E C O N O M I C S B U L L E T I N

Environmental regulation incidences towards international oligopolies: pollution taxes vs emission permits

Florent Pratlong
ERASME, Ecole Centrale Paris. EUREQua and PRISM−LASI, Université Paris 1.

Abstract

The purpose of this paper is to analyze whether the choice between two instruments of environmental policy (pollution taxes vs emission permits) affects the market shares in the presence of imperfectly competitive product markets. We consider two countries, referred to as the Domestic country and the Foreign country, agreeing on an equally stringent exogenous ceiling on pollution. These countries are also suppliers on the international markets of two commodities produced by two separate sectors competing à la Cournot. The environmental policy taken by each government is different. The Domestic country implements a tradable emission permits market, while the Foreign country imposes a specific pollution tax across sectors. Thus, the Higher Abatement Cost (the Lower) sector in the Domestic country increases (decreases) its market shares compared to its counterpart in the Foreign country.

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1 Introduction

The development of environmental regulation is regarded as an important policy concern in different countries. At the international level environmental policies, which might be implemented, may be different from one country to another. They might diverge owing to each country's collective choices and their specific characteristics. Then, it won't be surprising if the environmental regulatory regimes implemented in each country would be different in their design and rules. Hence, Dijkstra [1999] demonstrates that decisions in environmental policy are based on public-choice considerations and are heavily influenced by the pleadings of special-interest groups, which result to the different environmental regulations applied.

This paper is concerned with the choice of two instruments to implement an emission constraint: pollution taxes or a tradable emission permits (TEP) system. The relationship between industry oligopoly and environmental regulation has been widely analyzed. Simpson [1995] and Carraro et al. [1996] consider pollution taxes incidences within Cournot oligopoly on output and profitability. In an international framework, Barrett [1994] developed a partial equilibrium model of environmental regulation standards as a strategic industrial policy - dealing with the concept of "ecological dumping". In a partial framework Malueg [1990] and Sartzetakis [1997] also investigate the interaction between the market for emission permits with an oligopolistic product market and the comparison with a command-and-control (CAC) approach. In the past, command and control measures were mainly used to regulate pollution but more recently ecological taxes and emission permits have been implemented. The public choice approach address the motivations of this wider acceptance for the use of market-based instruments in environmental policy. Used as policy instruments for regulating emissions, environmental market-based instruments (discriminated pollution taxes or emission trading) have attracted indeed much attention in many countries in order to introduce more flexibility on pollution control. Actually, pollution taxes are implemented in a differentiated way between sectors for strategic exemption considerations. On the other hand, a tradable permits market represents a system of property rights for the management of environmental pollution. Beyond determining the optimal level of emission permits, policy makers face the difficulty to find an efficient mechanism of allocating the permits. Indeed, the initial allowance of permits issued may lead to competitive distortions between firms on the international market product. As noted by Van der Laan and Nentjes [2001], there are two interpretations of competitive market distortion concept: as an inefficiency in allocation of resources and as an inequity of firms starting conditions. A government might allocate emission permits to its domestic industries, whilst the other would impose pollution taxes to its industries, operating in the same international product market. This is the reason why we can wonder as Woerdman [2001] if grandfathering distribution of permits could be interpreted as a form of implicit subsidization according to the WTO rules or as a form of "State Aid"[1] under the European law.

[1] The notion of State Aid is formulated in the Article 87(1) in the Treated of Amsterdam as "...

This paper intends to analyze the strategic trade implications of alternative choices for environmental instruments (pollution taxes *vs* emission permits). Over last decade, pollution taxes have indeed often be implemented in a differentiated way (OECD [1994], [1999]) between industries due to distributional concerns, leackage incentives or strategic trade considerations. This idea has been analyzed in Hoel [1996]. He investigates the optimal tax differentiation across industries. Nannerup [2001] considers also environmental tax differentiation as a strategic environmental policy to extract foreign rents in an international product market. Sartzetakis and Constantatos [1995] examine how country's choice of environmental regulation (command-and-control or permits) affects trade patterns. This paper differs from these previous studies as it compares in an international framework the implications of differentiated taxes *vs* emission permits.

