Redealing the Cards: How the Presence of an Eco-Industry Modifies the Political Economy of Environmental Policies

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Summary

An incumbent government maximizes its chances of being reelected. Its objective function encompasses both social welfare and political contributions. Its only instrument is a pollution tax. In an open-economy context, we introduce an eco-industry in addition to lobbies of polluting firms and environmentalists. Not only does the eco-industry lobby add a new political contribution toward a higher environmental tax, it also modifies the incentives of the usual lobbies. When the foreign environmental policy is constant, environmentalists can be in favor of a decrease in the local tax in order to reduce foreign pollution. It could also be in the interest of a vertical industrial pressure group to lobby toward more stringent environmental policy. In general, the impact of lobbying activities on the politically optimal tax is ambiguous as pressure groups push in different directions.

Keywords: Eco-Industry, Environmental Taxation, Lobbies, Political Economy

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1 Introduction

The usual analysis of environmental lobbying activities focuses on the role played by environmentalists and polluters. However, the interests of the other stakeholders deserve some consideration in order to understand the various stakes of environmental policy-making. Herein, we introduce the lobby of the environment industry, also called the eco-industry. The eco-industry consists of activities that measure, prevent, limit, minimize or correct environmental damages (OECD 1999). Examples of lobbying activities from this sector are common, notably in Brussels to the European institutions. For instance, two eco-industry associations—the UK-based Environmental Industries Commission (EIC) and the European Committee of Environmental Technology Suppliers Associations (EUCESTA)—have launched a new campaign to gain recognition for the benefits they bring to the economy and society by cutting down pollution. They want the Commission's Impact assessment to consider the economic benefits of environmental protection measures, such as reduced health costs, cost savings to mainstream industry from more efficient use of resources and innovation and competitiveness in environmental technologies. More interestingly, an energy-efficiency coalition of eco-industry associations and environmental NGOs have launched a common campaign on the need to promote energy-efficiency and strengthen the Energy Services directive.[1] The abatement sector lobby is also relatively efficient in influencing the environmental policy of climate change. For instance, the German Electricity Feed-In Law subsidizing renewable electricity was maintained in 1997 after a big effort by the German Wind Energy Association (Michaelowa 1998, Michaelowa 2004).

Furthermore, the presence of an eco-industry sector can explain unusual behaviors from traditional lobbies. One of the best examples concerns Greenpeace France in the case of the French aircraft carrier Clémenceau. This ship, full of asbestos, was supposed to be sent to India by the French government, where she would be dismantled by a local eco-industry. Greenpeace France imposed a strong lobby campaign on the French government to cancel its decision. In other words, Greenpeace France pushed for an increase in domestic pollution as well as a decrease in foreign pollution. They thought that the Indian eco-industry was not able to dismantle her without significant environmental damage for local workers and population. Another example is the case of clean development mechanisms (CDM) in the Kyoto Protocol. CDM are a way to lessen the burden of climate policies in countries listed in Annex 1 by including the financing of foreign abatement investments. These mechanisms have been highly supported by environmental NGOs because there was the risk that countries not included in Annex 1 would increase their emissions so much that it would cancel out the efforts made by developed countries. In these two examples, environmentalists took their lobby decisions not only based on the amount of pollution at home but also in a foreign country. This causes one to wonder why they did not try to directly lobby the foreign government. In both cases, the institutional framework of the

[1] http://www.foeeurope.org/climate/download/Joint_statement_Energy_services_Directive_Final.pdf

foreign country could not allow the implementation of stringent environmental policies. In the case of greenhouse gases, it is simply because the Kyoto Protocol does not recognize binding agreements in developing countries. In the case of asbestos, the Indian government has to consider the trade-off between poverty and environment. Increasing environmental regulations would reduce the competitiveness of Indian firms. Furthermore, the environment is considered as a superior good, which means that the environmental damage of one unit of pollution is positively correlated with income. Therefore, we consider in this analysis that local lobbies cannot influence the foreign environmental regulation, set at a given low level.

Another example of unexpected behavior concerns the European Directive 93/59/CEE on car polluting emissions. First, the Directive was supposed to demand relatively low emission reductions, but it soon became a question of which abatement technology was going to be used: a catalytic converter or a clean motor. The introduction of catalytic converters was favorable to German manufacturers because their eco-industry sub-contractors—mainly Bosch—had the capacity to produce this technology. On the other hand, French manufacturer Peugeot had invented a clean motor and its former chairman Jacques Calvet was lobbying to impose it as the new European environmental norm. The clean motor was more efficient for low emission reductions, so German manufacturers and their eco-industry pushed toward a more restrictive environmental regulation so that their technology would become the most efficient one. By the end of the legislative process, the Directive was more restrictive than the first draft, giving a competitive advantage to German car manufacturers.

If the empirical proof of the role of the eco-industry on lobbying activities is abundant, a detailed theoretical analysis remains to be made. Lobbying activities are often seen as one of the reasons justifying why environmental policies differ so much from what the economic theory has recommended. It can be a question of the choice of instruments—Buchanan & Tullock (1975) showed why polluting firms tend to prefer direct control mechanisms rather than incentive-based environmental policies, even though the latter are more efficient[2]—or it can be a question related to the stringency of the policy (see Oates & Portney (2001) for a good survey). This model tries to answer the second question by exploring the collective choice facet of environmental policymaking. We model the environmental regulatory choice as one in which interest groups vie with one another through a political process to determine the extent of environmental policies. The government pursues its own goals, seeking a mixture of political contributions and social welfare. Only one instrument is available, an environmental tax. We detail the political behavior of three lobbies, polluters, environmentalists and the eco-industry. Then, we derive the impact of lobbying activities on the politically optimal environmental taxation.

Our work is based on two strands of literature. First, it refers to the existing normative literature on eco-industries. This literature explains how the market power of these firms modifies

[2]Boyer & Laffont (1999) show why constitutional constraints on the instruments of environmental policy can be desirable when they impose limitations on the politicians' ability to distribute rents.

the optimal environmental policy that should be chosen by a benevolent regulator (David & Sinclair-Desgagné 2005, Nimubona & Sinclair-Desgagné 2005, Canton et al. 2005). The eco-industry sector is modeled as competing à la Cournot, the last two papers adding imperfect competition among polluting firms. As the price of environmental goods and services is fixed above marginal cost, it is in the interest of the regulator to increase the tax above the traditional Pigouvian tax so as to give enough incentives for abatement activities. This impact should be balanced with the negative incentives that imperfect competition among polluting firms induce on the optimal pollution tax.[3] In an open economy context, the eco-industry sector can be a source of strategic environmental policies (Fees & Muehlheusser 2002, Greaker 2006, Canton 2006) or can imply heterogeneous tax rates across polluting sectors (Copeland 2005) so as to benefit from economies of scale within the abatement sector without compromising the competitiveness of the polluting industry. In all these papers, even though the eco-industry is considered as highly concentrated, it is always assumed that the sector takes for granted the environmental policy. In contrast, the present model allows us to consider cases where the eco-industry influences the choice of environmental regulation.

In order to do so, we refer to the literature on the political economy of environmental policies. An incumbent government maximizes its chances of being reelected. In this context, its objective function encompasses both social welfare and political contributions. Political contributions are proposed by lobby groups in a two-stage game. Lobby groups move first and simultaneously offer the government contribution schedules that specify the payment to be made to the government as a function of the pollution tax. Taking the contribution schedules and the economic behavior of the private sector as given, the government moves second and implements the politically optimal pollution tax. This standard game was first applied to environmental policies by Fredriksson (1997) and Aidt (1998). The first paper discusses politically optimal policies depending on lobby group membership and the relative importance of lobbying activities. It also introduces pollution abatement subsidies and shows that total pollution may be increasing, due to altered influence of the lobby groups in the political equilibrium. The second paper derives the characteristics of endogenous optimal environmental policy and shows that lobbying activities can be a source of internalization of economic externalities. More recently, in an open economy context, Conconi (2003) and Aidt (2005) discussed cases where environmentalists are in favor of a decrease in environmental taxation. Pollution leakage[4] in the first analysis and a direct interest in foreign pollution in the second explain these unintuitive results. One of the aims of this paper is to confirm these results by including the eco-industry. It introduces a third agent, which enables us to demonstrate that international interactions among polluters are not necessary to conclude that environmentalists can be in favor of a reduction in domestic environmental taxation.

