Why so many Tradeable Emission Permits within the European Union? *

Alessio D'Amato
Università di Roma
"Tor Vergata"

Edilio Valentini[†]
Università "G. D'Annunzio"
di Chieti-Pescara

*Previous versions of this paper were presented at the Universities of Bari, Cassino and Nottingham and at the 14th EAERE, XVII SIEP, SES 2006 and XVIII Villa Mondragone conferences. We are very much indebted to Stefano Alaimo for his contribution at earlier stages of this research, as well as Paolo Casini, Laura Castellucci, Giuseppe Coco, Bouwe Dijkstra, Stefano Gorini, Tim Hoffmann, Alberto Iozzi, Tito Pietra and Piercarlo Zanchettin for their comments. The usual disclaimer applies.

†Corresponding author: Università "G. D'Annunzio" di Chieti-Pescara , DEST, Viale Pindaro 42, I-65127 Pescara, Italy. E-mail: `valentin@unich.it`

Abstract

This paper suggests a possible theoretical rationale for some pieces of evidence referred to the EU emissions trading system. To this end, we develop a three stage game played by two governments, their respective polluting industries and the environmental authorities taking part to an economic union. Our results show that a decentralized emissions trading system (DETS) does not provide the correct incentives to allocate permits at their socially optimal level, bringing about excessive emission targets with respect to the first best outcome that would arise under a centralized emissions trading system (CETS). We also investigate the channels through which inefficiency arises under the DETS, finding a number of spillovers that are vehiculated by the equilibrium price of permits. Finally, we show how a DETS could result to be the only viable political choice if each member state is captured by its national industries and has veto power in the political decision process.

(**JEL numbers:** F18, Q50. **Keywords:** emissions trading, environmental dumping, environmental federalism)

1 Introduction

The most recent and important evidence of the growing attention that tradeable emission permits are receiving from environmental policy makers is definitely the implementation by the European Union of a trading system for Greenhouse Gases emissions, as a step towards the achievement of the Kyoto targets (Directive 2003/87/CE). The EU market for emission permits was launched in January 2005.

> *"Like any market, the key to prices is scarcity, and the price depends on both the absolute quantity of allowances available and expectations about the future. The most fundamental difference of emissions trading from any normal market is that the amount available depends directly on government decision about allocations; and expectations about the future are largely expectations about future emission targets. The large reduction of EU ETS prices in spring 2006 is the first tangible sign of the scale of the problems around allocation in the EU ETS"* (Grubb and Neuhoff [7], p. 8).

Furthermore, since the slump in spring 2006, the permits price within the EU has continued its slide, towards incessant new records low[1]. In this paper we argue that this evidence is a direct outcome of the regulatory design which has been chosen to allocate permits within the EU. Indeed, by using a stylized theoretical model we show that, on one hand, the EU ETS does not provide the correct incentives to allocate permits at their socially optimal level - bringing about excessive emission targets - and, on the other hand, it results as the preferred political choice if the member states are "captured" by their national industries. Moreover we also investigate the channels through which inefficiency might arise when decisions on the optimal level of permits are delegated to member states.

[1]See, for instance, *http://www.pointcarbon.com* or *http://www.carbonpositive.net.* Last access February, 19^{th}, 2007.

As a matter of facts, the EU Directive provides an example of a decentralized emission trading system (DETS): under this regime permits are traded at the Union level, but each member state has a certain degree of freedom in specifying both the total amount of permits to be allocated within its boundaries and how this amount may be divided among the sectors subject to regulation, and among installations within each sector. Such a devolution of responsibilities is likely to cause an intense lobbying activity by national industries aimed at affecting the distributional impact of permits allocation and the possible consequences on production costs and industrial competitiveness. In fact, there is an increasing concern, mainly expressed by the UK industry, about the risk of competitive distortion within the EU because of an emission trading system which is not fairly and equally implemented in different member states (Carbon Trust [4]). Basically, national governments might use tradeable permits as a means of state aid (Smale et al. [10]) and, more generally, to alleviate domestic firms from the burden of pollution abatement. This concern is already supported by some evidence: indeed, most of the National Allocation Plans (NAPs) that, according to the EU Directive 2003/87/CE, each member state had to submit to the European Commission for the first trading phase (from 2005 to 2007), originally set a number of permits above the one which would have been consistent with the Kyoto target (see Gilbert, Bode and Phylipsen [6]); moreover also for the second phase (from 2008 to 2012) the European Commission had to scale back 11 out of 12 of the first NAPs proposals (the only exception being the UK).

