summary and Discussion

The purpose of this paper has been to derive pollution taxes in the context of lobbying and transboundary pollution. In the specific setup, pollution in one country is assumed to affect not only residents in that country but also residents in another country. A standard lobby group model is used to characterize the influence from environmental and industrial lobbying on an incumbent government. The framework is then extended to incorporate environmental policies determined in a negotiation between the two countries affected by pollution.

It is found that the assumption of local lobbying, implying that the domestic government puts no weight on the preferences of the other country's environmentalists, tends to reduce the pollution tax. The intuition is that a government has no incentive to satisfy the preferences of lobby group members in the other country. Note, however, that it will still be a bargaining outcome where each country considers the other country. Second, a general increase in the environmental concern and in the weight the governments attach to social welfare, respectively, tends to increase the pollution tax in a symmetric equilibrium. The intuition for the first part is that more people experience disutility from pollution, which increases the willingness to pay for reduced pollution levels and hence increases the tax on pollution. The second part is explained by the fact that when a government increases the relative weight attached to social welfare, it increases the weight attached to environmentalists' preferences in the other country.

The model also shows that an increase in the number of environmentalists in just one country may reduce the other country's tax on pollution in a symmetric equilibrium. The intuition behind this result is that a government tends to accept a higher tax on pollution when the number of environmentalists in that country increases, which implies that the other country tends to reduce its tax on pollution.

Allowing for asymmetries between the two countries gives rise to interesting consequences. For example, it is possible that a general increase in the environmental concern reduces the taxes on pollution. The driving force behind this result follows the same intuition as in the symmetric equilibrium when the number of environmentalists in just one country increases. That is, a government becomes more eager to reach an agreement when the number of environmentalists increases in that country, which leads to reduced pressure on the other country to implement a high tax on pollution.

The main implication of this paper is that it is not always correct that an increase in the environmental concern increases the pollution taxes. This is an interesting finding since it seems to correspond to results in Conconi (2003). However, it is important to emphasize that the result in the present paper arises strictly from the bargaining process and does not rest on the assumption of trade between the two countries, i.e. it is not a terms of trade effect as in Conconi (2003). Hence, the point to be made here is that, although due to completely different mechanisms than other studies, the present model gives rise to the counterintuitive possibility that an increase in the environmental concern increases the pollution taxes.

A possible extension of the present paper would be to change the setup slightly and allow for transboundary pollution in a more 'unrestricted' way. This is possible in our specific framework, although it would require a considerably more complicated analysis of the comparative statics. Another possible extension is to moderate the bargaining process in a more sophisticated manner (e.g. by endogenous participation). In addition, it would also be possible to extend the model to include 'cross-national' lobbying as discussed in the introduction. However as indicated, these extensions are left for future research.

A Appendix

In the Appendix, subindices denote partial derivatives, e.g. $\Psi^i_{\alpha^{E,i}} = \partial\Psi^i/\partial\alpha^{E,i}$ and $\Gamma_{t^j t^j} = \partial^2\Gamma/\partial\left(t^j\right)^2$.

A.1 Pollution taxes

The general case The 'general case' refers to the model defined in sections 2 and 3, i.e. the complete model without any simplifying assumptions. Section 4.4 follows from, and discusses, this 'general case'.

To derive the pollution taxes, first define

$$\beta^i = \frac{\delta^i}{\left[\alpha^{E,i} + \alpha^{I,i} + \lambda^i\right]\left(1+\delta^i\right) - \left(1+\lambda^i\right)} \tag{A.1}$$

where $\delta^i = \left[dx^i/dt^i\right]\left[t^i/x^i\right]$ is the tax elasticity of total pollution in country i. By substituting for $\Psi^i_{t^i}$ and $\Psi^j_{t^i}$ into the first order condition for an optimal pollution tax (equation (13)), simple rearrangement yields the following tax equation

$$t^i = \left[\alpha^{E,i}\left(1+\lambda^i\right) + \lambda^j\alpha^{E,j}\frac{\Psi^i}{\Psi^j}\right]\beta^i \tag{A.2}$$