[3]See also Requate (2005) on how to give enough incentives to firms for increasing their abatement activities.

[4]In the rest of the paper, we call *pollution leakage* the impact of emissions in one country on the other country's welfare through transboundary pollution. We call *emission leakage* the impact of a change in the domestic environmental tax on foreign emissions through the change in the price of abatement activities.

We maintain in our model an open economy context. In two countries, two polluting sectors are subject to an environmental taxation. An eco-industry sector arises which supplies polluting firms in abatement activities. Abatement goods and services are assumed to be internationally traded, creating the only industrial interaction between the countries. Therefore, emission leakage takes place through the impact of the domestic tax on the price of environmental goods, which modifies abatement incentives in the foreign country. Pollution can be transboundary or purely local. All cases are considered. Our main findings can be summarized as follows: first, the eco-industry lobbies in favor of more stringent environmental policies. Not surprisingly, polluting firms always lobby against tighter environmental policies. However, a more stringent environmental taxation can be favorable to a lobby maximizing joint profits of the polluting sector and the eco-industry, if foreign rent-shifting cancels out for the increase in the tax burden and production costs. We also show that an environmental pressure group can ask for a decrease in the environmental taxation at home in order to decrease pollution abroad. This result only relies on interactions between countries within the eco-industry sector. In general, the impact of lobbying activities on the politically optimal environmental policy is ambiguous.

The rest of the paper proceeds as follows. Section 2 presents the economic model. Section 3 examines the political model and the contributions of each lobby group. Section 4 gives the politically optimal pollution tax and discusses some comparative statics. Section 5 sums up our work.

2 The economic model

There are two countries in the economy, the superscript * standing for foreign variables. The local country has four types of citizens, consumers C, environmentalists E and shareholders divided into unethical shareholders US and ethical shareholders ES. The size of the population is normalized to one. As already explained in introduction, we consider that the foreign environmental policy is temporarily fixed. It implies that the institutional framework does not allow the foreign government to behave strategically.

Consider a representative polluting firm, producing a given commodity x at a world and domestic price P. On the commodity x market, both countries are too small to influence world prices. $c_d(x)$ is the production cost function, twice differentiable and increasing and convex, i.e. $\forall x \in \mathbb{R}_+$, $c'_d(x) > 0$ and $c"_d(x) > 0$. This activity generates some pollution which is summarized by an emission function $\epsilon(x)$. This function, identical for all firms is assumed to be increasing and convex with the level of production, i.e. $\forall x \in \mathbb{R}_+$, $\epsilon'(x) > 0$ and $\epsilon"(x) > 0$. Pollution is taxed at a per-unit rate t, giving firms an incentive to reduce this undesirable by-product by starting a clean-up activity which requires some specific inputs a_d sold by an upstream eco-industry at a price p. The efficiency of this activity is given by a function $w(a_d)$ which measures the amount of

pollution cleaned by the purchase of a_d environmental goods. We assume that the technology is characterized by a decreasing marginal productivity, i.e. $\forall a_d \in \mathbb{R}_+$, $w'(a_d) > 0$ and $w"(a_d) < 0$. We also add that $\lim_{a_d \to 0} w'(a_d) = +\infty$ and $\lim_{a_d \to +\infty} w'(a_d) = 0$. More environmental goods consumed decrease the net amount of pollution, but at a decreasing rate.

From this point of view, the representative polluting firm maximizes the following profit function over two variables, x and a_d:

$$\max_{x,a_d} \Pi = Px - c_d(x) - pa_d - te(x, a_d) \tag{1}$$

where $e(x, a_d) = \epsilon(x) - w(a_d)$ is the net emission function. Polluting firms are price-takers in both the output and the eco-industry market. Abatement decisions are additively separable to production decisions[5], i.e. $e_{xa_d}(x, a_d) = 0$. First order conditions of profit maximization are:

$$P = c'_d(x) + t\epsilon'(x) \tag{2}$$

$$p = tw'(a_d) \tag{3}$$

Equation 2 determines the optimal level of production of the final good. The overall demand in abatement activities is determined by including the optimal decision of the foreign polluting firm. It optimizes its abatement decisions such that $p = t^* w'(a_d^*)$. Under our assumptions about the clean-up process $w(a_d)$, the individual demands in environmental goods are such that $a_d(p, t) = (w')^{-1}\left(\frac{p}{t}\right)$ and $a_d^*(p, t^*) = (w')^{-1}\left(\frac{p}{t^*}\right)$.

Abatement activities are supplied by the eco-industry. The environmental market is composed of two firms, one based in each country and selling indifferently environmental goods and services to firms in both countries.[6] Since the players of the upstream eco-industry are able, as usually in a subgame perfect equilibrium, to anticipate the behaviors of downstream firms, the expected demand in environmental goods is given by:

$$A = a_d(p, t) + a_d^*(p, t^*) = \left(w'\right)^{-1}\left(\frac{p}{t}\right) + \left(w'\right)^{-1}\left(\frac{p}{t^*}\right) = \omega(p, t, t^*)$$

where A denotes the expected total amount of environmental goods produced by the eco-industry.

Lemma 1 *An increase in the domestic pollution tax shifts upward the demand in environmental goods.*

Proof: Let us define $\Psi(p, t, t^*) \equiv A - (w')^{-1}\left(\frac{p}{t}\right) - (w')^{-1}\left(\frac{p}{t^*}\right)$. In equilibrium, $\Psi(p, t, t^*) = 0$.

[5]This assumption simplifies the algebra without changing the main results of the model.

[6]Paragraph 31(iii) of the World Trade Organization's 2001 Doha Development Agenda mandates negotiations at the WTO on "the reduction or, as appropriate, elimination of tariff and non-tariff barriers to environmental goods and services" (Steenblick et al. 2005). Even if this objective has not been fulfilled yet, we simplify the analysis by assuming that no tariffs or transport costs limits the trade of environmental goods and services.

Using the implicit function theorem, we know that $\frac{\partial p}{\partial t} = -\frac{\frac{\partial \Psi}{\partial t}}{\frac{\partial \Psi}{\partial p}}$. Furthermore, $\frac{\partial \Psi}{\partial t} = -\frac{\partial w'^{-1}(\frac{p}{t})}{\partial t}$. $\forall f$ a C^2 function, $(f'^{-1})'(z) = \frac{1}{f''(f'^{-1}(z))}$ if $f''(f'^{-1}(z)) \neq 0$, so we have $\frac{\partial \Psi}{\partial z} = -\frac{1}{w''(w'^{-1}(z))}$, with $z = \frac{p}{t}$. As z decreases in t and $w''\left(w'^{-1}(z)\right) < 0$, $\forall z \in \mathbb{R}_+^*$, we have that $\frac{\partial \Psi}{\partial t} < 0$. Following the same method, $\frac{\partial \Psi}{\partial p} > 0$. Therefore, $\frac{\partial p}{\partial t} > 0$. $\square$

$\forall t, t^* > 0$ the demand function is continuous and strictly decreasing in p. Therefore, it can be invertible, which yields: $p = \omega^{-1}(a_s + a_s^*, t, t^*)$, where a_s is the production of the domestic eco-industry and a_s^* the production of the foreign one. The domestic eco-industry firm supports a production cost $c_u(a_s)$. It is assumed that marginal production costs are constant for both firms, i.e. $c_u'(a_s) = c_u$ and $c_u^{*'}(a_s^*) = c_u^*$, with $c_u \lessgtr c_u^*$. The domestic eco-industry firm is going to produce the amount of environmental goods that maximizes its profits:

$$\max_{a_s} \Pi^{up} = p(A, t, t^*)a_s - c_u(a_s) \tag{4}$$

Appendix 6.1 summarizes sufficient conditions for a unique equilibrium in the environment market. Appendix 6.2 provides some comparative statics, where it is shown that $\frac{dx}{dt} < 0$ and $\frac{dA}{dt} > 0$. In other words, an increase in the domestic tax is always going to decrease the domestic production in final goods. In terms of abatement activities, the demand is switched upward when t is higher. It has a negative impact on foreign demand in abatement activities, leading to an increase in foreign emissions. This decrease in foreign demand is more than compensated by an increase in domestic demand, which explains why overall environmental production increases.

