Which role for eco-industries in the political economy of environmental policy?

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Abstract

This work analyses the political economy of environmental policy in the presence of an eco-industry pressure group in addition to lobbies of polluting firms and environmentalists. The incumbent government maximizes its chances of being reelected. Her objective function encompasses both social welfare and political contributions. Not only does the introduction of the eco-industry lobby introduce a new political contribution, but it also modifies the incentives of the traditional lobbies. We underline the conditions under which environmentalists and eco-industries can be political allies. We also explain that a capitalist lobby group considering the profit of the whole supply chain could be favorable to a more stringent environmental policy. In general, the impact of lobbying activities on the politically optimal tax will be ambiguous as pressure groups push in different directions. When refunding schemes are introduced, it is in the interest of polluting firms to increase their political pressure in answer to a rise of eco-industries lobbying activities.

Keywords: political economy, eco-industry, pollution taxes

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1 Introduction

The new EU chemicals policy—the so-called REACH[1] regulation—is one of the most striking examples of the role that can be played by lobbies so as to influence environmental regulations. Since 2003 and the first discussions about a new regulation for chemicals, lobby groups have put a lot of pressure on the European Commission and the European Parliament in order to influence the final decision. CEFIC—the European chemicals industry lobby—and environmental NGOs have both tried to emphasize the relative costs and benefits of that environmental legislation so as to push toward more (environmental NGOs) or less (CEFIC) regulation. Lobbying is often one of the reasons given to explain why environmental policies differ so much from the instruments that economic theory has recommended for three decades. 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—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. As already assumed in the literature, the government pursues its own goals, seeking a mixture of political contributions and social welfare (Aidt 1998, Conconi 2002, Conconi 2003, Aidt 2005). Previous models deal with two kinds of lobbies: capitalists and environmentalists. We introduce in the process a third pressure group representing the eco-industry sector.[2] We derive the impact on the politically optimal environmental taxation. More specifically, considering the most important feature of the eco-industry sector—a sector that grows according to the stringency of environmental policies—we wonder whether this sector, as a pressure group, behaves like environmentalists—pushing toward higher tax rates—or more like a normal industrial lobby. In fact, it is well known that polluting firms lobby against tighter environmental policies as they consider them as ad-

[1] Registration, Evaluation and Authorisation of Chemicals

[2] "Eco-industries may be described as including firms producing goods and services capable of measuring, preventing, limiting or correcting environmental damage such as the pollution of water, air, soil, as well as waste and noise-related problems. They include clean-technologies where pollution and raw-material used is being minimized" (OECD 1999)

ditional production costs and lower profits. However, if the industry also means the eco-industry—a sector supplying polluting firms in abatement goods and services—then the impact of a change in the environmental policy could be more ambiguous on the overall profits of the vertical chain. We also show that the eco-industry sector has an impact on the political choice of environmentalists, leading in some cases to a surprising result: environmentalists can be in favor of a decrease in the environmental tax.

Examples of lobbying activities from the eco-industry 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 method 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.[3] 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.[4] According to Michaelowa (1998), the abatement sector lobby is also relatively efficient in order to influence 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. So, if the empirical proof of the existence and dynamism of a lobby of eco-industries is abundant, it remains to study the interactions that appear between this lobby and other traditional group pressures.

Our work is based on two strands of the literature. First, it refers to the existing normative literature on eco-industries. This literature explains how the market power of these firms modify 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 well. Imperfect competition among eco-industries tends to push-up the optimal second-best environmental taxation. As the price of environmental goods

[3] http://www.euractiv.com/en/

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

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 from polluting firms induce on the optimal pollution tax. In an open economy context, the eco-industry sector can be a source of strategic environmental policies (Fees & Muehlheusser 2002, Greaker 2004, Canton 2006) with rent-shifting incentives, or can simply mean 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.

We also refer to the political economy of environmental policies. This literature mainly applies instruments that have been used in the political economy of trade policies (Grossman & Helpman 1994). An incumbent government maximizes its chances of being reelected. In this context, her 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 has first been 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) have discussed cases where environmentalists are prone to a decrease in environmental taxation. Pollution leakages in the first analysis and a direct interest in foreign pollution in the second one explain these unintuitive results. One of the aims of this paper is to comfort those results with a different approach and thus new interpretations.

We maintain an open economy context. In two countries, two polluting sectors are subject to an environmental taxation. Therefore, an eco-industry sector arises which supplies polluting firms in abatement activities. Abatement goods and services are assumed internationally traded, creating the

only industrial interaction between both countries. Pollution affects consumers in both countries. It can be transboundary or purely local. Both cases are analyzed. Our main findings can be summarized as follows: first, eco-industries will lobby in favor of more stringent environmental policies except if the impact of foreign competition more than compensates the increase in turnover that a higher tax rate induces. Not surprisingly, polluting firms always lobby against tighter environmental policies. However, a unique pressure group, representing the industry as a whole[5] and taking into account upstream and downstream profits, can sometimes be favorable to an increase in the environmental taxation, as it is going to lead to more profits. 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 does not rely on interactions between countries within the polluting sector. Interactions within the eco-industry sector is a sufficient condition so as to be able to demonstrate that environmentalists can be favorable to a decrease in the local pollution tax. In general, the impact of lobbying activities on the politically optimal environmental policy will be ambiguous. We also introduce refunding schemes, that is payments collected from the tax as subsidies toward both the polluting and the eco-industry sector. That kind of mechanism has been applied in Sweden, which has decided to fully refund emission taxes on NOx to the polluting firms proportional to market shares. However, the mechanism we discuss more precisely refers to the French system of "Les Agences de l'eau", which use the tax collected on polluted water in order to subsidy depollution activities.[6] In our model, this mechanism can have counter-intuitive implications, namely a decrease in the politically optimal pollution tax following an increase in the eco-industry's lobbying activities.

The rest of the paper proceeds as follows. Section 2 presents the economic model. Section 3 examines the political model and comparative statics in order to precise the incentives of each lobby group. Section 4 gives the politically optimal pollution tax and discusses the impact of a change in the number of people in each lobby group. Section 5 considers the role played by refunding schemes on the incentives of each industrial lobby group. Section 6 sums up our work.