The main aim of this paper is to rationalize all the above evidence. To this end we employ a three stage game played by two governments, their respective polluting industries and the environmental authorities taking part to an economic union (we could alternatively think about a federal state). We show that, when emission permits are traded competitively within the common market, a DETS leads to distortions with respect to a "first best" centralized emission trading system (CETS), that is a regulatory regime setting the power of permits allocation at a central (i.e. economic union) level[2]. Such distortions are due to spillovers that are new with respect to the received literature and that are vehiculated by the equilibrium price of permits. Further, we show that under the assumptions that national governments are completely captured by their firms, a CETS might never be chosen, and agreement (if any) might only converge on a DETS[3].

The attempt of national governments to relax environmental policy in order to secure to domestic firms competitive advantages in international markets is the subject of a number of papers dealing with "environmental dumping" in both international (as in Barrett [1] and Ulph [11]) and federal settings (Ulph [12] and [13]). Our modelling strategy follows the one adopted by that strand of literature but, unlike all the above papers, we *a)* consider emission trading instead of standards or taxes, *b)* extend the analysis also to the case of transboundary pollution (which is more suitable to illustrate the case of Greenhouse Gases emissions), and *c)* do not need to assume any imperfect competition in the output market (which is, in the above cited literature, a necessary condition for having national governments acting strategically). As a consequence, the source of distortion identified in this paper adds to the ones addressed in the received literature[4].

[2]As an example of CETS we can think about the SO_2 trading system implemented in the US where a centralized regulatory agency controls at a federal level the allocation of all emission permits for all participating firms in all states.

[3]To show this result we will assume that the decision of centralizing the allocation responsibility requires unanimity of all involved countries. This assumption will be discussed forward in the paper (see section 5).

[4]We also differ from Pratlong [9] who analyzes the possibility of environmental dumping under emissions trading in a completely different setting, where national firms act in oligopolistic product markets and trade their emission permits in perfectly competitive national markets.

Other theoretical papers deal with questions which are closely related to the issue analyzed in this paper. Böhringer and Lange [2], for instance, show that the optimal design for allocating tradeable emission permits depends on whether the system is closed, that is regulated by a unique centralized agency, or open, when different regulatory agencies assign a fraction of the total number of allowances to be traded with outsider firms. The main focus of their paper, however, is on the most appropriate metrics for the allocation of allowances - namely lump sum allocation (that is not based on historical emissions/output) versus assignment rules which allocate permits proportionally to the emissions or production of the preceding periods. On the contrary, we evaluate the DETS by comparing its aggregate emissions target with the socially optimal one which would arise under the CETS.

Our paper is also close to the work by Helm [8] who analyzes in a very similar setting the allocation of emission permits under two alternative regulatory regimes, namely with and without the possibility of trading permits. In his paper Helm finds that the possibility of trading may induce more pollution since the higher number of permits chosen by environmentally less concerned countries may offset the choices of the more concerned ones[5]. Nevertheless since he focuses on an international scenario where the allocation of emission permits *"is chosen by interdependent yet sovereign states"* (Helm [8], p.2738), his analysis does not allow for the case of a centralized authority (CETS).

The main features of our model are presented in the next section whereas the rest of the paper is organized as follows. Section 3 derives the conditions characterizing the optimal choices of the firms which choose emission levels in order to maximize their profits. In section 4 we compare the optimal choices of allowances to be issued to the firms under the two regulatory regimes and

[5] Boom and Dijkstra [3] expand the analysis of Helm [8]. By including boundary solutions they show that in some cases the results presented by Helm do not hold.

emphasize the main international spillovers characterizing the inefficient outcomes under the DETS. Section 5 derives a possible explanation for the choice of a DETS. Finally, section 6 contains some short concluding remark.

2 The structure of the model

We analyze a stylized model representing an Economic Union - we could alternatively think about a Federal State - formed by two countries (a domestic one, labelled as d, and a foreign one, labelled as f).

In each country there is a national government and a large number of identical firms. By normalizing to 1 the number of firms in each country, we deal with one "representative" firm in the domestic country (firm d) and one in the foreign country (firm f). Each firm's production activity generates polluting emissions e_i $(i = d, f)$. In the rest of the paper we assume that emissions cause *transboundary pollution*; then the environmental damage in country i is given by $D_i\left(e_d + e_f\right)$, where, as it is standard, we assume that $\frac{\partial D_i}{\partial e_i} = \frac{\partial D_i}{\partial e_j} > 0$, $\frac{\partial^2 D_i}{\partial e_i^2} > 0$ and $\frac{\partial^2 D_i}{\partial e_i \partial e_j} > 0$ $(i, j = d, f)$[6].

We believe that imposing transboundary pollution is important to represent an emission trading scheme regulating CO_2 emissions. Nevertheless, in Appendix B we are going to remove this specific assumption in order to prove that our main results do not depend on the international externality due to the nature of emissions.

The interactions among the two firms and the institutional actors playing within the Economic Union are defined by the following three stage game of complete (but imperfect) information. In the first stage, the two governments have to decide about two alternative institutional frameworks, namely the CETS and the

[6]Emissions coming from the two countries are, therefore, implicitly assumed to be perfect substitutes in the environmental damage function.