All citizens have the same preferences with respect to goods and environmental quality at home, but differ with respect to their source of income and in their concern about pollution abroad. The baseline utility function is:

$$U = u(x) + y - \nu E(X, A) \tag{5}$$

where y is a numeraire good, produced with constant returns to scale and labor only, with a world and domestic price equal to 1. $E(X, A) = (1 - \theta)e(x, a_d) + \theta e(x^*, a_d^*)$ stands for the amount of local pollution with $e(x, a_d)$ the emissions of domestic polluting firms and $e(x^*, a_d^*)$ the foreign ones. We assume $u_x' > 0$ and $u_x'' \leq 0$.[7] Following Conconi (2003), domestic consumers are affected by foreign emissions through a parameter $\theta \in [0, 1/2]$. When $\theta = 0$, pollution is purely local whereas when $\theta = 1/2$, pollution is purely global. ν is the marginal environmental damage of each unit of pollution, strictly positive and constant.

Following Aidt (2005) we assume that a proportion $\bar{\alpha_E}$ of the country's population are environmentalists. They differ from normal citizens as they care about pollution abroad. In addition

[7]The choice of quasi-linear utility functions could lead to corner solutions. We suppose that they do not arise. Furthermore, quasi-linear preferences imply that monetary transfers are equivalent to transferable utility among the principals and their common agent. This is usual and acceptable in the partial equilibrium analysis of industrial organization (Dixit et al. 1997), even though it would be inappropriate in a more general framework.

to the environmental damage created to each citizen by local pollution, environmentalists' utility decreases when foreign pollution increases. Therefore, their utility function can be written as follows:

$$U^E = U - \gamma E^*(X, A) \tag{6}$$

where, $E^*(X, A) = (1 - \theta^*)e(x^*, a_d^*) + \theta^* e(x, a_d)$ is the overall pollution in the foreign country. We assume that pollution leakage is symmetric between countries, i.e. $\theta = \theta^*$. γ is the disutility incurred to environmentalists by each unit of pollution abroad.

Citizens receive two common sources of income, a wage l and a lump-sum transfer $R(.)$. The transfer is financed from the revenue of the pollution tax. The y good is produced in a perfectly competitive sector with constant returns to scale and labor as the only input. As we have normalized the price of y to 1 and labor is assumed to be mobile domestically, the wage rate is equal to 1 in both sectors. The third source of income are firms' profits and they are allocated to shareholders as dividends. Recall that "unethical shareholders" hold shares in polluting firms whereas "ethical shareholders" are the owners of the domestic eco-industry firm. From utility maximization subject to given income I^k,[8] we derive the demand function for good x as $d(P)$, where $d(.)$ is the inverse of $u'(x)$. Consumption of the numeraire good equals $y^k = I^k - Pd(P)$. Therefore, the indirect utility function of citizens is:

$$v^k = I^k + u[d(P)] - Pd(P) - \nu E(X, A) - \tau.\gamma E^*(X, A) \tag{7}$$

where τ is a dummy variable equal to 1 for environmentalists and 0 otherwise.

3 The political model

The welfare of this economy is:

$$W = L + CS(.) + R(.) + \Pi + \Pi^{up} - \nu E - \bar{\alpha_E}\gamma E^* \tag{8}$$

where L stands for overall wages and $CS(.)$ for consumers' surplus. In a traditional normative approach, the government would choose its environmental taxation by maximizing that function. In our approach though, its choice deviates from the social welfare maximization policy if lobby groups offer positive contributions. Let $M^k(t)$ be the contribution of lobby group k if the policy chosen is t. The payoff function v^g of the government becomes:

$$v^g = \lambda W(t) + \sum_k M^k(t) \tag{9}$$

[8] $k \in K = \{C, E, US, ES\}$ stands for consumers, environmentalists and both types of shareholders

where λ is the political weight given to the economy's welfare. We introduce three lobby groups: environmentalists and both types of shareholders. We do not consider the way these lobby groups form and overpass the free-riding problem (see Olson (1965) for a discussion on the logic of collective action). We assume that lobby groups are functionally specialized. While examples of lobby groups with multiple goals can be found, empirical studies seem to show that pressure groups are highly specialized (Aidt 2005). They only care about one particular aspect of an issue, namely pollution for environmentalists—who, nevertheless, are also consumers—and profits for shareholders—who are also consumers and suffer from pollution.

3.1 The Game

The political game is a two-stage common agency game where lobby groups are principals and the government the only agent. The objective of the incumbent government is to be reelected. This implies that it cares about the utility level achieved by the representative voter, particularly if voters are well informed about the effects of government policy and base their vote partly on their standard of living. The incumbent politician also values political contributions for financing future campaigns and deterring competitors. Therefore, it is going to maximize a weighted function of national welfare and lobbies contributions. Political contributions are proposed by lobby groups. Lobby groups move first and simultaneously offer the government contribution schedules that specify the payment to be made to the government as a function of the pollution tax. Lobbies make contributions up to the point where the benefit on their pay-off function of the resulting change in economic policies is exactly offset by the marginal cost of the contributions. Taking the contribution schedules and the economic behavior of the private sector as given, the government moves second and implements the politically optimal pollution tax.

Bernheim & Whinston (1986) characterizes the equilibrium for a menu auction problem with a finite set of actions. Their model has found many applications, including the study of lobbying for tariffs (Grossman & Helpman 1994) and for consumer and producer taxes and subsidies (Dixit 1996). Fredriksson (1997) precises the conditions ensuring the existence of a truthful equilibrium for an environmental tax from a choice set T. For this menu auction, a set of contribution schedules and a policy t^{po} is a subgame perfect Nash equilibrium if four main conditions are satisfied.

Lemma 2 *Fredriksson (1997):* $(\{M^{k^{po}}\}_{k\in K}, t^{po})$ *is a Subgame Perfect Nash Equilibrium iff*

1. $M^{k^{po}}$ *is feasible for all* $k \in K$*;*
2. t^{po} *maximizes* $\sum_{k\in K} M^{k^{po}} + \lambda W(t)$ *on* T*;*
3. t^{po} *maximizes* $v^j(t) - M^{j^{po}}(t) + \sum_{k\in K} M^{k^{po}}(t) + \lambda W(t)$ *on* T *for every* $j \in K$*;*

4. *for every* $j \in K$*, there exists a* $t^{-j} \in T$ *that maximizes* $\sum_{k \in K} M^{k^{po}}(t) + \lambda W(t)$ *on* T *such that* $M^{k^{po}}(t^{-j}) = 0$.

