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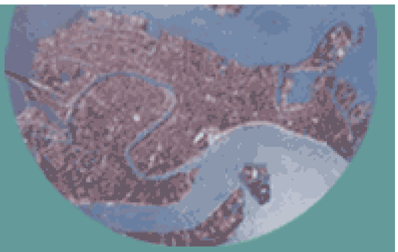

International competitiveness and strategic distribution of emission permits

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Abstract: This paper combines issues related to strategic environmental policy in the case of the design of emissions permits, which affects the rules of international trade. Indeed, policy makers and industrialists frequently express concern about the impact of environmental policy on potential loss of international competitiveness. Our model, based on strategic trade and environmental policy's frameworks, analyses a class of two stage Cournot game involving two governments (domestic and foreign) and their respective industry, which compete in a third country market. It shows that the domestic government may have a strong incentive to distort its distribution of emissions permits from the first-best rule so as to achieve trade-related policies objectives enabling their domestic producers to improve its market share in non cooperative rivalries with the foreign firms. We find that the domestic government issue a higher strategic distribution of emission permits than the optimal level. Therefore, the environmental damage is no more internalise such that the effects of this strategic policy setting on economic welfare is ambigous.

Keywords : International Competition, Strategic Policy, Emissions permits

JEL Classification : F13, F18, Q28

Summary: Since international trade agreements restrict the use of tariffs instruments, environmental policy appears as the only feasible substitute to extract foreigners' rents. Then as government acts strategically in environmental policy maters in an attempt to maximise its own social welfare, it's interesting to consider that strategic distribution of emission permits stands for the concept of 'ecological dumping". This paper combines issues related to strategic environmental policy in the case of the design of emissions permits, which affects the rules of international trade. Within an imperfectly competitive product market, the design choice of rules requiring and allocation emission allowances has distributional implications among firms in the international output market. We use a variation of strategic environmental policy models and extend it to tradeable emission permits systems in the framework of an imperfect international product. Our particularly focus differs in that, instead of considering only on the level of environmental objective, it develops explicitly a tradeable emission permits scheme and deals with the implication of the initial distribution of permits on trade patterns.

The move structure of our model, based on strategic trade and environmental policy's frameworks, analyses a class of two stages Cournot game involving two governments (domestic and foreign) and their respective industry, which compete in a third country market. The first stage is the initial distribution of permits by each government. Then, in the second stage, the firms take this distribution of permits as given by the preceding stage and choose their output level in a Cournot game. The firms play Nash-Cournot against each other and the governments play Stackelberg "vis-à-vis" the firms and Nash against each other. In this paper, we show that the domestic government may have a strong incentive to distort its distribution of emission permits from the first-best rule so as to achieve trade-related policies objectives enabling their domestic producers to improve its market share in non cooperative rivalries with the foreign firms. We find that the domestic government acting strategically, loosens its environmental objectives and sets initially a greater amount of free permits allowances than the optimal level. Deviating from its optimal distribution of permits to encourage its domestic industry to produce more, the domestic government calculates that the rival foreign firms will respond by reducing its output level, thereby raising the profit of its domestic firms. Nevertheless, the environmental damage is no more internalise such that the effects of this strategic policy setting on economic welfare is ambiguous.

1 Introduction:

Facing climate change problems, the industrialised parties (known as "Annex I" parties) collectively decided , during the Kyoto conference in 1997, to stabilize their overall emissions of greenhouse gases by at least 5,2% below their 1990 levels by the years 2008-2012. In particular, imposing an international emissions trading system is an effective means to guarantee the implementation of the Kyoto Protocol. However, at the international level and particularly at the European one, environmental policies, which might set the emissions permits systems, are 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 permits market, implemented in each country, would be different in their design and rules.

First proposed by Crocker (1966) and Dales (1968), the permits market represent a system of tradeable property rights for the management of environmental pollution. The advantages of emissions permits have been widely discussed by Xepapadeas (1997) and Baumol and Oates (1988). They showed that the main difficulty facing policy makers, beyond determining the optimal levels of emissions permits, is to find an efficient mechanism of allocating the permits. In a perfect competitive market, it has been pointed out that the impact of the allocating rules of emissions permits has few effects regardless of the other factors, on the determination of costs and prices. Therefore, as permits are tradeable, the choice of the allowance method has no effect on the partial equilibrium in output market.

Nevertheless, within an imperfectly competitive product market, the design choice of rules requiring and allocating emissions allowances has distributional implications among firms in the international output market. Firms can benefit greatly, depending on the allocation method chosen.

The distribution of emissions permits can be done through two major mechanisms: - "grandfathering" is an allocation rule, where emissions permits are given freely to existing regulated firms on the basis of their historical emissions. It has an opportunity cost, equal to the price at which the permit can be sold, when permits are used to cover the emissions of the permits owner. However, grandfathering could give rise to entry barriers for new sources to enter the market or to grant a subsidy to the pre-existing firms. Kling and Zhao (2001) and Cramton and Kerr (2002) consider that free distribution of emission permits represents a form of "periodic" subsidies, which might influence profits and the decision in output level.