[5] One can think of an investment fund, holding shares of both types of firms

[6] cf Glachant (1999) for an economic analysis of this mechanism

2 The economic model

Consider a representative polluting firm, producing an output x_s and a certain level of pollution $e(x_s, a_d)$. Net pollution is positively correlated to production and negatively affected by abatement activities a_d, purchased to an international eco-industry. Polluting firms purchase environmental goods and services as they are subject to an environmental taxation. The environmental market is composed of two firms, one based in each country selling indifferently environmental goods and services to firms in both countries.[7] We are only interested in the political decision in country one, so we assume for now that the other environmental policy is kept constant. Profits of the polluting firm can be written as follows:

$$\max_{x_s, a_d} \Pi = px_s - c(x_s) - qa_d - te(x_s, a_d) \tag{1}$$

where $p = f(X)$ is the price taken by the representative firm, $c(x_s)$ the production cost function twice differentiable and increasing and convex, q the price of environmental inputs a_d necessary to abate pollution. t is the level of environmental taxation and $e(x_s, a_d)$ the emission function. The emission function is assumed continuous and twice differentiable. Partial derivatives have the following signs: $e_{x_s}(x_s, a_d) > 0$ (more production entails more pollution), $e_{a_d}(x_s, a_d) < 0$ (more abatement decreases total emissions), $e_{x_s x_s}(x_s, a_d) > 0$ (emissions from the last unit produced increase with the production level), and $e_{a_d a_d}(x_s, a_d) > 0$ (abatement is subject to diseconomies of scale). Abatement decisions are additively separable to production decisions, which yields $e_{x_s a_d}(x_s, a_d) = 0$

From the First Order Conditions of profit maximization, we get the inverse demand in environmental goods and services.

$$p = c'(x_s) + te_{x_s}(x_s, a_d) \tag{2}$$

$$-q - te_{a_d}(x_s, a_d) = 0 \tag{3}$$

In each market, polluting firms optimize their abatement demands such that $q = -te_{a_d}(x_s, a_d)$ and $q = -t^* e_{a_d^*}(x_s^*, a_d^*)$.[8] Therefore, $a_d = w'^{-1}(\frac{q}{t})$ and $a_d^* = w'^{-1}(\frac{q}{t^*})$. The overall demand, $A = a_d + a_d^*$ is equal to $A = w'^{-1}(\frac{q}{t}) +$

[7] 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). It allows us to simplify the analysis by assuming that no tariffs or transport costs limits the trade of environmental goods and services.

[8] The uppercase * stands for foreign variables

$w'^{-1}(\frac{q}{t^*}) = \omega(q, t, t^*)$. The overall inverse demand can be written as follows: $q(A) = \omega^{-1}(A, t, t^*)$. The price of environmental inputs is decreasing in A. Appendix 1 shows that an increase in the local tax increases both the overall demand and the price of environmental goods and services.

The profit function of the local eco-industry is:

$$\max_{a_s} \Pi^{up} = q(A)a_s - c_u(a_s) - F_u \tag{4}$$

where A is the world production, $c_u(a_s)$ the variable cost function, twice differentiable, increasing and convex and F_u some fixed costs. The first order condition of profit maximization is: $q(A) + q'(A)a_s = c'_u(a_s)$.[9]

All citizens have the same preferences with respect to goods and environmental quality at home. 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, and $E(X, A) = (1-\theta)e(x_s, a_d) + \theta e(x_s^*, a_d^*)$ is the amount of pollution suffered at home with $e(x_s, a_d)$ pollution produced by local polluting firms and $e(x_s^*, a_d^*)$ pollution produced by foreign firms abroad. We assume $u'_x > 0$ and $U''_x \leq 0$. Following Conconi (2003), local consumers are affected by foreign pollution toward a parameter $\theta \in [0, 1/2]$. According to the value of this parameter, various sorts of pollution can be considered. For instance, when $\theta = 0$, it is local pollution only and when $\theta = 1/2$, whatever the source of emissions, the impact of pollution is global. The marginal environmental damage of pollution is assumed strictly positive and constant and equal to ν.

Following Aidt (2005) we assume that environmentalists differ from normal citizens as they care about pollution in the foreign country. In addition to the environmental damage created to each citizen by pollution coming

[9] In order to ensure the existence and uniqueness of a Nash-equilibrium, we add the following assumptions:

Assumption 1 $\frac{\partial^2 \Pi^{up}}{\partial a_s a_s^*} < 0,\ \frac{\partial^2 \Pi^{up}}{\partial a_s a_s^*} < 0$

Assumption 2 $\frac{\partial^2 \Pi^{up}}{\partial a_s^2} \frac{\partial^2 \Pi^{up}}{\partial (a_s^*)^2} - \frac{\partial^2 \Pi^{up}}{\partial a_s a_s^*} \frac{\partial^2 \Pi^{up}}{\partial a_s a_s^*} > 0$

Assumption 1 means that reaction functions are downward sloping and Assumption 2 ensures the stability condition is satisfied. We are sure that there exists a unique Cournot-Nash equilibrium (a_s, a_s^*).

from abroad, environmentalists' utility decreases when foreign citizens suffer more from pollution. Therefore, their utility function can be written as follows:

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

where, $E^*(X, A) = [(1 - \theta^*)e(x_s^*, a_d^*) + \theta^* e(x_s, a_d)]$ is the overall pollution in the foreign country, θ^* being the way local pollution affects the foreign country. γ is the disutility incurred to environmentalists by each unit of pollution abroad. We assume that pollution leakages are symmetric between countries, i.e. $\theta = \theta^*$. There is $\bar{\alpha_E}\%$ of environmentalists in this country.

In our model, there exists two sorts of capitalists, according to which kind of firms they hold shares in. "Brown capitalists" are the shareholders of polluting firms whereas "green capitalists" are the owners of the local eco-industry firm. There are three sources of income in this economy, two are commons to consumers, environmentalists and capitalists, a wage l—coming from the supply of one unit of labor—and lump-sum transfers received from the government $R(.)$. The third source of income is dividends received by capitalists from firms.