Proof of Proposition 1 The assumptions of symmetry and $\alpha^{E,i} + \alpha^{I,i} = 1$ imply that $\Psi^i = \Psi^j$ and $\beta^i = 1/\left(1+\lambda^i\right)$, respectively. By substituting this into equation (A.2), the following is obtained

$$t^i = \alpha^{E,i} + \alpha^{E,j}\frac{\lambda^j}{\left(1+\lambda^i\right)} \tag{A.3}$$

Proof of Proposition 3 The assumption that $\alpha^{E,i} + \alpha^{I,i} = 1$ implies that $\beta^i = 1/\left(1+\lambda^i\right)$. By substituting this into equation (A.2), the following is obtained

$$t^i = \alpha^{E,i} + \alpha^{E,j}\frac{\lambda^j}{\left(1+\lambda^i\right)}\frac{\Psi^i}{\Psi^j} \tag{A.4}$$

A.2 Proof of Proposition 4

A simultaneous system of the tax equations can be written as

$$\begin{bmatrix}\Gamma_{t^i t^i} & \Gamma_{t^i t^j}\\ \Gamma_{t^j t^i} & \Gamma_{t^j t^j}\end{bmatrix}\begin{bmatrix}\frac{dt^i}{d\alpha^{E,i}}, \frac{dt^i}{d\lambda^i}\\ \frac{dt^j}{d\alpha^{E,i}}, \frac{dt^j}{d\lambda^i}\end{bmatrix} = \begin{bmatrix}-\Gamma_{t^i\alpha^{E,i}}, -\Gamma_{t^i\lambda^i}\\ -\Gamma_{t^j\alpha^{E,i}}, -\Gamma_{t^j\lambda^i}\end{bmatrix} \tag{A.5}$$

The determinant of the first matrix on the left can be written as $|H| = z^i \left(2\Gamma_{t^i t^j} + z^i\right) > 0$, where $z^i = \left(1 + \lambda^i\right) x_p^i \Psi^j$. It can be shown that, by using the first order condition for the maximization of the Nash product (see equation (13)), $\Gamma_{t^i t^j} = \Gamma_{t^j t^i} > 0$. Moreover, the second order conditions for a maximum imply that $\Gamma_{t^i t^i}, \Gamma_{t^j t^j} < 0$.

The 'home country' effect Starting with equation (A.5), Cramer's rule gives that

$$\frac{dt^i}{d\alpha^{E,i}} = \frac{-\Gamma_{t^i \alpha^{E,i}} \Gamma_{t^j t^j} + \Gamma_{t^j \alpha^{E,i}} \Gamma_{t^i t^j}}{|H|} \tag{A.6}$$

Since $|H| > 0$, the numerator determines the sign of $dt^i/d\alpha^{E,i}$. Starting with symmetric countries, the numerator of equation (A.6) can be re-written as

$$\left[z^i + \lambda^j \alpha^{E,j} x_p^i \Psi^i_{\alpha^{E,i}}\right] z^j + \left[z^i + \lambda^i x_p^j \Psi^j\right] \Gamma_{t^i t^j} > 0 \tag{A.7}$$

implying that $dt^i / \, d\alpha^{E,i} > 0$.

The 'cross-country' effect Starting with equation (A.5), Cramer's rule gives that

$$\frac{dt^i}{d\alpha^{E,j}} = \frac{-\Gamma_{t^i \alpha^{E,j}} \Gamma_{t^j t^j} + \Gamma_{t^j \alpha^{E,j}} \Gamma_{t^i t^j}}{|H|} \tag{A.8}$$

Since $|H| > 0$, the numerator determines the sign of $dt^i/d\alpha^{E,i}$. Starting with symmetric countries, the numerator of equation (A.8) can be re-written as

$$\left[-\lambda^j \alpha^{E,j} x_p^i \Psi^j_{\alpha^{E,j}} + \lambda^j x_p^i \Psi^i\right] z^j + \left[z^j + \lambda^j x_p^i \Psi^i\right] \Gamma_{t^i t^j} \gtreqless 0 \tag{A.9}$$

implying that $dt^i / \, d\alpha^{E,i} \gtreqless 0$.

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