- "auctioning", by selling emissions allowances[1] to the highest bidder. Auc-

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[1] For example, in the US SO_2 allowance program, auctionned permits represent less than 2% of

tionning emissions allowances ensures that permits are available for new firms and to deliver signals on permit prices.

Thus, 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 the competitive distortion concept: as inefficiency in allocation of ressources and as inequity of firms' starting conditions. Indeed, states may have an incentive to allocate their permits so as to favour domestic firms against their foreign rivals. A government might allocate a generous amount of grandfathered permits to domestic firms whilst the others would adopt more stringent initial distribution of permits to their firms, operating in the same international product market. That's the reason why we can wonder, as Woerdman (2001), if grandfathering, in a manner of strategic distribution of permits, could be interpreted as a form of implicit subsidisation according to the WTO rules or as a form of "State Aid" under the European Community law (article 87). In fact, without any harmonisation of the modalities of initial distribution, the allocation of permits can be used as a strategic instrument to alter global international trade conditions.

Indeed, in support of this idea, it's interesting to consider that the strategic distribution of permits stands for the concept of "ecological dumping". In general, ecological dumping occurs when government implements less stringent environmental standards, which act as a hidden subsidy to producers, in order to give its domestic industries a competitive advantage. According to Rauscher (1994), ecological dumping is a "policy which prices environmentaly harmful activities at less than the marginal cost of environmental degradation". This allows them to dump their products on international trade markets at prices that do not reflect the cost of production. In our analysis, the strategic distribution of permits is interpreted as a proxy of this "less stringent environmental standards".

The purpose of this paper is to look at these hypotheses from a strategic-environmental policy point of view. In this case, a government acts strategically in environmental policy matters in an attempt to maximise its own social welfare, taking into account the choices made by competitors. The Orginal model of strategic policy is based on Spencer/Brander's (1983) and Brander/Spencer's (1985) analyses on export subsidisation related to trade patterns. Then, since international trade agreements restrict the use of tariffs instruments, environmental policy appears as the only feasible substitute to extract foreigners'rents.

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the total allowance allocated.

A substantial litterature applied this proposition. Barrett (1994) considered the effects of lower environmental standards in strategic trade policy and showed that when a firm has domestic monopoly power, the government may have an incentive to set less strict environmental standards. This methodology was employed by Ulph (1992), Conrad (1993) and Kennedy (1994), who examined the implication of hidden subsidies by means of low abatement requirements. Others, as Constantatos and Sartzetakis (1995), investigate the impact of the difference between environmental instruments on international competitiveness.

Here, we use a variation of these models and extend it to tradeable emissions permits systems in the framework of an imperfect international product market. Our particular focus differs from previous studies in that, instead of focusing only on the level of environmental objective, it considers explicitly a tradeable emission permits scheme and deals with the implications of the initial distribution of permits on trade patterns. The paper is organised as follows. In section 2, the general framework is introduced and define the Cournot equilibrium under a tradeable emission permits regulation. Results on the implications of the initial distribution of permits are also provided. Then, section 3 turns to define both the optimal and strategic distribution of permits. We show that the strategic distribution of permits is higher compared to its first-best level.

2 The model:

The move structure of this model is based on a two stages game played by firms, located in different countries. The first stage is the initial distribution of permits by each government. Then, in the second stage, the firms take this distribution of permits as given by the preceding stage and choose output level in a Cournot game. The firms play Nash-Cournot against each other and the governments play Stackelberg *vis-à-vis* the firms and Nash against each other. This gives rise to a subgame perfect equilibrium (Selten, 1975). This game is solved by using backward induction. What is important to focus in this study is to determine how the differences on emission permits lead to distorsions on international product market. Then the strategic variable of each regulator is its environmental standard, which defines its initial distribution of permits.

2.1 2nd stage: Cournot Competition in the product market

Assume that there are two countries $u = d, f$ (domestic d and foreign f), whose industry is constituted by two Cournot oligopolists $i = 1, 2$, producing and selling a final product on the international market respectively: $Q_u = \sum_{i=1}^{2} q_u^i$. Output is sold by oligopolists only in a third country[2]. Consumers can choose this homogenous good, perfectly substituable, produced by both countries. Inverse demand function facing the firm is supposed linear such as the market price is given by : $p = p(Q) = a - bQ$ with $a > 0$ and $b > 0$. Also, each firm faces a total cost of production $C_u^i(q_u^i) = c_u q_u^i$, which is different accross countries and identical accross firms in the same country, where c_u is a technological parameter representing the constant marginal cost of production in the country u.

2.1.1 Cournot competition without environmental regulation

Under Cournot conjectures, firm i in the country u decides its output level q_u^i maximising its profit $\Pi_u^i = (p - c_u)q_u^i$. We obtain the following reaction function for firm i : $q_u^i = \frac{a-c_u}{2b} - \frac{q_u^j}{2} - \frac{Q_v}{2}$ taking as given both the rival's output q_u^j (of the other firm in the country u) and the total production Q_v (of the country v's industry). Thus, we can determine the optimal output level for each firm, the agregate supply for each country, the clearing product price on the international market and the profit earned by each firm:

$$\begin{aligned} \hat{q}_u^i &= \frac{a - 3c_u + 2c_v}{5b} && (1) \\ \hat{Q}_u &= \frac{2(a - 3c_u + 2c_v)}{5b} && (2) \\ \hat{p} &= \frac{a + 2(c_u + c_v)}{5} && (3) \\ \hat{\pi}_u^i &= \frac{(a - 3c_u + 2c_v)^2}{25b} && (4) \end{aligned}$$

Cournot competition leads firms to produce by more their unit cost of production is low and the other firm's production costs are high ($q_u^i = \eta(c_u, c_v)$, $\eta_1 < 0$, $\eta_2 > 0$).