First, each contribution schedule has to be feasible (it has to be positive and lower than the overall resources of the lobby group). Second, the policy t^{po} must maximize the government's pay-off function, taking the contribution schedules as given. Third, given the schedule of lobby group j, and the government's anticipated decision rule, no lobby group i has a feasible strategy that yields a net payoff greater than the equilibrium net payoff. In other words, the shapes of the schedules reveal the true preferences in the neighborhood of the equilibrium. We extend this notion of truthfulness—as Bernheim & Whinston (1986) do—to define a truthful contribution schedule. It is a contribution schedule that everywhere reflects the true preferences of the lobby. Truthful schedules are differentiable, because pay-off functions are differentiable. Bernheim & Whinston (1986) showed that players bear essentially no cost from playing truthful strategies, because the set of best responses to any strategies played by one's opponents includes a strategy that is truthful. They also showed that truthful Nash equilibria are the only equilibria stable to non-binding communications among the players. Fourth, the "anchor" level of net welfare from which each lobby decides of its political contribution must be chosen such that there exists a policy that elicits a contribution of zero from the lobby which the government finds equally attractive as the equilibrium policy.[9]

3.2 Polluters' contribution to the environmental tax

$\alpha_{us}\%$ of polluters' shareholders decide to form a lobby. As lobbies are assumed functionally specialized, the policy preference of polluters is only determined by the impact of the environmental policy on profits. Their payoff function v^{us} is then equal to:

$$v^{us} = \alpha_{us}\Pi = \alpha_{us}[Px - c_d(x) - pa_d - te(x, a_d)] \tag{10}$$

The lobby supports a change in the environmental policy that can ensure an increase in profits. As contributions have been assumed truthful, the way profits vary according to the tax rate precises whether contributions are increasing or decreasing in the pollution tax. Contrary to the individuals' decisions, the lobby considers the impact of polluters' demand in environmental goods on the price of these goods. So,

$$\frac{d\Pi}{dt} = \frac{\partial \Pi}{\partial x}\frac{dx}{dt} + \frac{\partial \Pi}{\partial a_d}\frac{da_d}{dt} + \frac{\partial \Pi}{\partial p}\frac{dp}{dt} - e(x, a_d) \tag{11}$$

[9] See Grossman & Helpman (1994) for a graphical illustration.

where $\frac{dp}{dt} = \frac{\partial p}{\partial t} + \frac{\partial p}{\partial A}\frac{da_d}{dt} + \frac{\partial p}{\partial A}\frac{da_d^*}{dt}$. Using the envelop theorem, the net impact of a tax variation on the polluters' lobby payoff function is:

$$\frac{dv^{us}}{dt} = \alpha_{us}[-e(x, a_d) + \frac{\partial \Pi}{\partial p}\frac{dp}{dt}] \tag{12}$$

Proposition 1 *The lobby of polluting firms offers political contributions to lessen the environmental tax.*

Proof: The first term into brackets is necessarily negative. The second term is negatively correlated with the price of abatement activities. As it is shown in Lemma 1, $\frac{\partial p}{\partial t} > 0$, i.e. an increase in t shifts upward the domestic demand in environmental goods. Appendix 2 recalls that overall, world production of abatement activities increases with a higher tax. The combination of a shift in the demand function and a higher production pattern implies an increase in the equilibrium price of abatement activities. □

As the pay-off function of the lobby of polluting firms is negatively correlated to the environmental tax, its political contributions is decreasing in the pollution tax.

3.3 The eco-industry's contribution to the pollution tax

A proportion α_{es} of the eco-industry's shareholders is assumed to form a new lobby. Like the polluters' lobby, their payoff function v^{es} is characterized by their profit function.

$$v^{es} = \alpha_{es}\Pi^{up} = \alpha_{es}[p(A, t, t^*)a_s - c_u(a_s)] \tag{13}$$

Following a change in the pollution tax, the payoff function of the eco-industry is modified as follows:

$$\frac{dv^{es}}{dt} = \alpha_{es}\frac{d\Pi^{up}}{dt} = \alpha_{es}[\frac{\partial \Pi^{up}}{\partial p}\frac{\partial p}{\partial t} + \frac{\partial \Pi^{up}}{\partial a_s}\frac{da_s}{dt} + \frac{\partial \Pi^{up}}{\partial p}\frac{\partial p}{\partial a_s^*}\frac{da_s^*}{dt}] \tag{14}$$

where a_s^* is the production of the foreign firm. From the envelop theorem, the net effect of a change in the tax on the payoff function is:

$$\frac{dv^{es}}{dt} = \alpha_{es}\left[\frac{\partial \Pi^{up}}{\partial p}\left(\frac{\partial p}{\partial t} + \frac{\partial p}{\partial a_s^*}\frac{da_s^*}{dt}\right)\right] \tag{15}$$

When Home changes its environmental taxation, it increases demand in environmental goods and services, and therefore their price. Some of this excess demand is supplied by foreign eco-industries, which has a negative impact on domestic profits. The impact on the production patterns of both firms depends on their relative cost functions. Canton (2006) presents a case of asymmetric competition in which an increase in a tax rate can reduce the production of an

eco-industry firm. It happens when firms are asymmetric enough and concerns the low cost firm. However, profits of both firms increase anyway. In fact, it is always possible to produce as much as before and as the new price is higher, profits at the former production level are also more important. Therefore, even if a firm decides to produce less, its profits increase.

Proposition 2 *An increase in the pollution tax shifts upward the demand in abatement activities. It has a positive impact on eco-industry's profits, which gives incentives to its lobby to push toward higher tax rates.*

We can notice that in a closed economy framework, the lobby of eco-industries would also push toward a more stringent environmental taxation and the polluters' lobby would maintain contributions toward a reduction in the tax. Therefore, an open-economy context does not change the qualitative results about the political contributions of independent industrial lobbies. However, this result does not hold anymore when we consider the decision of a vertical industrial lobby.

3.4 Political contribution of a vertical industrial lobby

We have assumed so far that sectors were segmented. However, the limit between eco-industries and downstream polluting industries is not always so clear. When interactions are repeated, contracts can be used between upstream and downstream firms. An often emphasized example concerns the supply of air control equipment to oil refineries. This technology needs repeated interactions and the presence of eco-industry sub-contractors in the refineries, which led to the emergence of contracts between downstream and upstream firms. These contracts introduce more complex relationships than the price-quantity one.[10] Moreover, it can also happen that upstream and downstream firms decide to lobby together, either because they have common shareholders—one can think of trust funds holding a portfolio of different activities—or because they have a similar interest on one specific issue. Recall the example described in introduction about catalytic converters. From sub-contractors to car sellers, the whole supply chain of German car manufacturers took a similar position on the issue.

So, we study in this subsection a case where a proportion α_{jp} of all the shareholders of this economy decides to form a vertical industrial lobby. The objective of this lobby is to maximize joint profits, which implies that side-payments are allowed between downstream and upstream firms. The payoff function v^{jp} of this lobby is then equal to:

$$v^{jp} = \alpha_{jp}\Pi^{jp} = \alpha_{jp}[Px - c_d(x) - p(A,t,t^*)(a_d - a_s) - te(x,a_d) - c_u(a_s)] \tag{16}$$

[10] For a treatment of vertical contracts on strategic environmental policies, see Hamilton & Requate (2004)

Simplifying this expression by using the first order condition of profit maximization of the polluting industry, the net impact of an increase in the pollution tax on overall profits is:

$$\frac{d\Pi^{jp}}{dt} = p(A,t,t^*)\left(\frac{da_s}{dt} - \frac{da_d}{dt}\right) + (a_s - a_d)\frac{dp}{dt} - c'_u(a_s)\frac{da_s}{dt} - e(x,a_d) \tag{17}$$

One can see immediately that in a closed-economy framework, the first two terms are equal to zero. In that case, overall profits necessarily decrease with an increase in the environmental tax. In fact, a more stringent environmental regulation increases tax revenues given to the government while at the same time increasing production costs of the eco-industry. As the revenues of the eco-industry are only transfers between firms, nothing positive is to be expected from an increase in the tax for the vertical supply chain.