3 The political model

The political game is a two-stage game where lobby groups are the principals and the government the only agent. It has been extensively used in the literature following the contribution of Grossman & Helpman (1994). The objective of the incumbent government is to be reelected. Therefore, it is going to maximize a weighted function of national welfare and lobbies contributions. The existence of a solution to this two-stage game has been proved by Bernheim & Winston (1986) in a discrete case and extended by Grossman & Helpman (1994) and Fredriksson (1997)—among others—to continuous functions. For this menu auction, a set of contribution schedules and a policy t^0 is a subgame perfect Nash equilibrium if four main conditions are satisfied. 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^0 must maximize the government's welfare 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. The fourth condition is less intuitive and explanations can be found in Fredriksson (1997). In any case, we do not study the existence of an equilibrium and therefore assume that all four conditions are fulfilled. The

welfare of this economy is:

$$W = L + CS(.) + R(.) + \Pi + \Pi^{up} - \nu E - \bar{\alpha_E}\gamma E^* \tag{7}$$

where L represents the overall wages, $CS(.)$ consumers' surplus and $R(.)$ lump-sum transfers using tax revenues. In a traditional normative approach, the government would choose her environmental taxation by maximizing that function. In our approach, however, her choice will deviate 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 of the government becomes:

$$v^g = \lambda W + \sum_k M^k(t) \tag{8}$$

where λ is the political weight given to the economy's welfare. We allow for three lobby groups. 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 specialised. They only care about one particular aspect of an issue, namely pollution for environmentalists (who are also consumers) and profits for capitalists (who are also consumers and suffer from pollution).[10]

3.1 The payoff function of polluting firms

$\alpha_{bc}\%$ of the $\bar{\alpha_{bc}}$ share-holders of the polluting industry decide to form a lobby. In order to check which kind of environmental taxation they support, we study the way a change in the environmental policy affects the payoff functions of the polluters lobby. As lobbies are assumed functionally specified, the polluting industry lobby group is only concerned by the impact of the environmental taxation on profits:

$$v^{bc} = \alpha_{bc}\Pi = \alpha_{bc}[px_s - c(x_s) - qa_d - te(x_s, a_d)] \tag{9}$$

The lobby supports a change in the environmental policy that can ensure an increase in profits. These profits vary according to the tax rate:

$$\frac{d\Pi}{dt} = \frac{\partial \Pi}{\partial x_s}\frac{dx_s}{dt} + \frac{\partial \Pi}{\partial a_d}\frac{da_d}{dt} + \frac{\partial \Pi}{\partial a_d^*}\frac{da_d^*}{dt} - e(x_s, a_d) \tag{10}$$

[10]While examples of lobby groups with multiple goals can be found, empirical studies seem to show that lobby groups are highly specialised (Aidt 2005).

where a_d^* is the foreign *demand* in environmental goods and services. Using first order conditions of welfare maximization, the net impact of a tax variation on the polluters' lobby pay-off function is:

$$\frac{dv^{bc}}{dt} = \alpha_{bc}[-e(x_s, a_d) + \frac{\partial \Pi}{\partial a_d^*}\frac{da_d^*}{dt}] \tag{11}$$

Proposition 1 *The lobby of polluting firms is unambiguously favorable to a reduction in environmental taxation*

As environmental taxation increases, more abatement efforts have to be implemented. Local demand is switched upward and the price of abatement activities increases. So, demand abroad is reduced, leading to an additional increase in the price of environmental inputs. It has a negative impact on domestic profits.

3.2 The pay-off function of eco-industry

$\alpha_{gc}\%$ of the α_{gc}^- eco-industries' share-holders are assumed to form a new lobby group. Let us study what the incentives are for the eco-industry sector with regard to the impact of a tax on its profits. The profit function will be modified as follows:

$$\frac{d\Pi^{up}}{dt} = a_s\frac{\partial q(A)}{\partial t} + \frac{\partial \Pi^{up}}{\partial a_s}\frac{da_s}{dt} + \frac{\partial \Pi^{up}}{\partial a_s^*}\frac{da_s^*}{dt} \tag{12}$$

After simplification, the net effect of a change in the tax on the pay-off function is:

$$\frac{dv^{gc}}{dt} = \alpha_{gc}\frac{d\Pi^{up}}{dt} = \alpha_{gc}[a_s\frac{\partial q(A)}{\partial t} + \frac{\partial \Pi^{up}}{\partial a_s^*}\frac{da_s^*}{dt}] \tag{13}$$

Proposition 2 *When eco-industry firms are symmetric or weakly asymmetric, the local eco-industry always lobbies for an increase in the tax. When firms are asymmetric enough, an increase in the tax can decrease profits and thus eco-industry firms could ask for lower tax rates.*

When the home country changes its environmental taxation, it increases local demand for environmental goods and services. Thus, it changes the price of environmental goods. It has a negative impact on foreign consumption. However, the overall demand increases. The impact on the production patterns of both firms depends on their relative cost functions. We have presented in another work a model of asymmetric imperfect competition

(Canton 2006) in which an increase in a tax rate can worsen the condition of an eco-industry firm. It happens when firms are asymmetric enough and concerns the low cost firm. If firms are relatively symmetric, both productions are going to increase with an increase in the tax. When they are asymmetric enough, the production of the low-cost firm can decrease, which leads to a decrease in profits. It is only in that case that the eco-industry would be favorable to a decrease in the environmental taxation. It should only be considered as a special case as conditions on cost functions are quite restrictive.[11]

3.3 The pay-off function of environmentalists

Some of the environmentalists create a lobby group. They represent a fraction α_E of the $\bar{\alpha_E}\%$ of environmentalists in this economy. The menu auctions of the environmentalists depend on the impact of a change in the tax on pollution, including pollution abroad. Their gross payoff function is:

$$V^E = -\alpha_E v^E = -\alpha_E[(\nu(1-\theta)+\gamma\theta)e(x_s,a_d)+(\nu\theta+\gamma(1-\theta)e(x_s^*,a_d^*)] \quad (14)$$