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[2] Due to the partial-equilibrium condition of this model, external effects on consumers have been neglected. If they were taken into account, some of the policy implications would be affected.

2.1.2 Cournot competition in the case of environmental regulation by tradeable emission permits systems

The production process generates a negative externality. Pollution is a by-product of production such that the amount of polluting emissions e^i_u affects environmental quality and imposes social costs for the others. We assume that emissions are proportional to the firms' output levels $e^i_u = \rho q^i_u$, where ρ represents the rate of emission per unit of output (the same for each firm). Countries aim to reduce pollution by determining constraints on their emissions. Each emission reduction is costly, to the extend that it needs either by reducing production or by undertaking emisisons abatement A^i_u or a combination of these strategies. Emissions abatement level, $a^i_u = \alpha^i_u q^i_u$, depends on both the output level or the abatement per unit of output α^i_u. Consequently, decisions in output and permits markets are linked. Firm's cost of abatement is assumed to be a quadratic function[3] in the abatement activities denoted by: $A^i_u(q_i, \alpha_i) = d^i a^i_u + g(a^i_u)^2$, where $d^i_u, g \geq 0$ are technological parameters. Assume that the abatement function is increasing in its both arguments $(A^i_u)'_{q^i_u} > 0$, $(A^i_u)'_{\alpha^i_u} > 0$ and convexe $(A^i_u)''_{q^i_u \alpha^i_u} > 0$. .

To make simplifying assumptions, the abatement technology is identical between countries but firms inside the same country have different abatement costs, $d^i_u = d^i_v$ whereas $d^i_u \neq d^j_u$, for instance firm $1's$ abatement technology is more efficient $d^1 < d^2$. If the costs of abatement are identical for firms in the same country then there is no interest to trade emission permits. Furthermore, the similarity in costs of abatement profile between countries allows us to remove all shifts of market shares induced by any technological advantages from a country. Therefore, we can focus on shifts strictly induced by differences in emission permits systems.

Without no environmental regulations, no firms would reduce its output or emission levels or engages in abatement. That's the reason why environmental authorithies decide to reduce their total emission levels and to create a domestic market for tradeable emission permits[4] by setting a standard $\bar{E}_u = \Psi_u \rho \hat{Q}_u$ on polluting emissions, with $\Psi_u \leq 1$. We also consider the environmental damages as independant of the pollution sources, such that each state might only concentrate on regulating its own emissions via permits market. Permits, allowed to be transfered or sold,

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[3] Similar to the work of Sartzetakis (1997), we consider different emission reduction technologies, while emissions per unit of output are similar between firms.

[4] When we consider tradeable emission permits, we should introduce another market to the model. In this paper, we suppose perfect emission permits market.

Pour une extension au cas non concurrentiel, lorsqu'une entreprise dispose d'un pouvoir de fixer le prix des permis, nous pouvons nous référer à Sartzetakis (1996).

stand for a "right to pollute". $\bar{E}_u$ represents the fixed supply of emission permits. After trade, the initial amount of permits given by the environmental agency must be equal to the resulting total emission. Each state can either auction or distribute free of charge (grandfather) permits to the overall polluting firms. We thus consider the variable Ψ_u as the portion of the emission permits initially grandfathered by the environmental regulatory agency in the country u, which is associated with the government's emission limits objectives.

In the case of grandfathering initial distribution of permits, we assume that permits are distributed to the existing firms according to their pre-regulation level of emissions, in which case firm i is given initially an amount $\bar{e}_u^i = \Psi_u \rho \hat{q}_u^i$ of emission permits. The total endowment of permits $\bar{E}_u = \sum_{i=1}^{2} \bar{e}_u^i$ is exogenously determined by country u's environmental authorities. Permits can initially be distributed among firms independantly of their market position, for instance equiproportionately such as $\bar{e}_u^i = \frac{\bar{E}_u}{2}$. To the assumption that both firms have the same marginal costs of production, c_u, the same emissions proportional rates, ρ, then they get the same initial endowment of emission permits. Thus, firm i's net demand of permits is given by its initial permit endowment, the abatement and the rate of emissions per unit of output : $NE_u^i(q_i, \alpha_i) = e_u^i - a_u^i - \bar{e}_u^i = \rho q_u^i - \alpha_u^i q_u^i - \bar{e}_u^i$. Trade of permits are authorized after their initial allocation.