DETS. Under the CETS both the governments appoint the power of allocating permits to a single environmental authority acting at the Union level whereas, under the DETS, each government delegates the decision on permits allocation to its national authority.

If the CETS has been chosen at stage 1, in the second stage the centralized authority chooses the amount of emission permits, $\overline{e}_d$ and $\overline{e}_f$, to be issued to each representative firm in order to maximize the difference between total profits and total environmental damages,

$$W = \Pi_d \left(e_d(\overline{e}_d, \overline{e}_f)\right) + \Pi_f \left(e_f(\overline{e}_d, \overline{e}_f)\right) - D. \tag{1}$$

where $D = D_d \left(e_d \left(\overline{e}_d, \overline{e}_f\right) + e_f \left(\overline{e}_d, \overline{e}_f\right)\right) + D_f \left(e_d \left(\overline{e}_d, \overline{e}_f\right) + e_f \left(\overline{e}_d, \overline{e}_f\right)\right)$.

On the other hand, if the DETS is in charge, the two national authorities play a simultaneous-move "Cournot-Nash game". In this game, each national authority chooses the amount of permits to be issued to the firm(s) located within its national borders and takes other authority's choices as given. In this case, each national authority i chooses $\overline{e}_i$ in order to maximize the following objective function:

$$W_i = \Pi_i \left(e_i(\overline{e}_i, \overline{e}_j)\right) - D_i \left(e_i \left(\overline{e}_i, \overline{e}_j\right) + e_j \left(\overline{e}_i, \overline{e}_j\right)\right). \tag{2}$$

with $(i = d, f)$ and $i \neq j$.

Taking as given the values of $\overline{e}_d$ and $\overline{e}_f$, in the third stage the two "representative" firms choose their emission levels (e_d and e_f respectively) in order to maximize their **net** profits, Π_d and Π_f. Net profits of the "representative" firm operating in country i $(i = d, f)$ are

$$\Pi_i = \pi_i(e_i) - p_e(e_i - \overline{e}_i) \tag{3}$$

where $\pi_i(e_i)$ are **gross** profits[7] while p_e is the permits price respectively. Gross

[7] Alternatively, we could strictly follow Helm [8] and interpret function π_i as "benefits from emissions". Our results would not be affected by this alternative specification.

profits are assumed to be increasing and concave in e_i, that is $\frac{\partial \pi_i}{\partial e_i} > 0$, $\frac{\partial^2 \pi_i}{\partial e_i^2} < 0$. The last term of the **net** profit function is the amount of money the firm spends (earns) if it is a net buyer (seller) of permits.

In the following sections we solve this game at its different stages in order to identify the subgame perfect Nash equlibria.

3 The firms' choices

In this section we derive the conditions characterizing the optimal choices of the firms in the third stage of the game. Assuming interior solutions, the first order conditions for the maximization of (3) are:

$$\frac{\partial \Pi_i}{\partial e_i} = \frac{\partial \pi_i(e_i)}{\partial e_i} - p_e = 0 \tag{4}$$

$(i = d, f)$[8]. Condition (4) simply requires that marginal benefits of emissions equal permits price. Comparative statics over this condition leads to

$$\frac{\partial^2 \pi(.)}{\partial e_i^2} \frac{de_i}{dp_e} - 1 = 0$$

that is

$$\frac{\partial e_i}{\partial p_e} = \frac{1}{\frac{\partial^2 \pi_i(.)}{\partial e_i^2}} < 0 \tag{5}$$

i.e. the firms' optimal level of emissions decreases as the equilibrium price in the emission permits market increases.

The equilibrium price of permits is implicitly defined by the following market clearing condition[9]:

$$e_d + e_f = \overline{e}_d + \overline{e}_f. \tag{6}$$

From such condition we can derive the sign of the relationship between the equilibrium level of p_e and the initial endowments of permits in the two countries.

[8]Second order sufficient conditions for an optimum are clearly satisfied.

[9]We limit our attention to the case of a strictly positive equilibrium permits price.

Differentiating (6) with respect to $\overline{e}_d$ and $\overline{e}_f$ respectively, and using (5) we get:

$$\frac{\partial p_e}{\partial \overline{e}_d} = \frac{\partial p_e}{\partial \overline{e}_f} = \frac{\partial p_e}{\partial e} = \frac{1}{\frac{1}{\frac{\partial^2 \pi_d(\cdot)}{\partial e_d^2}} + \frac{1}{\frac{\partial^2 \pi_f(\cdot)}{\partial e_f^2}}} < 0. \tag{7}$$

where the assumption that gross profits are increasing and concave in e_i guarantees the negativeness shown in (7), while $e = \overline{e}_d + \overline{e}_f$. From (5) and (7) we can further conclude, as it is reasonable, that $\frac{\partial e_i}{\partial \overline{e}_i} = \frac{\partial e_i}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_i} > 0$ and $\frac{\partial e_i}{\partial \overline{e}_j} = \frac{\partial e_i}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_j} > 0$.