The policy preference of the environmental group is determined by the sign of the derivative:

$$\frac{\partial V^E}{\partial t} = -\alpha_E[(\nu(1-\theta)+\gamma\theta)\frac{\partial e(x_s,a_d)}{\partial t} + (\nu\theta+\gamma(1-\theta))\frac{\partial e(x_s^*,a_d^*)}{\partial t}] \quad (15)$$

with

$$\frac{\partial e(x_s,a_d)}{\partial t} = e_{x_s}(x_s,a_d)\frac{dx_s}{dt} + e_{a_d}(x_s,a_d)\frac{da_d}{dt}$$

and

$$\frac{\partial e(x_s^*,a_d^*)}{\partial t} = e_{x_s^*}(x_s^*,a_d^*)\frac{dx_s^*}{dt} + e_{a_d^*}(x_s^*,a_d^*)\frac{da_d^*}{dt}$$

We assume that depollution is end-of-pipe. Thus, a change in the price of environmental inputs has no influence on the optimal production pattern abroad ($\frac{dx^*}{dt} = 0$). Environmentalists push toward an increase in the pollution tax if:

$$\frac{\partial V^E}{\partial t} > 0 \Leftrightarrow \frac{\nu\theta+\gamma(1-\theta)}{\nu(1-\theta)+\gamma\theta} < |\frac{\frac{\partial e(x_s,a_d)}{\partial t}}{\frac{\partial e(x_s^*,a_d^*)}{\partial t}}| \quad (16)$$

[11] When costs are linear, the marginal costs of the high-cost firm has to be at least twice as much as important as the marginal cost of the low-cost firm.

This condition encompasses various situations. We discuss successively the right-hand and the left-hand side.

The RHS of this condition specifies the impact on global pollution of a tax variation at home. We know that an increase in the tax increases the total number of environmental goods and services consumed. It decreases 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 the overall pollution is going to be reduced. In fact, it depends on the marginal efficiency of abatement activities in both countries. The RHS of condition 16 can be rewritten:

$$\frac{-\frac{\partial e(x_s,a_d)}{\partial t}}{\frac{\partial e(x_s^*,a_d^*)}{\partial t}} = \frac{-e_{x_s}\frac{dx_s}{dt}}{e_{a_d^*}\frac{da_d^*}{dt}} - \frac{e_{a_d}\frac{da_d}{dt}}{e_{a_d^*}\frac{da_d^*}{dt}} \tag{17}$$

When countries are symmetric, this fraction is necessarily greater than one.[12] Therefore, when countries are symmetric, world pollution always decreases with an increase in the environmental taxation. If we allow for asymmetric situations, where taxes differ across countries, we find that $|e_{a_d}| < |e_{a_d^*}|$ when $a > a^*$, which means $t > t^*$. As depollution activities have decreasing returns to scale, the marginal impact of a change in the environmental tax can be less important at home than abroad, leading to an increase in the world pollution. We call symmetric countries the case where world pollution decreases in the tax. Conversely, we call asymmetric countries the case where world pollution increases.

The LHS of condition 16 presents the relative impact of emissions on environmentalists' utility. Let us call this ratio Φ. If pollution is purely local, $\theta = 0$ and $\Phi = \frac{\gamma}{\nu}$. When pollution is global, $\theta = 1/2$ and $\Phi = 1$, $\forall\ \nu,\ \gamma$. If $\gamma < \nu$ (resp. $\gamma > \nu$), Φ increases (resp. decreases) in θ.

The following proposition sums up the environmentalists' position toward the environmental policy chosen:

Proposition 3 *1. If $\nu < \gamma$ and countries are symmetric, environmentalists are favorable to an increase in the tax if pollution is relatively* **mobile***;*

2. If $\nu < \gamma$ and countries are asymmetric, environmentalists are always prone to push toward a reduction in the environmental tax;

3. If $\nu > \gamma$ and countries are symmetric, environmentalists are always favorable to an increase in the tax;

[12] We know that $|\frac{da_d}{dt}| > |\frac{da_d^*}{dt}|$ and the first term on the RHS is necessarily positive.

4. *If $\nu > \gamma$ and countries are asymmetric, environmentalists are favorable to an increase in the tax if pollution is relatively* **immobile**.

The comparison between ν and γ precises whether the environmentalist's utility is more affected by one unit of pollution at home or abroad. Usually, it is assumed that consumers are only affected by pollution at home. In that case and if countries are symmetric, i.e world pollution is negatively correlated to the local tax rate, environmentalists would always lobby toward an increase in pollution tax (case 3). However, if pollution is transboundary and if global pollution increases in the tax, environmentalists can actually be favorable to a reduction in the tax (case 4). It has nothing to do with the fact that they care about pollution abroad, it is just that global pollution increases with a more stringent environmental policy, therefore increasing their environmental damage.

Now, assume that $\gamma > \nu$, that is environmentalists are more affected by one unit of emission abroad than at home. In that case, if pollution is immobile and countries are symmetric, the environmentalists' utility is increased if the local tax rate is reduced. It increases pollution at home but decreases it abroad. However, the overall impact on pollution is negative. When pollution is global, foreigners suffer from the increase in local pollution. It is not anymore in the interest of environmentalists to push toward a reduction in the pollution tax (case1). If countries are asymmetric, global pollution is going to be reduced by a decrease in the tax. Therefore, the former drawback disappears and the strategy of environmentalists will always be to push toward less environmental taxation (case 2).

Case 1 is only a reinterpretation of Proposition 1 in Aidt (2005). Indeed, case 4 could be seen as a special case of Proposition 1 in Conconi (2003), when emission leakages are not due to terms-of-trade effects but to differences in abatement efficiency. So, our presentation is first a way to gather both works in a single condition. But what makes our analysis different is also the path through which interactions take place. The only link between both countries is the eco-industry. There is no need to have interactions in the downstream market to give incentives to environmentalists to modify optimal tax rates. For instance, an eco-industry firm is in charge of cleaning water in two cities in two countries. If environmentalists in one country care about the cleanness of water in the foreign country, they can possibly ask for less stringent environmental policies at home so as to shift downward environmental demand at home and increase it abroad.