Our result are similar to Sartzetakis and Constantatos [1995] with a differentiated tax instead of using a CAC regulation. The shift of product market shares operates also when a country uses a price incentive for emission control (represented by pollution taxes) compared with a direct regulation (CAC). However market-based instruments for pollution control is actually more commonly used and this paper reflects the public choice preferences. Pollution taxes introduce also more flexibility for a lower abatement cost industry to increase its market share than in a CAC approach. Our work suggests that a high abatement cost industry (regulated through a tradable permits system) can increase its market shares compared to its rivals (regulated through pollution taxes system). The reverse applies for a low abatement cost industry. It follows that a permits system is not always beneficial for each industry.

The paper is organized as follows. Section 2 describes the framework of the analysis and presents the trade equilibrium model without any environmental regulations. We focus on the Cournot-Nash industry equilibrium on the international markets with pollution regulated in a Domestic country with differentiated pollution taxes and a tradable emission permits scheme in the Foreign country. Then, section 3 considers the incidences of the different environmental regulation mechanisms on market shares and profits. Section 4 offers conclusion.

2 The model

Consider two countries, indexed by $i = d, f$, referred to as the Domestic country and the Foreign country respectively. Each country is constituted by two oligopoly industry sectors, indexed by $j = 1, 2$, which are the sole suppliers on the international market of different commodities. Each industry is consisting of a single representative firm. Denote by q_{ij} the output level of firm j located in country i. It is further assumed that all production is sold for export in a third country, in which inverse

any State Aid granted by a Member State or through State resources in any form whatsover which distorts or threatens to distort competition by favouring certain undertakings or the production of certain good shall, in so far as it affects trade between Member States, be incompatible with the common market".

demand is assumed linear of the form: $P_j = A_j - q_{dj} - q_{fj}$. The competition on the side of each exporting firms is *à-la* Cournot-Nash. Firm ij faces a total cost of production $C_{ij}(q_{ij}) = c_j q_{ij}$, where c_j is a technological parameter representing the constant marginal cost of production in industry j equal across oligopolists in the same sector and located different countries.

2.1 Trade equilibrium without environmental regulations

Consider, as the benchmark case, a situation in which governments don't impose any constraints on the aggregate level of emissions. Thus, each representative firm j located in country i is maximizing its profits, taking as given the decision of its rival in the other country: $\underset{q_{ij}}{Max}\ \Pi_{ij} = (P_j - c_j)q_{ij} = (A_j - q_{dj} - q_{fj})q_{dj} - c_j q_{ij}$ for $i = d, f$ and $j = 1, 2$.

In the trade equilibrium without any environmental regulations, the Cournot-Nash level of output, the level of price and the profit earned by each firm in the international product market are respectively given by:

$$q_{ij}^* = \frac{A_j - c_j}{3} \quad , \quad P_j^* = \frac{A_j + c_j}{3} \quad \text{and} \quad \Pi_{ij}^* = (q_{ij}^*)^2 \tag{1}$$

where the uperscript $(*)$ denotes the variables values in the benchmark case.

2.2 Trade equilibrium with environmental regulations

Let's now turn to the trade equilibrium with environmental regulation. We address here the issue of the regulatory intervention regime to highlight the incidences of introducing different environmental feedbacks in the previous model.

Suppose production for both industries is resulting in emissions of a common pollutant, which generates a negative externality. The emissions in each industry increase with the level of output and are taken to be inversely proportional to the level of abatement efforts. Our specification for the polluting emissions and the abatement activities are based on Kennedy [1994] and Nannerup [2001]. Let $e_{ij} = \frac{q_{ij}}{a_{ij}}$ denotes the amount of pollutant emitted by industry j located in country i, with a_{ij} representing the chosen level of abatement effort interpreted as the chosen output-emission ratio in industry j. The emission reduction imposes a cost to undertake emission abatement activities. Firm j's total cost of abatement in country i, denoted by $K_{ij}(q_{ij}, a_{ij}) = \gamma_j^2 a_{ij} q_{ij}$, is supposed to be a non-decreasing function in both of its arguments. The technological parameter γ_j is different across industry and captures the efficiency in controlling emissions. It denotes the change in industry j' s marginal cost of abatement. Hence, each sector is characterized by a heterogenous cost of abatement profile within the same country and a symmetric abatement cost structure across countries. For simplicity, we assume that industry 1 refers to the Lower-Abatement-Cost (LAC) sector and industry 2 to the Higher-Abatement-Cost (HAC) sector, in the sense that $\gamma_1 < \gamma_2$ for a given level of output. Therefore industry 1, having substantially a more efficient technology in abatement activities, faces a lower expenditures in reducing emission discharges.