Now we can study how maximum profits vary with the initial endowment of permits. To deal with this issue we have to consider two possible effects related to a change in the amount of emission permits issued by the environmental authority. First of all there is a direct positive effect: getting more emission permits make firms better off as they can either sell more or buy less permits. We call this the "wealth effect". On the other hand, firms' profits are also indirectly affected by the levels of emission permits through the negative relationship between p_e and $\overline{e}_i$ $(i = d, f)$. This second effect, that we define as the "price effect", is positive (negative) only if the firm is a net buyer (seller) of permits. Therefore we can state and proof the following result:

Proposition 1. *Increasing the amount of emission permits allocated to the "representative" firm operating in country i makes the same firm better off*

- *always, when the firm itself is a net permits buyer*
- *only if the "wealth effect" dominates the "price effect" when the firm itself is a net seller.*

Increasing the amount of emission permits allocated to the "representative" firm operating in country j makes the firm operating in country i better off

- *always, when the firm itself is a net permits buyer*
- *never, when the firm itself is a net seller.*

Proof. Differentiating Π_i w.r.t. $\overline{e}_i$ we get:

$$\frac{\partial \Pi_i}{\partial \overline{e}_i} = \frac{\partial \pi_i}{\partial e_i}\frac{\partial e_i}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_i} - \frac{\partial p_e}{\partial \overline{e}_i}e_i + \frac{\partial p_e}{\partial \overline{e}_i}\overline{e}_i - \frac{\partial e_i}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_i}p_e + p_e$$

By using (4) we get:

$$\frac{\partial \Pi_i}{\partial \overline{e}_i} = p_e - \frac{\partial p_e}{\partial \overline{e}_i}(e_i - \overline{e}_i)$$

The first term on the right hand side is the "wealth effect" related to an increase in the initial endowment of permits, while the second is the "price effect", whose sign depends on the firm being net buyer or seller of permits.

Differentiating Π_i w.r.t. $\overline{e}_j$ and following the same argument as for $\overline{e}_i$ we get:

$$\frac{\partial \Pi_i}{\partial \overline{e}_j} = -\frac{\partial p_e}{\partial \overline{e}_j}(e_i - \overline{e}_i)$$

In this case, of course, the wealth effect disappears.

From the two partial derivatives it is clear that:

- $\frac{\partial \Pi_i}{\partial \overline{e}_i} > 0$ if $e_i > \overline{e}_i$, while the sign of $\frac{\partial \Pi_i}{\partial \overline{e}_i}$ is ambiguous if $e_i \leq \overline{e}_i$
- $\frac{\partial \Pi_i}{\partial \overline{e}_j} \geq 0$ if $e_i \geq \overline{e}_i$, $\frac{\partial \Pi_i}{\partial \overline{e}_j} < 0$ otherwise.

□

Because of our assumption on the lobbying capacity of national firms, this result has a crucial role in determining what regulatory setting will be in charge.

4 The allocation of permits

In the second stage of the game the environmental authorities choose (at federal or national level) the amount of emission allowances to be issued to the two "representative" firms, $\overline{e}_d$ and $\overline{e}_f$, taking into account how firms will react in the third stage. In so doing the authorities realize that the equilibrium price in the permits market can be influenced by their choice of $\overline{e}_i$ $(i = d, f)$. The aim of this section is, therefore, to assess how the amount of permits allocated in each country changes when moving from a centralized setting to a decentralized one. We start analyzing what happens when the decisions are taken by a single entity maximizing (1).

The FOCs from the welfare maximization problem under the CETS are[10]

$$\frac{\partial W}{\partial \overline{e}_d} = \frac{\partial \Pi_d}{\partial \overline{e}_d} + \frac{\partial \Pi_f}{\partial \overline{e}_d} - \frac{\partial D_d}{\partial \overline{e}_d} - \frac{\partial D_f}{\partial \overline{e}_d} = 0 \tag{8}$$

$$\frac{\partial W}{\partial \overline{e}_f} = \frac{\partial \Pi_d}{\partial \overline{e}_f} + \frac{\partial \Pi_f}{\partial \overline{e}_f} - \frac{\partial D_d}{\partial \overline{e}_f} - \frac{\partial D_f}{\partial \overline{e}_f} = 0 \tag{9}$$

where $\frac{\partial D_d}{\partial \overline{e}_d} = \frac{\partial D_d}{\partial e_d}\frac{\partial e_d}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_d} + \frac{\partial D_d}{\partial e_f}\frac{\partial e_f}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_d}$, $\frac{\partial D_f}{\partial \overline{e}_d} = \frac{\partial D_f}{\partial e_d}\frac{\partial e_d}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_d} + \frac{\partial D_f}{\partial e_f}\frac{\partial e_f}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_d}$, $\frac{\partial D_d}{\partial \overline{e}_f} = \frac{\partial D_d}{\partial e_d}\frac{\partial e_d}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_f} + \frac{\partial D_d}{\partial e_f}\frac{\partial e_f}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_f}$ and $\frac{\partial D_f}{\partial \overline{e}_f} = \frac{\partial D_f}{\partial e_d}\frac{\partial e_d}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_f} + \frac{\partial D_f}{\partial e_f}\frac{\partial e_f}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_f}$.