When the market of abatement activities is global, the first term can be positive if it is optimal for the foreign eco-industry firm to reduce its level of production with an increase in the tax. The second term is positive if Home is a net exporter. In other words, a positive impact of the environmental policy on firms' profits can be expected if the international position of the domestic eco-industry firm is favorable. The following proposition sums up the industry position.

Proposition 3 *(i) The policy preference of a lobby maximizing joint profits is indeterminate. (ii) A necessary condition for this lobby to contribute toward an increase in the pollution tax is a dominant position of the domestic eco-industry on the international market of abatement activities.*

This analysis can explain the behavior of German car manufacturers, which chose to push toward more stringent emission standards as they knew that it was only with highly restrictive standards that they would be efficient enough to impose their technologies on international markets. As German eco-industries were winning market shares on European markets, it could compensate the increase in abatement costs for German car manufacturers.

3.5 Environmentalists' contribution to the pollution tax

Some of the environmentalists create a lobby group. The proportion of organized environmentalists is $\alpha_E \leq \bar{\alpha_E}$. The menu auctions of environmentalists depend on the impact of a change in the tax on pollution, including pollution abroad. Their gross payoff function v^E is:

$$v^E = B - \alpha_E V^E = B - \alpha_E[(\nu(1-\theta) + \gamma\theta)e(x,a_d) + (\nu\theta + \gamma(1-\theta))e(x^*,a_d^*)] \tag{18}$$

where B is a constant. The policy preference of the environmental group is determined by the sign of the derivative:

$$\frac{dv^E}{dt} = -\alpha_E[(\nu(1-\theta)+\gamma\theta)\frac{de(x,a_d)}{dt} + (\nu\theta+\gamma(1-\theta))\frac{de(x^*,a_d^*)}{dt}] \tag{19}$$

with $\frac{de(x,a_d)}{dt} = \epsilon'(x)\frac{dx}{dt} - w'(a_d)\frac{da_d}{dt}$ and $\frac{de(x^*,a_d^*)}{dt} = -w'(a_d^*)\frac{da_d^*}{dt}$.[11] In a closed-economy framework, a change in the local tax would have no impact on foreign emissions, i.e. $\frac{de(x^*,a_d^*)}{dt} = 0$. The lobby of environmentalists would unambiguously push toward higher tax rates in order to reduce local emissions. This result does not hold when the market of abatement activities is global, as it becomes possible to influence foreign emissions through a change in the local tax. Environmentalists only push toward an increase in the pollution tax if:

$$\frac{\nu\theta+\gamma(1-\theta)}{\nu(1-\theta)+\gamma\theta} < |\frac{\frac{de(x,a_d)}{dt}}{\frac{de(x^*,a_d^*)}{dt}}| \tag{20}$$

where:

$$|\frac{\frac{de(x,a_d)}{dt}}{\frac{de(x^*,a_d^*)}{dt}}| = \frac{\epsilon'(x)\frac{dx}{dt}}{w'(a_d^*)\frac{da_d^*}{dt}} - \frac{w'(a_d)\frac{da_d}{dt}}{w'(a_d^*)\frac{da_d^*}{dt}}$$

In our model, a higher domestic tax increases global abatement activities. It decreases consumption of abatement goods abroad, due to an increase in the price of environmental goods but it is more than compensated by more environmental inputs consumed at home. This quantity effect does not necessarily signify that overall emissions are reduced. In fact, it depends on the initial level of abatement activities in both countries. When the initial level of abatement is identical between countries, the RHS of condition 20 is necessarily higher than one. We know that $|\frac{da_d}{dt}| > |\frac{da_d^*}{dt}|$ and the first term on the RHS is necessarily positive.

However, this work mainly focuses on situations where taxes differ across countries. In fact, we have seen in introduction that it is only when the foreign environmental policy is set at a given low level that it becomes in the interests of environmentalists to influence foreign pollution through local environmental taxation. When initial environmental tax rates are such that $t > t^*$, we know that $a_d > a_d^*$ and thus $w'(a_d) < w'(a_d^*)$. In other words, as depollution activities have decreasing returns to scale, if the initial tax rate is significantly higher at home than it is abroad, the marginal impact on emissions of an increase in the environmental tax can be less important at home than abroad, leading a bigger world amount of emissions.

Definition 1 *We define countries as symmetric (resp. asymmetric) when an increase in the*

[11] We have assumed that depollution is end-of-pipe. Thus, a change in the price of environmental inputs has no influence on the foreign optimal production pattern ($\frac{dx^*}{dt} = 0$).

domestic pollution tax reduces (resp. increases) overall pollution. In other words, countries are symmetric (resp. asymmetric) when $|\frac{\frac{de(x,a_d)}{dt}}{\frac{de(x^*,a_d^*)}{dt}}|$ *is higher (resp. lower) than* 1.

Using the previous definition, the following proposition summarizes environmentalists' political influence on environmental taxes.

Proposition 4 *1. When countries are symmetric:*

(a) If $\nu > \gamma$*, environmentalists are always in favor of an increase in the tax;*

(b) If $\nu < \gamma$*, environmentalists are only in favor of an increase in the tax if pollution is relatively* **mobile***;*

2. When countries are asymmetric:

(a) If $\nu < \gamma$*, environmentalists are never in favor of a higher environmental tax;*

(b) If $\nu > \gamma$*, environmentalists are only in favor of an increase in the tax if pollution is relatively* **immobile***.*

Proof: Let us call $\Phi(\theta)$ the LHS of Condition 20. (i) If $\nu < \gamma$, $\Phi(\theta)$ is decreasing in θ and $\theta \in [0; 1/2] \Rightarrow \Phi(\theta) \in [1; \frac{\gamma}{\nu}]$. Thus, if countries are asymmetric, condition 20 cannot be fulfilled. If countries are symmetric, it is satisfied when θ is not too low, i.e. when pollution spillovers among countries are important enough. (ii) If $\nu > \gamma$, $\Phi(\theta)$ is increasing in θ and $\theta \in [0; 1/2] \Rightarrow \Phi(\theta) \in [\frac{\gamma}{\nu}; 1]$. Thus, if countries are symmetric, condition 20 is always fulfilled. If countries are asymmetric, it is be satisfied only if θ is not too high, i.e. when pollution is mainly local. □

When countries are symmetric, world pollution is reduced by an increase in the domestic tax. In addition, if environmentalists' utility is more affected by one unit of pollution at home than abroad, their utility always increases with an increase in the domestic tax. Even though pollution is increased abroad, it cannot compensate the rise in utility due to the reduction in domestic pollution. It is not the case anymore when environmentalists suffer more from one unit of pollution abroad. When pollution is relatively immobile, it can be in the environmentalists' interest to lobby toward a reduction in the pollution tax as it is going to reduce pollution abroad. This puzzling result actually corresponds to Greenpeace's behavior with respect to French aircraft carrier Clémenceau. Greenpeace France has pushed for an increase in domestic pollution in order to ensure a decrease in foreign pollution because the NGO judged that the marginal environmental damage was lower in France—one can think of a higher protection for workmen—than their perception of each unit of emissions abroad. However, this argument does not hold if pollution is global, as the increase in domestic emissions is going to increase pollution suffered abroad anyway.