3.4 The pay-off function of the vertical supply-chain

Until now, we have assumed that capitalists lobby according to the sector they hold shares in. However, the limit between eco-industries and downstream polluting industries is not always so clear. Contracts exist among upstream and downstream firms which are more complex than the simple price-quantity relationship presented here.[13] One can also consider the case of pension funds making a portfolio of different types of activities. In those cases, a lobby of capitalists would behave so as to maximize the overall profits of the vertical chain. Side-payments would be allowed between downstream and upstream firms. We are interested in such a lobby's behavior with regard to a change in the pollution tax. The profit on the vertical chain is:

$$\Pi^{vc} = f(X)x_s - c(x_s) - q(A)(a_d - a_s) - te(x_s, a_d) - c_u(a_s) - F_u \qquad (18)$$

where a_s is the production of the local eco-industry. Let us see how this function varies with a change in the environmental taxation.

$$\frac{\partial \Pi^G}{\partial t} = \frac{\partial \Pi}{\partial x_s}\frac{dx_s}{dt} + \frac{\partial \Pi}{\partial a_d}\frac{da_d}{dt} + \frac{\partial \Pi}{\partial a_d^*}\frac{da_d^*}{dt} - e(x_s, a_d) + \frac{\partial \Pi^{up}}{\partial a_s}\frac{da_s}{dt} + \frac{\partial \Pi^{up}}{\partial a_s^*}\frac{da_s^*}{dt} + a_s\frac{\partial q}{\partial t} \qquad (19)$$

So, the net impact of an increase in the pollution tax on the overall profits of the industry is:

$$\frac{\partial \Pi^{vc}}{\partial t} = \frac{\partial \Pi}{\partial a_d^*}\frac{da_d^*}{dt} + \frac{\partial \Pi^{up}}{\partial a_s^*}\frac{da_s^*}{dt} - e(x_s, a_d) + a_s\frac{\partial q}{\partial t} \qquad (20)$$

This sign is a priori indeterminate. The first three terms are negative and the last one is positive. Therefore, there is ambiguity on whether the overall sector should choose to support a decrease in the tax or not. The trade-off is particularly easy to catch in a closed economy framework. In this context, the first two terms disappear. Recalling that $\frac{\partial q}{\partial t} = -e_{a_d}(x_s, a_d) > 0$, the previous condition can be rewritten:

$$\frac{\partial \Pi^{vc}}{\partial t} = -(e(x_s, a_d) + a_s e_{a_d}(x_s, a_d)) = -e(x_s, a_d)(1 + \xi_{e/a_d}) \qquad (21)$$

where ξ_{e/a_d} is the elasticity of net emissions to a change in abatement activities. If the elasticity is lower than -1, global profits increase if the tax increases.

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

Proposition 4 *A necessary condition for a vertical chain capitalist lobby to support an increase in the pollution tax is a high efficiency of environmental goods and services.*

The overall profit of the vertical chain can only increase if a rise of 1% in the number of environmental goods consumed results in a more than proportional decrease in the level of net emissions. Transfers take place between the upstream and the downstream industry. Overall, there would be a positive gain if they allowed to reduce tax revenues given to the government. Of course in an open economy context, negative impacts coming from foreign reactions should also be considered.[14]

4 The politically optimal environmental policy

We can now present the impacts of these lobby activities on the policy chosen by the regulator. As already recalled, the incumbent government maximizes her own political payoff function, namely:

$$v^g = \lambda W + \sum_k M^k(t) \tag{22}$$

If the government was benevolent, she would maximize welfare following next condition:

$$\begin{aligned} \frac{dW}{dt} = 0 \quad \Leftrightarrow \quad & -Xf'(X)\frac{dX}{dt} + \frac{\partial \Pi}{\partial a_d^*}\frac{da_d^*}{dt} + t\frac{\partial e(x_s, a_d)}{\partial t} \\ + \quad & \frac{\partial \Pi^{up}}{\partial a_s^*}\frac{da_s^*}{dt} + a_s\frac{\partial q}{\partial t} - \nu\frac{\partial E}{\partial t} - \bar{\alpha_E}\gamma\frac{\partial E^*}{\partial t} = 0 \end{aligned}$$

The trade-off that faces a benevolent regulator in the presence of eco-industries have already been discussed extensively (David & Sinclair-Desgagné 2005, Canton et al. 2005, Nimubona & Sinclair-Desgagné 2005). We do not linger over the issue. Now, the social optimal policy is balanced according to the auctions menu proposed by lobby groups. So the government maximizes her own pay-off function:

$$\frac{dv^g}{dt} = 0 \Leftrightarrow \lambda\frac{dW}{dt} + \alpha_{bc}\frac{\partial \Pi}{\partial t} + \alpha_{gc}\frac{\partial \Pi^{up}}{\partial t} - \alpha_E\frac{\partial v^E}{\partial t} = 0 \tag{23}$$

[14] We do not study the coalition formation between both industries. It is an important extension of this work that should be considered in future research.