An international environmental agreement imposes a similar target level on pollution $\bar{E} = \bar{E}_d = \bar{E}_f$ to these countries. However the measures taken by each country, through which this level is achieved, are different. The Domestic country implements an economic incentive mechanism through a grandfathering tradable emission permits system, whereas the Foreign country imposes a specific-industry pollution tax across firms in a form of a differentiated emission tax per unit of waste discharged in the global environment. In this framework consider now the international trade equilibrium to focus on output redistribution effects and on distortion of competition between countries.

2.2.1 The Domestic country: the tradable emission permits case

The Domestic regulator aims at reducing its emissions to the target $\bar{E}$ defined in the international environmental agreement and implements a tradable emission permits (TEP) market. This latter approach requires all polluting industries to obtain emission permits for their quantity of pollutant released. Emission permits are distributed free of charge to the two domestic industries by initiating a grandfathering system, which allocates permits on the basis of their historic pre-regulation level of emissions.

Industry j receives an initial allocation of permits denoted by $\bar{e}_{dj}$ for $j = 1, 2$. The total endowment of permits is equal to the aggregate emissions ceiling set by the domestic regulator, defined as $e_{d1} + e_{d2} = \bar{E}$. After the initial distribution, industry j's net demand for permits is determined by $NE_{dj} = e_{dj} - \bar{e}_{dj}$. Then, trade of permits is authorized. Now firm j, choosing its level of output and abatement effort, maximizes its profits taking the permits price p_d^{pen} as given according to:

$$\underset{q_{dj},\, a_{dj}}{Max}\ \Pi_{dj} = P_j q_{dj} - K_{dj}(q_{dj}, a_{dj}) - c_j q_{dj} - p_d^{pen}(e_{dj} - \bar{e}_{dj}) \tag{2}$$

The necessary and sufficient first-order conditions for the profit-maximizing choice of production q_{dj} and of abatement efforts a_{dj} imply:

$$\frac{\partial \Pi_{dj}}{\partial q_{dj}} = A_j - 2q_{dj} - q_{fj} - c_j - \gamma_j^2 a_{dj} - \frac{p_d^{pen}}{a_{dj}} = 0 \tag{3}$$

$$\frac{\partial \Pi_{dj}}{\partial a_{dj}} = -\gamma_j^2 q_{dj} + \frac{p_d^{pen} q_{dj}}{a_{dj}^2} = 0 \tag{4}$$

In equation (3), the initial endowment of permits doesn't affect sector j's marginal decision since the permits price is considered as given. As pointed out in the latter condition of equation (4), industry j trades permits until its marginal cost of abatement is equal to the opportunity cost of holding an additional permits, represented by the permits price p_d^{pen}. This price reflects indeed the global emission target. Thus, this optimality rule leads to the fact that the permits price provides the correct incentive for industries to arrange their emission levels. From equation (4), the following abatement effort in industry j yields to:

$$\bar{a}_{dj} = \frac{\sqrt{p_d^{pen}}}{\gamma_j} \qquad \text{for } j = 1, 2 \tag{5}$$

Under a tradable permits market these conditions imply that, in equilibrium, the two industries' marginal costs of abatement are equal to the permits price. As $\gamma_1 < \gamma_2$, then $\bar{a}_{d2} < \bar{a}_{d1}$. The LAC sector (whose marginal cost of abatement is lower) undertakes more emission reductions and sells its permits to the HAC sector 2. Moreover, equalization of marginal abatement costs yields an efficient distribution of abatement efforts across industries in the Domestic country.

We obtain industry j's best reaction function by rearranging conditions (3) and (4). This reaction function is derived for a given permits price. If the domestic permits price is reduced, the domestic reaction function is shifted outwards.

$$q_{dj} = r_{dj}(q_{fj}) = \frac{1}{2}[A_j - 2\gamma_j\sqrt{p_d^{pen}} - c_j - q_{fj}] \quad \text{for } j = 1, 2 \tag{6}$$

The above remarks demonstrates that both market demand and cost function are modified by the introduction of a tradable emission permits regulation.