As the environmental damage in each country depends on the total amount of emissions in both countries, then $\frac{\partial D_d}{\partial e_d} = \frac{\partial D_d}{\partial e_f}$ and $\frac{\partial D_f}{\partial e_d} = \frac{\partial D_f}{\partial e_f}$, so that $\frac{\partial D_d}{\partial e_d} + \frac{\partial D_f}{\partial e_d} = \frac{\partial D_d}{\partial e_f} + \frac{\partial D_f}{\partial e_f}$. Moreover, $\frac{\partial e_d}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_d} + \frac{\partial e_f}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_d} = \frac{\partial e_d}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_f} + \frac{\partial e_f}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_f} = 1$. Therefore we can rewrite the first order conditions for the centralized case as follows:

$$\frac{\partial W}{\partial \overline{e}_d} = p_e - \frac{\partial p_e}{\partial \overline{e}_d}(e_d - \overline{e}_d) - \frac{\partial p_e}{\partial \overline{e}_d}(e_f - \overline{e}_f) - \frac{\partial D_d}{\partial e_d} - \frac{\partial D_f}{\partial e_d} = 0 \tag{10}$$

and

$$\frac{\partial W}{\partial \overline{e}_f} = p_e - \frac{\partial p_e}{\partial \overline{e}_f}(e_f - \overline{e}_f) - \frac{\partial p_e}{\partial \overline{e}_f}(e_d - \overline{e}_d) - \frac{\partial D_d}{\partial e_d} - \frac{\partial D_f}{\partial e_d} = 0 \tag{11}$$

Given that $e_d + e_f = \overline{e}_d + \overline{e}_f$ always holds in equilibrium, we may conclude that $(e_d - \overline{e}_d) = -(e_f - \overline{e}_f)$, so that the two first order conditions imply

$$p_e|_{cen} = \frac{\partial D_d}{\partial e_d} + \frac{\partial D_f}{\partial e_d} \left(= \frac{\partial D_d}{\partial e_f} + \frac{\partial D_f}{\partial e_f} \right) \tag{12}$$

which, together with (4), implies that under the CETS the number of emission allowances distributed in each country is such to guarantee that the necessary

[10] Given our assumptions concerning $\pi(.)$ and $D(.)$, (1) is strictly concave, so that the FOCs are also sufficient for a maximum.

conditions for the maximization of the social welfare function, as defined in (1), hold, that is

$$\frac{\partial \pi_i(e_i)}{\partial e_i} = \frac{\partial D_d}{\partial e_i} + \frac{\partial D_f}{\partial e_i}; i = d, f.$$

Of course, under the CETS the emissions target is set at its first best level and equation (12) represents the necessary condition required for the social optimum, i.e. that total marginal damages equal the equilibrium price of permits.

We move, then, to FOC's from the welfare maximization problem under the DETS in order compare the amount of emission allowances and the overall emissions target set under this regime with the optimal amounts arising under the CETS. By defining country d as the high (low) damage country and country f as the low (high) damage country when $\frac{\partial D_d}{\partial e_d} = \frac{\partial D_d}{\partial e_f} > (<) \frac{\partial D_f}{\partial e_d} = \frac{\partial D_f}{\partial e_f}$, we can start stating the following result which is in line with proposition 1 in Helm [8].

Lemma 1. *Under the DETS, the "representative" firm located in the high damage country is a permit buyer, while the one located in the low damage country is a permit seller.*

Proof. The FOC for the welfare maximization problem of the domestic authority is[11]

$$\frac{\partial W_d}{\partial \overline{e}_d} = \frac{\partial \Pi_d}{\partial \overline{e}_d} - \frac{\partial D_d}{\partial e_d}\frac{\partial e_d}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_d} - \frac{\partial D_d}{\partial e_f}\frac{\partial e_f}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_d} = 0 \tag{13}$$

that, following the same arguments as in the centralized case, may be written as

$$p_e - \frac{\partial p_e}{\partial \overline{e}_d}(e_d - \overline{e}_d) - \frac{\partial D_d}{\partial e_d} = 0, \tag{14}$$

while the FOC for the foreign authority maximization problem is

$$\frac{\partial W_f}{\partial \overline{e}_f} = \frac{\partial \Pi_f}{\partial \overline{e}_f} - \frac{\partial D_f}{\partial e_d}\frac{\partial e_d}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_f} - \frac{\partial D_f}{\partial e_f}\frac{\partial e_f}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_f} = 0$$

that is,

$$p_e - \frac{\partial p_e}{\partial \overline{e}_f}(e_f - \overline{e}_f) - \frac{\partial D_f}{\partial e_d} = 0 \tag{15}$$

[11] Again, our assumptions imply that (2) is strictly concave.