Firms are Cournot players in the product market and price-takers in emission permits market. Each firm determines its output and abatement optimal values by solving the following optimization problem taking as given P_u^{tep} the permit price[5]:

$$\max_{q_u^i, \alpha_u^i} \Pi_u^i = pq_u^i - C_u^i(q_u^i) - A_u^i(q_u^i, \alpha_u^i) - P^{tep} NE_u^i(q_u^i, \alpha_u^i) \text{ for } i \neq j \text{ and } u \neq v \qquad (5)$$

As initial allowance of emission permits $\bar{e}_u^i$ is constant, we can notice that it doesn't influence firm marginal decision because every firms take permits price as given. The property of equivalence[6] is verified between both modes of initial permits allocation.

From first-order condition on abatement rate, we determine hereafter the corresponding optimal abatement level:

$$\breve{a}_u^i = \frac{P_u^{tep} - d^i}{2g} \qquad (6)$$

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[5] P_u^{tep} represents competitive emission permits price in the country u, such as equilibrium on permits market leads to $\sum_{i=1}^{2} NE_u^i = 0$.

[6] Montgommery (1971) established, in the case of perfect competition, that initial distribution of emission permits has no influence on the final allocation of emission permits. It's in the framework of the independance between allocative and distributive effects established by Coase.

Proposition 1 *As at Cournot-Nash equilibrium both firms' marginal costs of abatement are equal to the equilibrium permits price, then the implementation of this environmental regulation doesn't induce a switch in market shares in country* u*.*

Each firm sells or buys emission permits until its marginal cost of an additive permit is equal to its marginal cost of abatement. As $d_1 < d_2$ then $\breve{a}_u^1 > \breve{a}_u^2$. Firm 1, whose marginal cost of abatment is lower, abates more and sells permits to the less efficient firm with higher costs of abatement.

First order conditions to each firms' maximization problem yield to determine the following optimal Cournot-Nash variable choice levels in the case of an environmental regulation (see Appendix 1):

$$\begin{aligned}
\breve{q}_u^i &= \hat{q}_u^i + \rho \frac{2P_v^{tep} - 3P_u^{tep}}{5b} && (7) \\
\breve{Q}_u &= \hat{Q}_u + 2\rho \frac{2P_v^{tep} - 3P_u^{tep}}{5b} && (8) \\
\breve{p} &= \hat{p} + 2\rho \frac{P_v^{tep} + P_u^{tep}}{5} && (9) \\
\breve{\pi}_u^i &= \frac{(a - 3c_u + 2c_v + 2\rho P_v^{tep} - 3\rho P_u^{tep})^2}{25b} + \frac{(d^i - P_u^{\varepsilon})^2}{4g} + P_u^{\varepsilon} \bar{e}_u^i && (10)
\end{aligned}$$

The trade in permits affects several aspects of market interaction, such that it changes the total equilibrium output and thus affects price, revenues and therefore allocative efficiency. What's more, the optimal choice of the output and abatement level is independant from the initial way of allocating emission permits. This distribution only affects firm's profit. As both firms' marginal cost of abatement is equal to equilibrium permits price, therefore the introduction of an environmental regulation, on polluting emissions by the dint of permits market, doesn't affect market shares among firms in the same country u. Moreover, this yields to an efficient distribution of abatement efforts that minimises total costs of compliance since marginal costs of abatement are equalised between firms.

Proposition 2 *Firms shares between countries on product market are then modified according to the relative spread between national and foreign permits price.*

The environmental regulation, via tradeable emission permits, sets additional costs to firms. Nevertheless, the aggregate output level $\breve{Q}_u$ in country u's industry is decreasing in relation to its ex ante level $\hat{Q}_u$ when $P_u^{\varepsilon} > \frac{2}{3}P_v^{\varepsilon}$. Besides, when the environmental regulation implements a tradeable permits market, some firms increase their profits $\breve{\pi}_u^i$ in the regulated case in comparaison with its ex ante level $\hat{\pi}_u^i$ in the non-regulated case if they get enough benefits on permits markets. This possibility to increase its profit comes from a technological superiority or from a more favorable permits distribution.

Replacing the optimal values of firms' decision variables in the clearing condition of emission permits market, $\sum_{i=1}^{2} NE_u^i = 0$, we obtain the following equilibrium permits price:

$$P_u^{tep} = \frac{8\rho^2 bg^2(\rho\hat{Q}_u - \bar{E}_u) + 2bg(5b+6\rho^2)(\rho\hat{Q}_v - \bar{E}_v) + (d_1+d_2)(5b^2+10\rho^2 bg)}{10b^2 + 24\rho^2 bg + 8\rho^4 g^2} \text{ for } u = d, f \tag{11}$$

The emission permits price in the country u can hereafter be written in an open form:

$$\begin{aligned} P_u^{tep} &= L\left[M(\rho\hat{Q}_u - \bar{E}_u) + N(\rho\hat{Q}_v - \bar{E}_v) + (d_1+d_2)(5b^2+10\rho^2 bg)\right] \quad (12) \\ \text{where } L &= \frac{1}{10b^2+24\rho^2 bg+8\rho^4 g^2} > 0,\ M = 8\rho^2 bg^2 > 0 \text{ and } N = 2bg(5b+6\rho^2) > 0 \end{aligned}$$

Permits price depends on the aggregate emission standard level $\bar{E}_u$ and remains independant from the mode of initial permits distribution. This is not surprising because both firms are price takers in country u 's permits market and their permits endowment are exogenous. Country u 's permits price is increasing with country v 's. Indeed these prices are linked because the net demand of emission permits in each country is associated to output, itself a function of permits prices represented by costs.