2.2.2 The Foreign country: the pollution taxes case

The Foreign regulator imposes a differentiated specific-industry tax rate per unit of waste released regarding its emissions target $\bar{E}$. Let t_{fj} denote the specific pollution tax for industry j. This assumption of differentiating tax duties among the two foreign industries reflects the consideration of realistic environmental policy on tax exemption requirement (OECD [1994,1999]) or the incentive to adopt strategic environmental policy for controlling pollution (Nannerup [2001]). As industry 1 - the LAC sector - is assumed to be more efficient than industry 2 - the HAC sector - in controlling emissions (*ie.* $\gamma_1 < \gamma_2$) the foreign regulator decides to levy a lower tax for this former industry. Then, $t_{f1} < t_{f2}$. Confronted with t_{fj}, each firm j chooses its level of output and abatement efforts by maximizing its profit:

$$\underset{q_{ij},\, a_{ij}}{Max}\ \Pi_{fj} = P_j q_{fij} - c_j q_{fj} - K_{fj}(q_{fj}, a_{fj}) - t_{fj} e_{fj} \text{ for } j = 1, 2 \tag{7}$$

The first-order necessary condition for Cournot-Nash equilibrium choice of output and abatement can be written as:

$$\frac{\partial \Pi_{fj}}{\partial q_{fj}} = A_j - 2q_{fj} - q_{dj} - c_j - \gamma_j^2 a_{dj} - \frac{t_{fj}}{a_{fj}} = 0 \tag{8}$$

$$\frac{\partial \Pi_{fj}}{\partial a_{fj}} = -\gamma_j^2 q_{fj} + \frac{t_{fj} q_{fj}}{a_{fj}^2} = 0 \tag{9}$$

From equation (9), we obtain the level of pollution abatement in the Cournot-Nash equilibrium for industry j as:

$$a_{fj} = \frac{\sqrt{t_{fj}}}{\gamma_j} \qquad \text{for } j = 1, 2 \tag{10}$$

Under a given industry-specific tax rate, we derive the following reaction function for industry j:

$$q_{fj} = r_{fj}(q_{dj}) = \frac{1}{2}[A_j - 2\gamma_j\sqrt{t_{fj}} - c_j - q_{dj}] \quad \text{for } j = 1, 2 \tag{11}$$

The foreign reaction function for industry j is decreasing with the foreign environmental specific tax rate.

2.2.3 Trade equilibrium

Under a Cournot-Nash competition in each international products market $j = 1, 2$, the trade equilibrium implies:

$$\bar{q}_{dj} = q^*_{dj} + \frac{2\gamma_j}{3}(\sqrt{t_{fj}} - 2\sqrt{p_d^{tep}}) \tag{12}$$

$$\bar{q}_{fj} = q^*_{fj} + \frac{2\gamma_j}{3}(\sqrt{p_d^{tep}} - 2\sqrt{t_{fj}}) \tag{13}$$

$$\bar{P}_j = P^*_j + \frac{2\gamma_j}{3}(\sqrt{t_{fj}} + \sqrt{p_d^{tep}}) \tag{14}$$

where the uperscipt $(-)$ denotes the variables' values at the trade equilibrium with environmental regulations. Comparison of equations (1) and (12)-(14) reveals how environmental regulations affect industry j's output compared to its pre-regulation level.

The permits price is determined by the market clearing condition: $\sum_{j=1}^{2} \frac{q_{dj}}{a_{dj}} = \bar{E}$.

$$p_d^{tep} = \left[\frac{\gamma_1(A_1 - c_1) + \gamma_2(A_2 - c_2) + 2t_{f1}\gamma_1^2 + 2t_{f2}\gamma_2^2}{3\bar{E} + 4\gamma_1^2 + 4\gamma_2^2}\right]^2 \tag{15}$$

The equilibrium permits price depends on the aggregate emission standard level $\bar{E}$ and remains independent from the initial distribution between industries. This is not surprising since each industry is price taker in the permits market and their permits endowments are exogenous. The equilibrium permits price also increases with the value of the differentiated taxes in the Foreign country.