Conditions (14) and (15) are both satisfied in equilibrium where, as in the centralized setting, it must be the case that $e_d - \overline{e}_d = -(e_f - \overline{e}_f)$. Moreover, given that, from (7), $\frac{\partial p_e}{\partial \overline{e}_d} = \frac{\partial p_e}{\partial \overline{e}_f}$, they can be rearranged as follows:

$$p_e = \frac{\partial p_e}{\partial \overline{e}_d}(e_d - \overline{e}_d) + \frac{\partial D_d}{\partial e_d} \tag{16}$$

and

$$p_e = -\frac{\partial p_e}{\partial \overline{e}_d}(e_d - \overline{e}_d) + \frac{\partial D_f}{\partial e_d} \tag{17}$$

Substituting (16) into (17) for p_e we get:

$$\frac{\partial p_e}{\partial \overline{e}_d}(e_d - \overline{e}_d) = \frac{1}{2}\left(\frac{\partial D_f}{\partial e_d} - \frac{\partial D_d}{\partial e_d}\right) \tag{18}$$

As a consequence, given that $\frac{\partial p_e}{\partial \overline{e}_d} < 0$, we can conclude that:

- when $\left(\frac{\partial D_d}{\partial e_d} > \frac{\partial D_f}{\partial e_d}\right)$ then $(e_d - \overline{e}_d) > 0$ and $(e_f - \overline{e}_f) < 0$
- when $\left(\frac{\partial D_d}{\partial e_d} < \frac{\partial D_f}{\partial e_d}\right)$ then $(e_d - \overline{e}_d) < 0$ and $(e_f - \overline{e}_f) > 0$

□

We can now use the result in Lemma 1 to derive the following

Proposition 2. *Under the DETS, permits allocation results in a larger than socially optimal aggregate emissions target, and in a lower than optimal equilibrium price.*

Proof. See Appendix A □

Before moving to the first stage of the game, it is crucial to investigate the nature of the result provided by Proposition 2. To understand the intuition for the tendency to allocate too many permits when the decisions on $\overline{e}_d$ and $\overline{e}_f$ are taken in a decentralized way, we compare the FOC's of the welfare maximization problem under the CETS with the FOC's of the welfare maximization problem under the DETS. Indeed, by subtracting (13) from (10) we get[12]

[12] Of course we can carry out the same analysis by subtracting $\frac{\partial W_f}{\partial \overline{e}_f}$ from $\frac{\partial W}{\partial \overline{e}_f}$.

$$\frac{\partial W}{\partial \overline{e}_d} - \frac{\partial W_d}{\partial \overline{e}_d} = \frac{\partial p_e}{\partial \overline{e}_d}(e_f - \overline{e}_f) + \frac{\partial D_f}{\partial e_f}\frac{\partial e_f}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_d} + \frac{\partial D_f}{\partial e_d}\frac{\partial e_d}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_d} \tag{19}$$

The right hand side of (19) identifies three spillovers that national authorities would not take into account when, under the DETS, they independently choose the amount of permits to be allocated:

1. The term $\frac{\partial p_e}{\partial \overline{e}_d}(e_f - \overline{e}_f)$ identifies a spillover due to the "*price effect*" already discussed in Proposition 1: an increase in the initial allocation of permits in country d also decreases the equilibrium permits price. If country f's "representative" firm is a net seller of permits, this will cause a negative spillover on country f's welfare. If the "representative" firm operating in country f is a net buyer of permits, then the "*price effect*" spillover will be positive. The overall effect among the two countries cancels out, however, because, when the permits market is in equilibrium, the positive spillover in one country perfectly offsets the negative spillover in the other. Such spillover is therefore likely to have only distributional consequences.

2. The term $\frac{\partial D_f}{\partial e_d}\frac{\partial e_d}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_d}$ captures a first type of international externality that the environmental authority of country d does not take into account. This is a standard, well recognized problem when dealing with transboundary pollution: the increase in e_d (due to an increase in $\overline{e}_d$ *via* p_e) causes an environmental damage also in country f. Nevertheless, if we remove transboundary pollution, this term disappears but we can still prove Proposition 2 (see Appendix B).