In the case of asymmetric countries, the increase in foreign emissions more than compensates a reduction in domestic emissions when a more restrictive environmental policy is introduced. Therefore, it is only when pollution is rather local and when environmentalists are more concerned by domestic pollution that they support a more stringent domestic environmental policy. Take the case of clean development mechanisms (CDM) in the Kyoto Protocol. CDM are a way to lessen the pressure of climate policies in countries listed in Annexe 1 by including the financing of foreign abatement investments. These mechanisms are supported by environmental NGOs because there is the risk that countries not included in Annexe 1 would increase their emissions so much that it would compensate the efforts made by developed countries, increasing worldwide pollution. However, environmental NGOs refuse to support the addition of carbon sinks to these mechanisms. It is definitely a way to compensate greenhouse gas emissions from developed countries but it also includes a reduction in bio-diversity, which directly damages foreign environment, an element not taken into account by Annexe 1 countries' governments.

Note that Case 1.b) can be seen as a reinterpretation of Proposition 1 in Aidt (2005). Indeed, Case 2.b) can correspond to a special case of Proposition 1 in Conconi (2003), when emission leakage comes through the price of abatement activities. Our work differs from previous analyses for two reasons. First, we generalize environmentalists' behaviors for all kinds of preferences and whatever the type of pollution considered. Second, we emphasize that international interactions in the polluting sector are not a necessary condition to explain why in some cases environmentalists push to lessen tax rates. Emission leakage through the abatement market is sufficient.

3.6 Common interests between environmentalists and the eco-industry

Empirically, it happens that environmentalists and eco-industry lobbies launch common political campaigns. These common campaigns can only happen if their interests are aligned. The following table precises in a context of symmetric and asymmetric countries in which cases they have similar interests. In rows, we differentiate between symmetric and asymmetric countries. In columns, we detail environmentalists' preferences with regard to environmental damage at home and abroad and in each situation, we present the cases of local and global emissions. A $+$ (resp. $-$) indicates that a pressure group lobbies toward an increase (resp. a decrease) in the environmental tax.

When pollution is mainly local, the interests of both pressure groups are aligned if environmentalists value more pollution at home than abroad. When pollution is global, lobbies push in the same direction under the condition that countries are symmetric, i.e. overall pollution is reduced following a more stringent domestic regulation. It corresponds to the example emphasized in introduction of a common campaign launched by environmentalists and eco-industries in order to strengthen the new EU Energy Services Directive. In fact, pollution from energy

		Environmentalists			
		$\nu < \gamma$		$\nu > \gamma$	
		Loc Poll	Glob Poll	Loc Poll	Glob Poll
Eco-Industry	Sym. Countries	(+,-)	(+,+)	(+,+)	(+,+)
	Asym. Countries	(+,-)	(+,-)	(+,+)	(+,-)

Figure 1: Positions of environmentalists and the eco-industry toward the environmental tax

suppliers is in general global—greenhouse gas emissions, nuclear accident, ...—and electricity demand is mainly local, so a change in the price on the European electricity market has a low impact on the foreign energy market price. Therefore, pollution abroad should not increase too much following a more stringent Energy Services Directive and the interests of environmentalists and the eco-industry are aligned.

4 The politically optimal environmental policy

We can now present the impacts of lobbying activities on the government's policy. We first consider as a yardstick what the socially optimal tax would be if the regulator was benevolent.

4.1 The socially optimal tax

If the government was benevolent, it would maximize the following function:

$$\begin{aligned} W &= L + \int_0^x Pdu - Px + te(x, a_d) + Px - c_d(x) - p(A)a_d - te(x_s, a_d) \\ &+ p(A)a_s - c_u(a_s) - \nu E(X, A) - \bar{\alpha_E}\gamma E^*(X, A) \end{aligned} \tag{21}$$

Simple algebra yields:

$$W = L + \int_0^x Pdu - c_d(x) - p(A)(a_d - a_s) - c_u(a_s) - \nu E(X, A) - \bar{\alpha_E}\gamma E^*(X, A) \tag{22}$$

The optimal environmental taxation would be given by the following condition:

$$\begin{aligned} \frac{dW}{dt} = 0 \quad \Leftrightarrow \quad & (P - c_d'(x))\frac{dx}{dt} - p(A)\left(\frac{da_d}{dt} - \frac{da_s}{dt}\right) - p'(A)(a_d - a_s)\frac{dA}{dt} \\ - \quad & c_u'(a_s)\frac{da_s}{dt} - \nu\frac{dE}{dt} - \bar{\alpha_E}\gamma\frac{dE^*}{dt} = 0 \end{aligned} \tag{23}$$

Simplifying this equation by using first order conditions of profit maximization for both firms, we get the following condition:

$$\begin{aligned}\frac{dW}{dt}=0 \quad \Leftrightarrow \quad & t\left(\epsilon'(x)\frac{dx}{dt}-w'(a_d)\frac{da_d}{dt}\right)+\frac{\partial\Pi}{\partial p}\frac{\partial p}{\partial A}\frac{dA}{dt} \\ + \quad & \frac{\partial\Pi^{up}}{\partial p}\frac{\partial p}{\partial a_s^*}\frac{da_s^*}{dt}-\nu\frac{dE}{dt}-\bar{\alpha_E}\gamma\frac{dE^*}{dt}=0 \end{aligned} \tag{24}$$

Let us call $\delta=\nu(1-\theta)+\bar{\alpha_E}\gamma\theta$ the average marginal disutility on citizens of one unit of domestic emissions and $\delta^*=\nu\theta+\bar{\alpha_E}\gamma(1-\theta)$ the average marginal disutility on citizens of one unit of foreign emissions. Then, the socially optimal pollution tax should be chosen such that:

$$t^{so}=\delta-\frac{1}{\frac{de(x,a_d)}{dt}}[\frac{\partial\Pi}{\partial p}\frac{\partial p}{\partial A}\frac{dA}{dt}+\frac{\partial\Pi^{up}}{\partial p}\frac{\partial p}{\partial a_s^*}\frac{da_s^*}{dt}-\delta^*\frac{de(x^*,a_d^*)}{dt}] \tag{25}$$

Proposition 5 *An optimal pollution tax chosen by a benevolent regulator would deviate from the average marginal environmental damage according to three distortions: (i) the market power of eco-industries, (ii) strategic incentives in the eco-industry market and (iii) the impact of domestic taxes on foreign emissions.*

The intuitions behind the first two distortions have already been discussed in the literature. The first term between brackets on the RHS of Equation 25 explains that the regulator must tax emissions more severely than the Pigouvian rate in order to lessen the distortion induced by the market power of eco-industries. The second one is a rent-shifting effect. As some of the new abatement activities are supplied by the foreign firm, there is an incentive for the local regulator to lessen the pollution tax.[12] The last term considers a new element, namely the impact of an increase in the domestic tax on foreign emissions. It tends to push toward a reduction in the domestic pollution tax. In fact, one unit of foreign emissions can increase domestic environmental damage through pollution leakage if pollution is transboundary and has in any case a negative impact on environmentalists' utility as it increases foreign pollution.

One can notice that if the price of abatement activities becomes exogenous—for instance if firms and countries are too small to influence it—all three terms disappear and the optimal tax is chosen equal to the average marginal environmental damage. In fact, eco-industry firms lose their market power and as the price of abatement activities does not change, the incentives of the foreign eco-industry and polluting firms are not modified. In a closed economy framework, only the first term would be maintained, leading to a tax unambiguously higher than the average marginal environmental damage.

[12]This holds true under the condition that $\frac{da_s^*}{dt}>0$. We have shown in Canton (2006) that it is not always the case. In those cases, there is one more incentive to push toward a higher tax rate.