In the Domestic country, both industries have an incentive to trade their permits at a price p_d^{tep}. In fact, trading of emission permits in the Domestic country implies a redistribution of abatement activities from the less efficient sector - the HAC industry - to the more efficient sector - the LAC industry. This latter industry increases its abatement per unit of output and, thus, its marginal cost of abatement. The domestic industries trade permits until equalization of their marginal cost of abatement. Since the domestic HAC sector (regulated through a TEP system) is less efficient in controlling its emission, it faces a lower implicit price for pollution p_d^{tep} than with a regulation through pollution taxes, such that $p_d^{tep} < t_{f2}$. The same relation applies to the LAC sector. Hence, it follows that the permit price is between the higher and the lower pollution tax, such that $t_{f1} < p_d^{tep} < t_{f2}$. This redistribution of emission control efforts among the domestic industries has two effects. First, the aggregate cost of abatement for a given level of output decreases. Second, market shares are redistributed between firms in the international products market.

3 Interpretation and comments

At this stage, let's have a closer look at the market shares shifting effect. The incidence of differences in environmental regulatory regimes on the trade equilibrium is illustrated as follows. Since environmental regulations increase marginal cost of each industry, firm's reaction function are shifting downwards. However, the effect of environmental regulations on market shares are different in each industries.

Proposition 1 *The domestic HAC (the LAC) sector, regulated through a tradable emission approach, in the Domestic country increases (decreases) its market shares compared to its foreign counterpart.*

As $t_{f1} < p_d^{tep} < t_{f2}$, marginal cost of the domestic LAC industry increases more than its foreign rival. Then the LAC industry's reaction function shifts more inwards than its foreign competitor, while the reverse applies in the HAC industry. The level of output in the domestic LAC industry decreases while the domestic HAC industry increases its level of output compared to the pre-regulation equilibrium. Compared to Sartzetakis and Constantatos[1995], this result shows that a tradable permit system does not systematically shift international trade patterns in favor of the domestic industry.

It appears also that domestic industries, regulated by a grandfathering permits system, don't need to acquire their emission level up to their initial permits endowment contrary to the foreign industry regulated by a specific pollution tax. Since the grandfathered industry obtains a windfall profit in the form of a capital gift, the domestic permits system implies a competitive distortion. Thus, the domestic industry has more financial resources than its foreign competitor. It can be argued that the international differences in environmental regulations change industry's starting condition, inducing thus an inequitable distortion in trade patterns.

From equation (2) and (12)-(14), the profits earned by each industry $j = 1, 2$ in the Domestic and the Foreign country are given by:

$$\bar{\Pi}_{fj} = \frac{1}{9}\left[A_j - c_j + 2\gamma_j(\sqrt{p_d^{tep}} - 2\sqrt{t_{fj}})\right]^2 \qquad (16)$$

$$\bar{\Pi}_{dj} = \frac{1}{9}\left[A_j - c_j + 2\gamma_j(\sqrt{t_{fj}} - 2\sqrt{p_d^{tep}})\right]^2 + p_d^{tep}\bar{e}_{dj} \tag{17}$$

Proposition 2 *Grandfathering permits can be regarded as "State Aid", in the sense that it grants a lump-sum subsidy to the domestic industries since the initial allocation implies for them a financial advantage.*

Nevertheless, a grandfathering emission permits system may not alter trade efficiency, since grandfathering permits generate an opportunity cost equal to the permits price. Indeed, grandfathering permits are used for covering the emissions of the permits owners. Instead of using them, the domestic industry could have sold them. From this perspective, grandfathering permits does not distort efficiency as its opportunity costs is also reflected in the product price.

These interpretations are only valid when the Foreign country implements discriminated pollution taxes across industries for exemption concerns. In the case of a uniform pollution tax, market shares among countries wouldn't have been modified since the foreign permits price would be equal to the pollution tax rate. Then, deviating from a uniform environmental tax and implementing different market-based instruments to control pollution have distributional implications in the international products market.

4 Conclusion

This paper has shown that if the environmental regulators in the Domestic and the Foreign country adopt different regulatory regimes to control emissions, then competition in the international products market is distorted. This argument can support a claim that governments may engage in environmental policy coordination to prevent from altering global international trade conditions.

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