Furthermore, using these values, we can get the corresponding variations of emission permits prnce in country u and v due to the initial amount of permits initially distributed. Then:

$$\frac{\partial P_u^{tep}}{\partial \Psi_u} = -LM\rho\hat{Q}_u < 0 \tag{13}$$

$$\frac{\partial P_v^{tep}}{\partial \Psi_u} = -LN\rho\hat{Q}_u < 0 \tag{14}$$

Both countries' permits price are decreasing with the initial amount of permits distributed by the regulator in the country u. The higher the quantity of permits initially allocated (*ie.* the lower the environmental standard objectives), the lower the competitive permits price owning to less emissions abated. Therefore, when government decide to tighten its environmental abatement objective, meaning a lower the global initial allowances of emission permits $\bar{E}_u$, the emission permits price remains high.

The total impact of changes in the distribution of permits on the aggregate output level in country u can be obtained by signing the following derivative (see Appendix 2):

$$\frac{\partial Q_u}{\partial \Psi_u} = 2L\rho^2 \hat{Q}_u (3bg + 2\rho^2 g^2) > 0 \tag{15}$$

Proposition 3 *The country u 's agregate output level is increasing with the initial amount of permits issued.*

Total effect is positive under our assumptions, nevertheless there are two opposite directions about the influence if free permits distribution on the country u 's final output level. Thus, we can characterise:

1. a "*direct price effect*" via national permits price. Country u 's permits price is decreasing with the amount of permits initially grandfathered. Then, costs of compliance are less important to the extend firms get initialy an opportunity cost from the free permits distribution. Then, firms in country u can increase their production level in comparaison with firms in country v.
2. an "*indirect competitive effect*", which comes from foreign permits price. As pervioully established, country v 's permits price is decreasing with the amount of permits initially grandfathered in country u. Country v 's permits price has been reduced by the initial grandfathered permits distribution in country u, which alters terms of trade between countries. Firms in country v get also a decrease (less important) of their costs, which enable them to keep their competitiveness.

Proposition 4 *The rival country's output level effect is negative. An increase in the distribution of permits in the country u induces a sharp fall of production abroad*

As more emission permits are distributed among the firms in the country u then they face a lower environmental cost of compliance, which enable them to increase their output level. Thus it leads, on the international product market, to a fall in the foreign output as shown by the sign of the following derivative, determining the impact of the initial allocation in country u on the country's v aggregate output (see Appendix 2):

$$\frac{\partial Q_v}{\partial \Psi_u} = -2Lgb\rho^2 \hat{Q}_u < 0 \tag{16}$$

This complete the analysis of the output stage where Ψ_u is traded as exogenous. We now analyse the preceding stage, in which each state sets a distribution of permits resulting from welfare maximisation. The domestic and foreign governments can be fully aware of how this distribution will affect the second-stage output values via the dependance of output on the distribution of permits (illustrated by equation eq. 7).

2.2 1st stage: Strategic environmental policy concerning the distribution of permits

We now consider the first stage, when the domestic government is fully aware of how this distribution will affect the second stage. In this section we demonstrate under wich conditions environmental policy, in the form of the strategic distribution of emission permits, can enable domestic firms to capture a large share of output market in oder to increase their profits and rents. Governments are observed to choose the distribution of permits Ψ_u in support of the domestic industry in the international output market. Strategic actions are designed to lower the costs of the domestic firms relative to their rivals' costs, which give them strong advantages over their foreign competitors. We consider alternatively the case for optimal and strategic distribution of permits in the domestic country.

2.2.1 Optimal distribution of permits

The domestic and foreign governments set their initial distribution of permits $\bar{E}_u$ associated to Ψ_u (with $u = d, f$) in order to maximise their social welfare W_u. We consider that environmental damage D_u is a quadratic function of emission flows. This formalization is linked to the feature of global warming: agents are affected without any consideration for their geographic origin. The function of the environmental damage is noted by: $D_u = (\bar{E}_u)^2 + (\bar{E}_v)^2$ with $D' \geq 0$ and $D'' > 0$. The environmental damage is a strictly convex function.

The domestic government wishes to maximize the social welfare, which is the domestic industry's profit less the environmental damage. There is no domestic surplus from consumption because it's assumed that all production is for export. This means that the domestic government ignores the distorsion from imperfect competition in output and the usual loss in consumer surplus when it maximises welfare with respect to the initial emission allowance.

$$\max_{\Psi_u} W_u = \sum_{i=1}^{2} \pi_u^i(q_u^i, q_u^j, Q_v, \Psi_u) - D_u(\Psi_u, \Psi_v) \text{ with } i \neq j \text{ and } u \neq v \tag{17}$$

From equation (11), the first order condition for welfare maximising is:

$$\frac{dW_u}{d\Psi_u} = \frac{d\pi_u^1}{d\Psi_u} + \frac{d\pi_u^2}{d\Psi_u} - \frac{dD_u}{d\Psi_u} = 0 \tag{18}$$

This relation points out the usual optimality rule in environmental economics: pollution is set to the level until the marginal benefits measured by marginal profits just equal environmental marginal damage. The total issued number of permits is chosen so that the market creates the correct incentive for firms which emit at the socially-optimum level. The Optimal Distribution of Permits (ODP) with the confines of the Cournot behaviour is determined by Ψ_u^{opt}. For the complete specification, we should refer to Appendix 3.