It can be developed as follows:

$$\begin{aligned}
\frac{dv^g}{dt} = 0 \quad \Leftrightarrow \quad & [\lambda t - \nu(1-\theta)(\alpha_E + \lambda) - \gamma\theta(\alpha_E + \lambda\bar{\alpha_E})]\frac{\partial e(x_s, a_d)}{\partial t} \\
- \quad & [\nu\theta(\alpha_E + \lambda) + \gamma(1-\theta)(\alpha_E + \lambda\bar{\alpha_E})]\frac{\partial e(x_s^*, a_d^*)}{\partial t} \\
- \quad & \lambda X f'(X)\frac{dX}{dt} + (\lambda + \alpha_{bc})\left(\frac{\partial \Pi}{\partial a_d^*}\frac{da_d^*}{dt}\right) - \alpha_{bc} e(x_s, a_d) \\
+ \quad & (\lambda + \alpha_{gc})\left(\frac{\partial \Pi^{up}}{\partial a_s^*}\frac{da_s^*}{dt} + a_s\frac{\partial q}{\partial t}\right) \\
= \quad & 0
\end{aligned} \tag{24}$$

The net impact on the tax depends on the relative size of each lobby group and on the relative impact of a change in the environmental policy on their pay-off function. In most cases, environmentalists and eco-industries will push in the same direction (toward higher environmental taxations). They can possibly compensate the lobbying activities of the polluting industry, generally more organized and more powerful than a single lobby of environmentalists or eco-industries. That is why when one of the two green pressure groups decides to lobby toward lower environmental taxation—because of a fear of foreign competition for the eco-industry or because environmentalists care about foreign pollution—it is likely that the politically optimal pollution tax will be lower than the socially optimal one. When both pressure groups lobby toward lower environmental taxation, the politically optimal tax will fall short of the socially optimal one.

Proposition 5 *(i) In the special case where an increase in the pollution tax decreases profits of the local eco-industry and increases pollution abroad so much that the utility of environmentalists decreases, the politically optimal tax will fall short of the socially optimal one. (ii) In all other cases, lobbying efforts are going in different directions, yielding an ambiguous overall impact on the government's decision.*

Comparative statics Using the implicit function theorem, we proceed to comparative statics. A rise of membership in one of the lobby groups will have the following impact on the politically optimal environmental taxation:

$$\frac{\partial t_{po}^*}{\partial \alpha_i} = -\frac{\frac{\partial g}{\partial \alpha_i}}{\frac{\partial g}{\partial t}} \tag{25}$$

where g is the first order condition of the government's pay-off function maximization. We assume that the second order condition of welfare maximization is satisfied, that is $\frac{\partial g}{\partial t} < 0$. Thus, the impact on the tax of a change in the size of one of the lobbies is given by the sign of the numerator. For each pressure group, the impact of a rise in lobbying membership is of the same sign than what is wished at an individual level. In other words, there are no distributional effects.

Using the same method, comparative statics is presented for the other parameters of the model. We present the results in the case of symmetric countries.

- $\frac{\partial g}{\partial \bar{\alpha_E}} = -\lambda\gamma\frac{\partial E^*}{\partial t} < 0$: a rise of (unorganized) environmentalists decreases the politically optimal tax. More environmentalists mean that the relative weight given to foreign pollution is increased in the welfare function.

- An increase in λ gives more weight to welfare in the pay-off function of the regulator, meaning that the tax will get closer to her optimal level.

- $\frac{\partial g}{\partial \nu} = -(\lambda + \alpha_E)\frac{\partial E}{\partial t} > 0$: an increase in the marginal damage increases the political tax, both via the impact on welfare and on the environmentalists' pay-off function.

- If $\nu > \gamma$, $\frac{\partial g}{\partial \theta} = (\nu(\alpha_E + \lambda) - \gamma(\alpha_E + \lambda\bar{\alpha_E}))\left(\frac{\partial e}{\partial t} - \frac{\partial e^*}{\partial t}\right) < 0$: more environmental spillovers leads to a lower pollution tax rate at home.

  If $\nu < \gamma$, the sign is ambiguous.

- $\frac{\partial g}{\partial \gamma} = -(\alpha_E + \lambda\bar{\alpha_E})\frac{\partial E^*}{\partial t} < 0$: more disutility with regard to foreign pollution leads to a lower political tax at home.

5 Refunding schemes and distributional issues

An important literature exists on refunding schemes and the way it can lead to first-best environmental policies when dealing with imperfect competition in addition to pollution. Gersbach & Requate (2004) examine how refunding emission taxes to firms dependent on market shares should be designed. A first-best self-financing tax/tax refunding scheme exists if the marginal damage from pollution exceeds the marginal distortion in an imperfectly competitive output market with symmetric firms. At the equilibrium, the gross tax rate must exceed marginal damage, but the net tax burden falls

short of marginal damage. In the literature on eco-industries, David & Sinclair-Desgagné (2006) show that the combination of an emission tax and a subsidy to polluters cannot achieve the first-best, while the opposite positive conclusion obtains if the subsidy is granted instead to environment firms. In the first case, as the subsidy on abatement compensates any rise in the price of environmental goods and services, eco-industry firms will rise their price as long as the regulator takes the bill. In the political economy literature, Fredriksson & Sterner (2005) have shown that in a world with two types of polluting firms, low-level polluting firms can be favorable to an increase in the environmental taxation if it allows them to receive a higher part of the refunding schemes.

The main idea of a refunding scheme is to weaken the stiff resistance of polluting industry lobby groups toward environmental policies. They could also be used so as to increase production of eco-industry firms and thus reduce the costs of abatement activities. In this work, the tax levied is going to be used to partly refund the polluting sector and partly used to subsidize the eco-industry firm. Refunding schemes are split between sectors according to their relative political influence. More precisely, let us define $\beta = \frac{\alpha_{bc}}{\alpha_{gc}+\alpha_{bc}}$ as the share of net emissions payment given back to the polluting industry. It can be seen as a political market share, which reflects the relative influence of each lobby. It is easy to check that β is increasing in α_{bc} and decreasing in α_{gc}. In other words, when defining the optimal refunding scheme, the government considers the relative political power of each lobby.

In the specific context considered in this analysis, refunding schemes do not modify the economic equilibrium. We have assumed perfect competition on the downstream market. Therefore, each individual firm cannot influence the global level of production and abatement. In other words, each firm takes as given the share of refunding scheme it receives. Thus, it does not modify the optimal decisions of production and pollution from polluting firms. From the eco-industry point of view, the refunding scheme has an ambiguous impact. On the one hand, receiving subsidies mean more profits for the sector. But on the other hand, refunding schemes are decreasing when the activity of the eco-industry increases. However, the demand faced by eco-industries is not going to change. If the local eco-industry decides to reduce production so as to increase tax revenues, the loss in production will be supplied by the foreign firm. Therefore, the eco-industry sector has no incentives to change her production level.