4.2 The tax optimizing the government's political payoff function

In our model, the incumbent government maximizes its own political payoff function. Thus, the socially optimal policy is balanced according to the auctions menu proposed by lobby groups such as to maximize the following payoff function:

$$v^g = \lambda W(t) + \sum_k M^k(t) \tag{26}$$

So, as we have seen that we can restrict our analysis to truthful Nash equilibria, the government actually determines the politically optimal pollution tax as follows:

$$\frac{dv^g}{dt} = 0 \Leftrightarrow \lambda \frac{dW}{dt} + \alpha_{us} \frac{d\Pi}{dt} + \alpha_{es} \frac{d\Pi^{up}}{dt} - \alpha_E \frac{dV^E}{dt} = 0 \tag{27}$$

Developing this expression and rewriting it in the same way than the socially optimal environmental tax yields:

$$\begin{aligned} \lambda t^{po} &= \left(\lambda\delta + \alpha_E \delta^E\right) - \frac{1}{\frac{de(x,a_d)}{dt}} \Big[\left(\lambda + \alpha_{us}\right) \frac{\partial \Pi}{\partial p} \frac{\partial p}{\partial A} \frac{dA}{dt} + \left(\lambda + \alpha_{es}\right) \frac{\partial \Pi^{up}}{\partial a_s^*} \frac{da_s^*}{dt} \\ &- \left(\lambda\delta^* + \alpha_E \delta^{*^E}\right) \frac{de(x^*, a_d^*)}{dt} - \alpha_{us} e(x, a_d) + \left(\alpha_{es} a_s - \alpha_{us} a_d\right) \frac{\partial p}{\partial t} \Big] \end{aligned} \tag{28}$$

with $\delta^E = \nu(1-\theta) + \gamma\theta$ is the environmentalists' marginal environmental damage of one unit of domestic emissions and $\delta^{*^E} = \nu\theta + \gamma(1-\theta)$ the environmentalists' marginal environmental damage of one unit of foreign emissions.

Proposition 6 *(i) The menu auctions proposed by lobby groups modify the optimal pollution tax in two ways: they change the relative weight given to each distortion emphasized in the socially optimal scenario and they introduce two other distortions. (ii) One cannot conclude in a general context whether political competition over-internalizes or under-internalizes the environmental externality.*

Each lobby contributes to modify one particular economic distortion emphasized in Equation 25. For instance, environmentalists increase the weight of the marginal environmental damage—due to local or foreign pollution—in the government's payoff function. Eco-industries, on the other hand, push to increase the consideration of the rent-shifting consequences of the environmental tax, while polluting firms want to emphasize the eco-industry's market power. Each distortion is modified according to the proportion of lobbyists in each pressure group. To those elements, the political game adds two other ones. The lobby of polluting firms takes into consideration the tax paid on each unit of pollution. When the tax rate increases, it increases the tax revenues perceived by the government, which is negatively correlated to polluting firms'

profits. Both industrial lobbies also consider the shift in the demand function following a change in the tax. It has a positive impact on the eco-industry but a negative one on polluting firms, as it increases the price of environmental goods. The net impact depends on the degree of concentration of each lobby and on the share of the overall supply or demand they represent in the international abatement market. Overall, as each lobby acts according to its own interests and as they are not similar, it is not clear whether the politically optimal tax will be set lower or higher than the socially optimal one.

If the price of abatement activities was maintained constant, only two incentives would remain. Environmentalists would keep lobbying toward a higher consideration for their local environmental damage and polluting firms would emphasize the impact of a change in the tax rate on tax revenues. However, eco-industries would have no interest in political contributions as their profits would not be modified by a change in the tax. In a closed-economy framework, no rent-shifting effect would exist and the local tax would have no impact on foreign emissions. Both elements would disappear from the politically optimal environmental taxation.

4.3 Comparative statics

Using the implicit function theorem, we proceed to comparative statics. We assume that the second order condition of the government's payoff function maximization is satisfied. Therefore, a change in one of the model's parameters has an impact of the same sign on the politically optimal tax than it has on the first order condition.

An increase in λ gives more weight to welfare in the regulator's payoff function, meaning that the tax gets closer to its optimal level. One can check that when $\lambda \to +\infty$, then $t^{po} \to t^{so}$.

A rise of membership in one of the lobby groups means that at the margin, the group is willing to contribute more money to the government. Consequently, the government adjusts the pollution tax depending on the strategy of each lobby characterized by Propositions 1-2-4. As lobbies are functionally specialized, there are no distributional effects.

$\frac{\partial t^{po}}{\partial \alpha_E^-} > 0 \Leftrightarrow -\lambda\gamma\frac{dE^*}{dt} > 0$. A rise of unorganized environmentalists increases (resp. decreases) the politically optimal tax if foreign overall pollution decreases (resp. increases) with an increase in the domestic tax. More environmentalists mean that the relative weight given to foreign pollution is increased in the welfare function. We observe that a change in the number of shareholders for polluting and eco-industry firms does not influence the optimal pollution tax. Only the proportion of organized shareholders matters.

$\frac{\partial t^{po}}{\partial \nu} > 0 \Leftrightarrow -(\lambda + \alpha_E)\frac{dE}{dt} > 0$: an increase in marginal damage increases (resp. decreases) the political tax if domestic pollution is reduced (resp. increased) by a rise in the environmental tax. This effect takes place both via the impact on welfare and on the environmentalists' payoff function.

$\frac{\partial t^{po}}{\partial \gamma} > 0 \Leftrightarrow -(\alpha_E + \lambda\bar{\alpha_E})\frac{dE^*}{dt} > 0$: more disutility with regard to foreign pollution leads to a lower (resp. higher) political tax at home if foreign pollution increases (resp. decreases) with an increase in the domestic tax. Here again, this effect takes place both via the impact on welfare and on the environmentalists' payoff function.

$\frac{\partial t^{po}}{\partial \theta} > 0 \Leftrightarrow (\nu(\alpha_E+\lambda)-\gamma(\alpha_E+\lambda\bar{\alpha_E}))\left(\frac{de}{dt} - \frac{de^*}{dt}\right) > 0$. An increase in environmental spillovers contributes to increase the environmental tax if $\nu < \gamma\frac{\alpha_E+\lambda\bar{\alpha_E}}{\alpha_E+\lambda}$. When θ is high, an increase in the tax makes local consumers less sensitive to local emissions and more sensitive to foreign ones. As an increase in the tax reduces local emissions and increases foreign ones, the higher the tax, the more significant local pollution. Therefore, it is only when ν is low compared to γ that the government has an interest in increasing the tax.

5 Conclusion

This work is a first attempt to introduce the eco-industry sector in the positive analysis of environmental regulation. As shown through many examples, the environment industry has strong incentives to create its own lobby. Furthermore, it also tends to modify the traditional behaviors of conventional lobbies, namely polluters and environmentalists. Therefore, we wanted to discuss in a general context the different positions taken by these three lobbies. We have shown that it is always in the interest of the eco-industry to push toward more restrictive environmental policies, as they shift upward the demand in abatement activities. We have also emphasized that the emergence of an international market for abatement activities can offer incentives for a vertical industrial lobby to give contributions toward higher tax rates when it is an opportunity to capture foreign rents. Indeed, when foreign environmental policy is exogenous, it can be in the interest of environmentalists to lobby for a less stringent environmental policy at home, so as to reduce pollution abroad. Furthermore, we have also underlined the conditions under which environmentalists and eco-industries can be political allies. We tend to believe that only in these cases their lobbying activities can compensate polluters' campaign contributions toward less restrictive environmental policies, as they will be more organized and more powerful than isolated green lobbies.

This work can be improved in various ways. At first, the institutional framework of developing countries is meant to change, leading place to more stringent environmental policies in these countries. Therefore, a political game introducing the possibility for local pressure groups to lobby abroad will be relevant. Furthermore, the formation of stable coalitions among the different stakeholders should be considered. It would be a way to precise why in some cases, environmentalists and eco-industries launch common campaigns and why in other cases, they take independent decisions. More work is also needed to understand the economic interactions

between the eco-industry sector and the polluting one as they have a direct impact on the political contributions chosen by both lobbies.