3. On the other hand, the term $\frac{\partial D_f}{\partial e_f}\frac{\partial e_f}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_d}$ captures another type of international externality not depending on the assumptions on the nature of pollutants. This externality is related to the influence that the initial distribution of permits in country d has, *via* the permits' price, on the emissions level

in country f and, therefore, on the related environmental damage. To the best of our knowledge, with respect to the existing literature, this represent a "new" channel through which a decentralized environmental policy could lead to distortions.

5 The regulatory choice

Now we can move to the political decision about the regulatory setting taken by the two national governments at the first stage of the game. By necessity, here the analysis imposes a couple of restrictive assumptions; such assumptions might affect the generality of the result obtained in this section.

First of all, we assume that the lobbying activity is effective and national governments are completely captured by their firms. In other words, the governments' preferences over the two institutional frameworks exactly reflect the preference of the firms. Of course, this is not necessarily the case. However, by assuming that governments are captured by their national firms, we incorporate one of the main concern about the current EU ETS into the analysis, and, by limiting the lobbying activity only to the first stage of the game, we show how national industries can affect the ETS market even if they cannot exercise any lobbying activity during the allocation choice.

Secondly, we assume that the decision of delegating the allocation responsibility, by moving it to a centralized authority, requires the unanimous approval of both countries, i.e. the CETS can be chosen only by an unanimous agreement, otherwise the DETS will be in charge. We are conscious that this does not represent the actual EU requirement for the approval of emission trading. In fact, Directive 2003/87/CE is based on Article 175 (1) of the EU Treaty, which requires a qualified majority in the Council (in co-decision with the European Parliament) for environmental measures[13]. The qualified majority is reached if both a majority of Member States approve (in some cases a two-thirds majority is required) and a minimum of 73.9 per cent of the total votes in the Council is cast in favor of the proposal. However, in a two country model, like the one analyzed in this paper, the qualified majority would imply a veto power of any single country: this is indeed as to assume unanimity.

Then, bearing the above caveats in mind, we can put together the results discussed in the previous sections and state the following proposition:

Proposition 3. *A CETS would never be chosen because at least one country would not consent it. Conversely, the only possible unanimous agreement between the two countries is on the DETS.*

Proof. From Proposition 1 it follows that when firms are net permits buyer, they always prefer the ETS regime that guarantees the largest amount of permits. Then, from Proposition 2, net permits buyers would always vote for the DETS. As a consequence, an unanimous agreement on the CETS can never be reached.

On the other side, if the "wealth effect" dominates the total "price effect", i.e. if $p_e > \frac{\partial p_e}{\partial \overline{e}_i}(e_i - \overline{e}_i) + \frac{\partial p_e}{\partial \overline{e}_j}(e_i - \overline{e}_i)$ $(i, j = d, f)$, also those firms which are net permits sellers would vote for the DETS. $\square$

6 Conclusion

This paper contributes to the current political debate about the European environmental policy. More specifically, we have argued that the recent evidence of excessive tradeable emission permits within the EU may be seen as a consequence of the choice of leaving the power of allocating permits to the single member states.

[13] On the contrary, a previous proposal to regulate CO_2 emissions within the EU by environmental taxes was discharged exactly because of the unanimity condition required for tax affairs.

Besides its political relevance, this issue also provides a fruitful field for theoretical investigations. Under this respect, we have expanded the analysis on emissions trading in several ways. Indeed, by using a a three stage game, we have shown that a DETS does not provide the correct incentives to allocate permits at their socially optimal level, bringing about excessive emission targets with respect to the first best outcome that would arise under a CETS. We have also investigated the channels through which inefficiency arises under the DETS finding a number of spillovers that are vehiculated by the equilibrium price of permits. Finally, we have shown how a DETS could result to be the only viable political choice if each member state is captured by its national industries and has veto power in the political decision process. Our work is also close to other papers dealing with environmental dumping. With respect to this strand of literature we have considered emission trading instead of standards or taxes and we have allowed the analysis to be extended also to the case of transboundary pollution. Notably, while in the environmental dumping literature imperfect competition in the output market is a necessary condition for having national governments acting strategically, we do not need to assume that.

Our analysis also suggests a number of insights for further research. For instance, a possible extension may be needed to learn whether our results would change according to different assumptions on the national lobbying activity and on the political decision process within the economic union. Moreover, by considering explicitly consumers' surplus in the governments' objective function, we would introduce other specificities with respect to the existing literature.