5.1 The impact on political incentives

If the economic equilibrium is not changed, the political one will be modified. In fact, as lobbies act from a global point of view, they endogenize the impact of a change in the tax on the overall tax revenues and therefore on refunding schemes. The pay-off function of the polluting industry is modified as follows:

$$v^{bc} = \alpha_{bc}[\Pi + \beta R(t)] \tag{26}$$

where Π is the profit function without refunding schemes and $R(t) = te(x_s, a_d)$ the tax revenue. We are going to assume that the tax chosen is always on the increasing part of the Laffer curve, that is tax revenues increase in the tax. A rise in the tax has the following consequences on the polluting industry:

$$\frac{\partial v^{bc}}{\partial t} = \alpha_{bc}[-e(x_s, a_d) + \frac{\partial \Pi}{\partial a_d^*}\frac{da_d^*}{dt} + \beta\left(e(x_s, a_d) + t\frac{\partial e(x_s, a_d)}{\partial t}\right)] \tag{27}$$

We have already seen that the first two terms of this function were negative. The last two terms are positive. The overall impact remains negative, though less and less when α_{bc} increases.[15] In other words, brown capitalists—although they benefit from the refunded emissions payment program—keep lobbying toward lower rates of environmental taxation.

Let us see what the impact of the refunding scheme is on the eco-industry pay-off function:

$$v^{gc} = \alpha_{gc}[\Pi^{up} + (1-\beta)R(t)] \tag{28}$$

If we derive that function with respect to t and simplify it, we get:

$$\frac{\partial v^{gc}}{\partial t} = \alpha_{gc}[a\frac{\partial q}{\partial t} + \frac{\partial \Pi^{up}}{\partial a^*}\frac{da^*}{dt} + (1-\beta)\left(e(x_s, a_d) + t\frac{\partial e(x_s, a_d)}{\partial t}\right)] \tag{29}$$

As we have assumed that an increase in the tax increases emissions payment, the impact of refunding schemes on the political decision of the eco-industry lobby will be positive. So, subsidizing the eco-industry gives more incentives for this lobby to push toward higher environmental taxation.

[15] $\beta = 1$ yields a corner solution, where polluting firms have no interest in abatement activities, as they receive a subsidy equal to the exact amount of taxes given to the government. Fredriksson & Sterner (2005) introduce incomplete property rights, so the accumulated funds may be captured by governments, excluding at the same time the possibility of corner solutions.

5.2 Refunding schemes and politically optimal environmental taxation

Until now, we have assumed that tax revenues were given back to each citizen as lump-sum transfers. Now, we suppose that only firms benefit from refunding schemes. The welfare function does not change but the politically optimal environmental taxation is modified via the influence of pay-off functions and thus political pressure by lobbies:

$$\begin{aligned}
\frac{dv^g}{dt} = 0 \quad \Leftrightarrow \quad & [\lambda t - \nu(1-\theta)(\alpha_E + \lambda) - \gamma\theta(\alpha_E + \lambda\bar{\alpha_E})]\frac{\partial e(x_s, a_d)}{\partial t} \\
- \quad & [\nu\theta(\alpha_E + \lambda) + \gamma(1-\theta)(\alpha_E + \lambda\bar{\alpha_E})]\frac{\partial e(x_s^*, a_d^*)}{\partial t} \\
- \quad & \lambda X f'(X)\frac{dX}{dt} + (\lambda + \alpha_{bc})\left(\frac{\partial \Pi}{\partial a_d^*}\frac{da_d^*}{dt} - e(x_s, a_d)\right) \\
+ \quad & (\lambda + \alpha_{gc})\left(\frac{\partial \Pi^{up}}{\partial a_s^*}\frac{da_s^*}{dt} + a_s\frac{\partial q}{\partial t}\right) \\
+ \quad & (\alpha_{bc}\beta + \alpha_{gc}(1-\beta))\left(e(x_s, a_d) + t\frac{\partial e(x_s, a_d)}{\partial t}\right) \\
= \quad & 0
\end{aligned} \tag{30}$$

First, it is noteworthy that the political tax chosen will be higher than without refunding schemes. In fact, lobbies are more inclined to higher tax rates, as polluters' losses are reduced and eco-industries' profits increased. It also questions distributional issues, as can be shown when introducing a rise in lobbying membership in one of the pressure groups. When the lobby of eco-industries increases, it modifies the political tax as follows:

$$\frac{\partial g}{\partial \alpha_{gc}} = \frac{\partial \Pi^{up}}{\partial a_s^*}\frac{da_s^*}{dt} + a_s\frac{\partial q}{\partial t} + \frac{\alpha_{gc}^2 + 2\alpha_{gc}\alpha_{bc} - \alpha_{bc}^2}{(\alpha_{gc} + \alpha_{bc})^2}\frac{dR(t)}{dt} \tag{31}$$

In the case of the lobby of brown capitalists, we have:

$$\frac{\partial g}{\partial \alpha_{bc}} = \frac{\partial \Pi}{\partial a_d^*}\frac{da_d^*}{dt} - e(x_s, a_d) + \frac{\alpha_{bc}^2 + 2\alpha_{gc}\alpha_{bc} - \alpha_{gc}^2}{(\alpha_{gc} + \alpha_{bc})^2}\frac{dR(t)}{dt} \tag{32}$$

On each equation, the first two terms are familiar. The last ones give the impact of a change in lobbying memberships on the way tax revenues are shared out. These terms have an ambiguous sign that depends on the number of members in each lobby.

Proposition 6 *a) If $\alpha_{gc} < \alpha_{bc}$: (i) an increase in α_{gc} may have a negative impact on the politically optimal pollution tax; (ii) an increase in α_{bc} may have a positive impact on the politically optimal pollution tax.*

b) If $\alpha_{gc} > \alpha_{bc}$: (i) an increase in α_{gc} has a non-ambiguous positive impact on the politically optimal pollution tax; (ii) an increase in α_{bc} has a non-ambiguous negative impact on the politically optimal pollution tax.