2.2.2 Strategic distribution of permits

Consider now that one of governments, for example the domestic firms' government, has an incentive to behave strategicaly and to distort its distribution of permits for reason of competitive advantages abroad. The domestic government commits itself to lowering the costs of compliance by domestic firms, which allows them to earn profits by more than the Cournot-Nash equilibrium level. This strategic distribution of permits (SDP) has the deterrent effect of reducing foreign rivals' competitiveness. In this case the domestic government maximises its social welfare W_D, taking as given the first order condition for firms and for foreign government (eq. 18 for $u = f$)[7].

The strategic equilibrium is defined by:

$$\begin{cases} \max\limits_{\Psi_d} \sum\limits_{i=1}^{2} \pi_d^i(q_d^i, q_d^j, Q_f, \Psi_d) - D_d(\Psi_d) \\ sc \ \frac{dW_f}{d\Psi_f} = \frac{d\pi_f^1}{d\Psi_f} + \frac{d\pi_f^2}{d\Psi_f} - \frac{dD_f}{d\Psi_f} = 0 \\ sc \ \frac{d\pi_u^i}{dq_u^i} = 0 \text{ for } i = 1, 2 \text{ and } u = d, f \end{cases} \tag{19}$$

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[7] The domestic government maximise its welfare according to the determination of an ODP abroad.

The first-order necessary condition for the strategic allocation of permits corresponding to this welfare maximisation can be written as:

$$\frac{dW_d}{d\Psi_d}+\left[\sum_{i=1}^{2}\sum_{j=1}^{2}\frac{d\pi_d^i}{dq_d^j}\frac{dq_d^j}{d\Psi_d}+\sum_{i=1}^{2}\frac{d\pi_d^i}{dQ_f}\frac{dQ_f}{d\Psi_d}\right]=0 \tag{20}$$

Equation (15) defines Ψ_d^{strat} as domestic country's strategic distribution of permits. For given q_d^1 and q_d^2, we demonstrate that the term between brackets in equation (15) is positive, then the domestic government sets its emissions limit, corresponding to its distribution of emission permits, to the level where the marginal damage exceeds the marginal benefits. Therefore, emission will be less stringently than could be implied by the optimal rule.

Proposition 5 *The Strategic Distribution of Permits SDP* Ψ_d^{strat} *is higher than the Optimal Distribution of Permits ODP* Ψ_d^{opt}*. Therefore, the domestic government loosens its environmental objectives and sets initialy a greater amount of free permits allowances.*

The reason for deviating from this optimal distribution of permits is because the term in brachets stands for the strategic trade incentive for the domestic regulator to use its environmental policy to encourage its domestic industry to produce more, as the domestic government calculates that the rival foreign firms will respond by reducing its output level, thereby raising the profit of its domestic firms.

3 Final comments:

This paper has shown that if domestic government acts strategically in distribution of emissions permits and competition in international market is imperfect, then domestic firms may improve their position abroad. The strategic distribution of permits issued results to loosen the environmental standard objective and to allocate more emission permits compared to the optimal level. As established, in theory, it's possible for governments to alter the rules of the game to shift output from foreign to domestic firms. The strategic distribution of permits is defined as a strategic environmental policy that conditions or alters a strategic relation between firms by deterring the foreign competitors' production and reshifting product market shares between the domestic and foreign firms.

However, the arguments for using distribution of permits strategically to improve the competitiveness of domestic are rather weak owning to the fact that it also increases environmental damage so that firms emit more than the social-optimum level. The domestic regulator faces then a trade-off between improving international competitiveness of its domestic firms or increasing environmental damage.

Futher extension of this model could be proposed. Policy implications might diverge if we consider that prices rather than quantities are used as strategic variables by the firms in the case of Bertrand oligopoly. In pratice there is also nothing to prevent the government in the other country from acting strategically, which could lead to an interaction game between governments using their environmental policy as a tool. Therefore, to prevent from strategic environmental policy,we sshould wonder whether the allocation of permits should be harmonised within countries competiting on the same international product market .