6 Appendix

6.1 Conditions for a unique equilibrium on the eco-industry market

Lemma 3 *Let us consider a Cournot game with* 2 *asymmetric players. Let* $p : R_{++} \to R$ *be the* C^2 *inverse demand function in abatement activities which verifies* $\forall A \in]0, +\infty[$, $p(A) > max\{c_u, c_u^*\}$, $\lim_{A\to 0} p'(A) > -\infty$ *and* $p''(A) \leq 0$. *Under these restrictions, there exists a unique Cournot equilibrium in which each firm maximizes its profits given by* $\Pi(a_s, a_s^*) = p(a_s + a_s^*)a_s - c_u(a_s)$ *for the domestic firm and* $\Pi(a_s, a_s^*) = p(a_s + a_s^*)a_s^* - c_u^*(a_s^*)$ *for the foreign firm.*

We make the demonstration for the domestic firm. It can be proceeded to a symmetric analysis in the foreign case. Let us construct $H : R_+ \times R_+ \to R$, given by $H(a_s, A) = p(A) + p'(A)a_s - c_u$ and let us observe that:

- $\forall (a_s, A) \in]0, +\infty[^2$, $\partial_{a_s} H(a_s, A) = p'(A) < 0$
- $\forall A \in]0, +\infty[$, $\lim_{a_s \to 0} H(a_s, A) = p(A) - c_u > 0$
- $\forall A \in]0, +\infty[$, $\lim_{a_s \to +\infty} H(a_s, A) = p(A) + \lim_{a_s \to +\infty} p'(A)a_s - c_u = -\infty$

We can therefore conclude that $\forall A \in]0, +\infty[$, $\exists \hat{a_s} = \psi(A)$ a unique $a_s$with the property that $H(\psi(A), A) = 0$.

- The second order condition is satisfied since this one is given by

$$\begin{aligned} \partial_{a_s} H(a_s, a_s + a_s^*)|_{a_s = \hat{a_s}} &= \partial_{a_s} H(a_s, A)|_{a_s = \hat{a_s}} + \partial_A H(a_s, A)|_{a_s = \hat{a_s}} \\ &= 2p'(A) + p"(A)\hat{a_s} < 0 \end{aligned}$$

- A unique Cournot equilibrium exists if $\Gamma(A) = H(a_s, A) + H^*(a_s^*, A) = 2p(A) + p'(A)A - c_u - c_u^* = 0$ admits a unique solution.

Let us now check this last point. First, we define $\Lambda(A) = 2p(A) + p'(A)A$, for $A \geq 0$, as the aggregate marginal revenue of the industry and $\Theta(A) = c_u + c_u^*$ its aggregate marginal cost. There exists an equilibrium if $\Gamma(A) = 0 \Leftrightarrow \Lambda(A) = \Theta(A)$. We first observe that $\forall A \in]0, +\infty[$:

$$\frac{d\Lambda(A)}{dA} = p'(A)\left(3 + e_{p'}(A)\right) < 0$$

$$\frac{d\Theta(A)}{dA} = 0$$

So, the aggregate marginal revenue of the industry is strictly decreasing and the aggregate marginal cost is constant. Now remark that:

- $\lim_{A\to+\infty} \Lambda(A) = -\infty$ since $\lim_{A\to+\infty} p'(A)A = -\infty$ and $\lim_{A\to+\infty} p(A)$ must be finite otherwise $p'(A) < 0$ makes no sense.
- $\lim_{A\to 0} \Lambda(A) = 2p(A) + p'(A)A > c_u + c_u^*$

Therefore, there exists a unique equilibrium value $\hat{A} > 0$ for which the aggregate marginal revenue equals the aggregate marginal cost.

6.2 Comparative statics

Equation 2 gives the optimal decision of the polluting firm with regard to its level of production x. Adding to this Equation the optimal decision on the demand side, i.e. $u'(x) = P$, we get the overall variation of x according to the pollution tax:

$$\frac{dx}{dt} = \frac{\epsilon''(x)}{u''(x) - c''(x)} < 0 \tag{29}$$

Let us now aggregate first order conditions of profit maximization for eco-industry firms. We have:

$$2p(A, t, t^*) + \frac{\partial p(A, t, t^*)}{\partial A} A + c_u + c_u^* = 0 \tag{30}$$

By totally differentiating this condition, we get:

$$\frac{dA}{dt} = -\frac{2\frac{\partial p(A,t,t^*)}{\partial t} + \frac{\partial^2 p(A,t,t^*)}{\partial A \partial t} A}{3\frac{\partial p(A,t,t^*)}{\partial A} + \frac{\partial^2 p(A,t,t^*)}{\partial A^2} A} \tag{31}$$

The denominator is always negative and we know that $\frac{\partial p}{\partial t}$ is necessarily positive. In our analysis, the inverse demand function has the remarkable property that it can be written as the product of two functions, i.e. $p(A, t, t^*) = f(t, t^*)\rho(A)$. Thus, $2\frac{\partial p(A,t,t^*)}{\partial t} + \frac{\partial^2 p(A,t,t^*)}{\partial t \partial A} A = \frac{\partial f(t,t^*)}{\partial t}\Lambda(A)$, where $\Lambda(A)$ is the aggregate marginal revenue of the industry. As this value is necessarily positive at the equilibrium, we know that the numerator of Equation 31 is positive. So, an increase in the pollution tax necessarily induces a higher world production and consumption of environmental goods.

Main notations

- x (resp. x^*): domestic (resp. foreign) production and consumption of the final goods. $X = x + x^*$
- P: exogenous international price of the final good.
- a_d (resp. a_d^*): demand in environmental goods made by domestic (resp. foreign) polluting firms
- a_s (resp. a_s^*): supply in environmental goods by the domestic (resp. foreign) eco-industry firm. $A = a_d + a_d^* = a_s + a_s^*$
- $p(A, t, t^*)$: world price of abatement activities
- $c_d(x)$: production costs of the domestic polluting industry
- $c_u(a_s)$ (resp. $c_u^*(a_s^*)$): production costs of the domestic (resp. foreign) eco-industry
- t (resp. t^*): domestic (resp. foreign) per unit environmental tax rate
- $\epsilon(x)$: gross emission function of polluters
- $w(a_d)$: depollution function of polluters
- $e(x, a_d) = \epsilon(x) - w(a_d)$ (resp. $e(x^*, a_d^*) = \epsilon(x^*) - w(a_d^*)$): net emission function of domestic (resp. foreign) polluting firms.
- ν: marginal environmental damage of one unit of pollution at home
- γ: marginal disutility for environmentalists of one unit of pollution abroad
- θ: measure of the impact of one unit of domestic emission on foreign pollution
- l: wage rate of one unit of labor supply. L are the overall wages in the economy.
- τ: dummy variable equal to 1 for environmentalists and 0 otherwise.
- α_{us}: proportion of the polluting firm's shareholders engaged in the polluter's lobby
- α_{es}: proportion of the eco-industry's shareholders engaged in lobbying activities
- $\bar{\alpha_E}$: proportion of citizens that are environmentalists
- α_E: proportion of environmentalists engaged in lobbying activities
- v^{us}: payoff function of the polluter's lobby

- v^{es}: payoff function of the eco-industry's lobby
- v^{E}: payoff function of the environmentalists' lobby
- v^{g}: government's payoff function
- v^{jp}: payoff function of a vertical industrial lobby
- λ: weight given to welfare in the government's payoff function
- δ (resp. δ^*): average marginal damage of one unit of domestic (resp. foreign) emissions on domestic citizens
- δ^{E} (resp. $\delta^{*^{E}}$): marginal damage of one unit of domestic (resp. foreign) emissions on environmentalists

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