Proof: We assume here that the eco-industry increases its profit with an increase in the tax. The sign of the last term of Equation 31 (resp. Equation 32) is the same sign as the one of the difference $\alpha_{gc}-\alpha_{bc}$ (resp. $\alpha_{bc}-\alpha_{gc}$). In the first case, if the difference is positive, then the whole expression is unambiguously positive. The second one is the symmetric case.

Distributional issues are the driving force of this proposition. An increase in the number of members in one of the lobby groups modifies the incentives of both groups with regard to the refunding scheme. The other lobby group is necessarily going to lose political market shares when the first one gets bigger, so it asks for lower tax rates—there is less to receive via refunding schemes. If that lobby is the dominant one—the one with the highest number of lobbyists—the overall impact is a pressure toward a decrease in the political tax.

In general, it is recognized that polluting firms represent a more powerful and more organized lobby than the lobby of eco-industries. Therefore, case *a*) seems more plausible. If the size of the eco-industry's lobby increases, it lowers refunding payments received by polluting firms. So they increase their pressure toward lower tax rates, possibly yielding a surprising result: if $|\frac{\partial \Pi^{up}}{\partial a_s^*}\frac{da_s^*}{dt} + a_s\frac{\partial q}{\partial t}| < |\frac{\alpha_{gc}^2+2\alpha_{gc}\alpha_{bc}-\alpha_{bc}^2}{(\alpha_{gc}+\alpha_{bc})^2}\frac{dR(t)}{dt}|$, a more organized eco-industry leads to lower rates of environmental taxation.

6 Conclusion

In conclusion, this work has allowed to precise the conditions under which environmentalists and eco-industries can be political allies. It is often the case, except when foreign competition on the eco-industry market is too strong or when the impact of the local environmental policy on foreign pollution is too important. We have also shown that a capitalist lobby which would consider the profits of the eco-industry could be favorable to a more stringent environmental policy. In general, the impact of lobbying activities on the politically optimal tax will be ambiguous as pressure groups will push in different directions. The role played by eco-industries allows us to

defend a more optimistic line of argument in terms of the impact of lobbying activities on the environmental performance. Lobbying activities are not necessarily bad news for the environment. Distributional issues can lead to counter-intuitive results when a government chooses to refund a sector. Subsidising the eco-industry sector can be counter-productive as it is in the interest of polluting firms to increase their political pressure in answer to a rise of eco-industries lobbying activities.

This work can be improved in many ways. For instance, the political game and the opportunity of proper coalitions among the different stakeholders should be considered. It would be a way to define precisely why in some cases, environmentalists and eco-industries lobby together and why in other cases, they take independent decisions, though quite similar. More work is also needed to understand the interactions between the eco-industry sector and the polluting one.

Appendix

We present the comparative statics of demand in environmental goods and services. We totally differentiate first-order conditions of welfare maximization:

$$-(\frac{\partial q}{\partial a} + te_{a_d a_d})da_d - (e_{a_d} + \frac{\partial q}{\partial t})dt - \frac{\partial q}{\partial a_d^*}da_d^* = 0$$

$$-(\frac{\partial q}{\partial a^*} + t^* e_{a_d^* a_d^*})da_d^* - \frac{\partial q}{\partial t}dt - \frac{\partial q}{\partial a_d}da_d = 0$$

Rewriting both conditions in matrix notation yields:

$$(\Delta)\begin{pmatrix} \frac{da_d}{dt} \\ \frac{da_d^*}{dt} \end{pmatrix} = \begin{pmatrix} e_{a_d} + \frac{\partial q}{\partial t} \\ \frac{\partial q}{\partial t} \end{pmatrix}$$

with

$$\Delta = \begin{pmatrix} -(\frac{\partial q}{\partial a_d} + te_{a_d a_d}) & -\frac{\partial q}{\partial a_d^*} \\ -\frac{\partial q}{\partial a_d} & -(\frac{\partial q}{\partial a_d^*} + t^* e_{a_d^* a_d^*}) \end{pmatrix}$$

Using Cramer's rule, we get:

$$\frac{da_d}{dt} = \frac{-(e_{a_d} + \frac{\partial q}{\partial t})(\frac{\partial q}{\partial a_d^*} + t^* e_{a_d^* a_d^*}) + \frac{\partial q}{\partial t}\frac{\partial q}{\partial a_d^*}}{|\Delta|}$$

$$\frac{da_d^*}{dt} = \frac{-(\frac{\partial q}{\partial a_d} + te_{a_d a_d})\frac{\partial q}{\partial t} + \frac{\partial q}{\partial a_d}(e_{a_d} + \frac{\partial q}{\partial t})}{|\Delta|}$$

$$\frac{dA}{dt} = \frac{-\frac{\partial q}{\partial t} t e_{a_d a_d} - t^* e_{a_d^* a_d^*}(e_{a_d} + \frac{\partial q}{\partial t})}{|\Delta|}$$

After simplification, we get:

$$\frac{da_d}{dt} = \frac{-\frac{\partial q}{\partial t} t^* e_{a_d^* a_d^*} - \frac{\partial q}{\partial a_d} e_{a_d} - t^* e_{a_d^* a_d^*} e_{a_d}}{|\Delta|}$$

$$\frac{da_d^*}{dt} = \frac{-\frac{\partial q}{\partial t} t e_{a_d a_d} + \frac{\partial q}{\partial a_d} e_{a_d}}{|\Delta|}$$

$$\frac{dA}{dt} = \frac{-\frac{\partial q}{\partial t} t e_{a_d a_d} - \frac{\partial q}{\partial t} t^* e_{a_d^* a_d^*} - t^* e_{a_d^* a_d^*} e_{a_d}}{|\Delta|}$$

Given the assumptions made about the emission function, Δ is necessarily negative. Therefore, a sufficient condition for the overall demand to increase is: $e_{a_d} + \frac{\partial q}{\partial t} \geq 0$. If we add the condition that $-\frac{\partial q}{\partial t} t e_{a_d a_d} + \frac{\partial q}{\partial a_d} e_{a_d} \geq 0$, we are in a normal case, where local demand increases and foreign demand decreases, the overall effect being positive.

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