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5 Appendix:

5.1 Appendix 1

We consider the following program for profit maximisation of the firm i located in the country u, which is facing the environmental regulation on its emissions *via* a tradable permits system. Each firm is caracterised by a revenue function R_u^i, which is decreasing with its rivals' output and set to zero without any productive activty $R_u^i(0, q_v^i, q_u^j, q_v^j) = 0$. The firm i 's problem is to choose output and abatement expenses to maximise its profit as:

$$\max_{q_u^i,\alpha_u^i} \Pi_u^i = R_u^i(q_u^i, q_u^j, q_v^i q_v^j) - C_u^i(q_u^i) - A_u^i(q_i, \alpha_i) - P_u^{pet} NE_u^i(q_i, \alpha_i) \tag{21}$$

$$\max_{q_u^i,\alpha_u^i} \Pi_u^i = pq_u^i - c_u q_u^i - d^i \alpha_u^i q_u^i - g(\alpha_u^i q_u^i)^2 - P_u^{pet}(\rho q_u^i - \alpha_u^i q_u^i - \Psi_u \rho \hat{q}_u^i) \tag{22}$$

The first-order necessary conditions for the optimal allocation $(\breve{q}_u^i, \breve{a}_u^i)$ corresponding to the Cournot-Nash equilibrium can be written as:

$$\frac{\partial \Pi_u^i}{\partial q_u^i} = a - 2bq_u^i - bq_u^j - bQ_v - c_u - d^i \alpha_u^i - 2gq_u^i(\alpha_u^i)^2 - P_u^{pet}(\rho - \alpha_u^i) = 0 \tag{23}$$

$$\frac{\partial \Pi_u^i}{\partial \alpha_u^i} = q_u^i(P_u^{pet} - d^i - 2g\alpha_u^i q_u^i) = 0 \tag{24}$$

From equation (25), we determine the Nash equilibrium value of the abatement efforts choosen by the firm i in the country u:

$$\breve{a}_u^i = \alpha_u^i q_u^i = \frac{P_u^{pet} - d^i}{2g} \tag{25}$$

Replacing this optimal value into equation (24), we obtain the following reaction function for the firm i in the country u:

$$q_u^i = \frac{a - c_u - \rho(1 - \Psi_u)P_u^{pet}}{2b} - \frac{q_u^j}{2} - \frac{Q_v}{2} \tag{26}$$

Substituing one reaction function into the other give us the output level produced by each firm, the total output level in each country, the output price and the profit at the Cournot-Nash equilibrium as described below:

$$\breve{q}_u^i = \frac{a - 3c_u + 2c_v + 2\rho P_v^{pet} - 3\rho P_u^{pet}}{5b} = \hat{q}_u^i + \rho \frac{2P_v^{pet} - 3P_u^{pet}}{5b} \tag{27}$$

$$\breve{Q}_u = \hat{Q}_u + 2\rho \frac{2P_v^{pet} - 3P_u^{pet}}{5b} \tag{28}$$

$$\breve{p} = \frac{a + 2c_u + 2c_v + 2\rho P_v^{pet} + 2\rho P_u^{pet}}{5} = \hat{p} + 2\rho \frac{P_v^{pet} + P_u^{pet}}{5} \tag{29}$$

$$\breve{\pi}_u^i = \frac{(a - 3c_u + 2c_v + 2\rho P_v^{pet} - 3\rho P_u^{pet})^2}{25b} + \frac{(d^i - P_u^{pet})^2}{4g} + P_u^{\varepsilon}\bar{e}_u^i \tag{30}$$

Substituting these optimal values in the equilibrium clearing condition for emission permits market, $\sum_{i=1}^{2} NE_u^i = 0$, we obtain the following equilibrium price for tradable emission permits:

$$P_u^{pet} = \frac{2bg(5b+6\rho^2)(\rho\hat{Q}_u - \bar{E}_u) + 8\rho^2 bg^2(\rho\hat{Q}_v - \bar{E}_v) + (d_1+d_2)(5b^2+10\rho^2 bg)}{10b^2 + 24\rho^2 bg + 8\rho^4 g^2} \text{ for } u = d, f \tag{31}$$

The price of traded quotas hence obtained in the country u is written as follows:

$$\begin{aligned} P_u^{pet} &= L\left[M(\rho\hat{Q}_u - \bar{E}_u) + N(\rho\hat{Q}_v - \bar{E}_v) + (d_1+d_2)(5b^2+10\rho^2 bg)\right] \qquad (32) \\ \text{where } L &= \frac{1}{10b^2 + 24\rho^2 bg + 8\rho^4 g^2} > 0,\ M = 2bg(5b+6\rho^2) > 0 \text{ and } N = 8\rho^2 bg^2 > 0 \end{aligned}$$

5.2 Appendix 2

Let us determine the variation of permits price in the country u and v induced by a change in the portion Ψ_u of the emission permits initially grandfathered (in the case of output-based allocation):

$$\frac{\partial P_u^{pet}}{\partial \Psi_u} = -LM\rho\hat{Q}_u < 0 \tag{33}$$

$$\frac{\partial P_v^{pet}}{\partial \Psi_u} = -LN\rho\hat{Q}_u < 0 \tag{34}$$

Combining equations (34), (35) and using equation (30) it's straightforward to point out how the output level in the country u is influenced by the initial distribution of permits as shown by an increase of the parameter Ψ_u. Using the following chain rules, we can sign this partial derivative:

$$\begin{aligned} \frac{\partial Q_u}{\partial \Psi_u} &= \frac{\partial Q_u}{\partial P_u^{pet}}\frac{\partial P_u^{pet}}{\partial \Psi_u} + \frac{\partial Q_u}{\partial P_v^{pet}}\frac{\partial P_v^{pet}}{\partial \Psi_u} && (35) \\ \frac{\partial Q_u}{\partial \Psi_u} &= \frac{2\rho}{5b}\left[2\frac{\partial P_v^{pet}}{\partial \Psi_u} - 3\frac{\partial P^{pet}}{\partial \Psi_u}\right] = \frac{2L\rho^2\hat{Q}_u}{5b}\left[3M - 2N\right] && (36) \\ \frac{\partial Q_u}{\partial \Psi_u} &= 2L\rho^2\hat{Q}_u(3bg + 2a^2g^2) > 0 && (37) \end{aligned}$$

Then, the influence on the country's v production from the initial endowment of quotas in the country u is determine by the sign of this partial derivative:

$$\frac{\partial Q_v}{\partial \Psi_u} = \frac{\partial Q_v}{\partial P_u^{pet}} \frac{\partial P_u^{pet}}{\partial \Psi_u} + \frac{\partial Q_v}{\partial P_v^{pet}} \frac{\partial P_v^{pet}}{\partial \Psi_u} \tag{38}$$

$$\frac{\partial Q_v}{\partial \Psi_u} = \frac{2\rho}{5b}\left[2\frac{\partial P_u^{pet}}{\partial \Psi_u} - 3\frac{\partial P_v^{pet}}{\partial \Psi_u}\right] = \frac{2L\rho^2 \hat{Q}_u}{5b}[3N - 2M] \tag{39}$$

$$\frac{\partial Q_v}{\partial \Psi_u} = -2gbL\rho^2 \hat{Q}_u < 0 \tag{40}$$

5.3 Appendix 3

There is no domestic surplus from consumption. The domestic government wishes to maximise the social welfare, which is the domestic industry's profit less the environmental damage:

$$\max_{\Psi_u} W_u = \sum_{i=1}^{2} \pi_u^i(q_u^i, q_u^j, Q_v, \Psi_u) - D_u(\Psi_u, \Psi_v) \text{ with } i \neq j \text{ and } u \neq v \tag{41}$$

From equation (42), the first order condition for welfare maximising is:

$$\frac{dW_u}{d\Psi_u} = \frac{d\pi_u^1}{d\Psi_u} + \frac{d\pi_u^2}{d\Psi_u} - \frac{dD_u}{d\Psi_u} = 0 \tag{42}$$

The Optimal Distribution of Permits (ODP) with the confines of the Cournot behaviour is defined by:

$$\Psi_u^{opt} = \frac{(5b^2 + 10\rho^2 bg)(d_1 + d_2) + 8\rho^2 b^2 g^2(\rho Q_v - \bar{E}_v) + 12\rho^3 bg^2 \hat{Q}_u}{\hat{Q}_u(24\rho^2 + 20\rho b^2 + 20b^2 g + 24\rho^3 bg^2 + 8\rho^5 g^2)} > 0 \tag{43}$$

5.4 Appendix 4

Consider now the strategic behavior of the domestic government, which determine its strategic distribution of permits. The domestic regulator solves its social welfare W_d (equation (42)) subject to first order condition for firms (equation (24) and (25)) and taking as given the number of permits issued in the foreign country defined by equation (45). The strategic equilibrium is defined by:

$$\begin{cases} \max\limits_{\Psi_d} \sum\limits_{i=1}^{2} \pi_d^i(q_d^i, q_d^j, Q_f, \Psi_d) - D_d(\Psi_d) \\ sc\ \frac{dW_f}{d\Psi_f} = \frac{d\pi_f^1}{d\Psi_f} + \frac{d\pi_f^2}{d\Psi_f} - \frac{dD_f}{d\Psi_f} = 0 \\ sc\ \frac{d\pi_u^i}{dq_u^i} = 0 \text{ for } i = 1, 2 \text{ and } u = d, f \end{cases} \tag{44}$$

The first-order necessary condition for this problem can be written as:

$$\frac{dW_d}{d\Psi_d} + \left[\sum_{i=1}^{2} \sum_{j=1}^{2} \frac{d\pi_d^i}{dq_d^j} \frac{dq_d^j}{d\Psi_d} + \sum_{i=1}^{2} \frac{d\pi_d^i}{dQ_f} \frac{dQ_f}{d\Psi_d} \right] = 0 \tag{45}$$

The strategic total distribution of permits is defined as a function of Ψ_d^{strat}, as:

$$\Psi_d^{strat} = \frac{a\rho g(2 + 3\rho + 2\rho^2 g)}{\hat{Q}_u(12\rho^2 + 10\rho b^2 + 10b^2 g + 12\rho^3 b g^2 + 4\rho^5 g^2)} + \Psi_u^{opt} \tag{46}$$

Comparing equation (48) and equation (45), we can notice that the strategic total number of permits issued is higher than its optimal level.

$$\Psi_d^{strat} - \Psi_u^{opt} = \frac{a\rho g(2 + 3\rho + 2\rho^2 g)}{\hat{Q}_u(12\rho^2 + 10\rho b^2 + 10b^2 g + 12\rho^3 b g^2 + 4\rho^5 g^2)} > 0 \text{ then } \Psi_d^{strat} > \Psi_u^{opt} \tag{47}$$