Appendix A

Proof of Proposition 2

Substitute from (18) back into (16) (or (17)); we get:

$$p_e|_{dec} = \frac{1}{2}\left(\frac{\partial D_f}{\partial e_d} + \frac{\partial D_d}{\partial e_d}\right) \tag{20}$$

The equilibrium prices of permits under the two alternative regimes allow us to characterize the optimal level of emissions chosen by the firms in the two countries both under the CETS and under the DETS. Indeed, substituting $p_e|_{cen}$ and $p_e|_{dec}$ into country i's first order conditions (given in (4)) we get:

$$e_i|_{cen} : \frac{\partial \pi_i(e_i)}{\partial e_i} = \left(\frac{\partial D_f}{\partial e_i} + \frac{\partial D_d}{\partial e_i}\right) \tag{21}$$

under the CETS and

$$e_i|_{dec} : \frac{\partial \pi_i(e_i)}{\partial e_i} = \frac{1}{2}\left(\frac{\partial D_f}{\partial e_i} + \frac{\partial D_d}{\partial e_i}\right) \tag{22}$$

under the DETS. We are going to show now that $e_i|_{cen} < e_i|_{dec}$. Suppose not, so that $e_i|_{cen} \geq e_i|_{dec}$. Then, from (21) and (22), and given the concavity of the gross profit function $\pi(.)$, we would have:

$$\frac{\partial \pi_i(e_i|_{cen})}{\partial e_i} \leq \frac{\partial \pi_i(e_i|_{dec})}{e_i}$$

that is,

$$\begin{aligned}\frac{\partial D_f(e_i|_{cen} + e_j|_{cen})}{\partial e_i} + \frac{\partial D_d(e_i|_{cen} + e_j|_{cen})}{\partial e_i} \leq \\ \frac{1}{2}\left(\frac{\partial D_f(e_i|_{dec} + e_j|_{dec})}{\partial e_i} + \frac{\partial D_d(e_i|_{dec} + e_j|_{dec})}{\partial e_i}\right)\end{aligned} \tag{23}$$

A necessary condition for (23) to hold when $e_i|_{cen} > e_i|_{dec}$ would require that $e_j|_{cen} < e_j|_{dec}$, and, therefore,

$$\frac{\partial \pi_j(e_j|_{cen})}{\partial e_j} > \frac{\partial \pi_j(e_j|_{dec})}{\partial e_j}$$

that is,

$$\frac{\partial D_f(e_i|_{cen}+e_j|_{cen})}{\partial e_j}+\frac{\partial D_d(e_i|_{cen}+e_j|_{cen})}{\partial e_j}> \quad (24)$$
$$\frac{1}{2}\left(\frac{\partial D_f(e_i|_{dec}+e_j|_{dec})}{\partial e_j}+\frac{\partial D_d(e_i|_{dec}+e_j|_{dec})}{\partial e_j}\right).$$

This is a contradiction; indeed, conditions (23) and (24) cannot be satisfied at the same time, as (12) and (20) require that $\frac{1}{2}\left(\frac{\partial D_f(e_i|_{dec}+e_j|_{dec})}{\partial e_i}+\frac{\partial D_d(e_i|_{dec}+e_j|_{dec})}{\partial e_i}\right)=\frac{1}{2}\left(\frac{\partial D_f(e_i|_{dec}+e_j|_{dec})}{\partial e_j}+\frac{\partial D_d(e_i|_{dec}+e_j|_{dec})}{\partial e_j}\right)$ and that $\frac{\partial D_f(e_i|_{cen}+e_j|_{cen})}{\partial e_i}+\frac{\partial D_d(e_i|_{cen}+e_j|_{cen})}{\partial e_i}=\frac{\partial D_f(e_i|_{cen}+e_j|_{cen})}{\partial e_j}+\frac{\partial D_d(e_i|_{cen}+e_j|_{cen})}{\partial e_j}$. As a consequence, it must be the case that

$$(e_d+e_f)|_{cen}=(\overline{e}_d+\overline{e}_f)|_{cen}<(\overline{e}_d+\overline{e}_f)|_{dec}=(e_d+e_f)|_{dec}.$$

Further, given that (from (7)) $\frac{\partial p_e}{\partial e}<0$, we can conclude that the equilibrium permits price will be lower under the DETS.

Appendix B

Proof of Proposition 2 in the absence of transboundary pollution

The aim of this appendix is to provide the proof of Proposition 2 also in the absence of transboundary pollution, that is when the damage functions are given by $D_d\left(e_d\left(\overline{e}_d,\overline{e}_f\right)\right)$ and $D_f\left(e_f\left(\overline{e}_d,\overline{e}_f\right)\right)$.

The FOCs when governments act under the CETS become:

$$\frac{\partial W}{\partial \overline{e}_d}=\frac{\partial \Pi_d}{\partial \overline{e}_d}+\frac{\partial \Pi_f}{\partial \overline{e}_d}-\frac{\partial D_d}{\partial e_d}\frac{\partial e_d}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_d}-\frac{\partial D_f}{\partial e_f}\frac{\partial e_f}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_d}=0 \quad (25)$$

$$\frac{\partial W}{\partial \overline{e}_f}=\frac{\partial \Pi_d}{\partial \overline{e}_f}+\frac{\partial \Pi_f}{\partial \overline{e}_f}-\frac{\partial D_d}{\partial e_d}\frac{\partial e_d}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_f}-\frac{\partial D_f}{\partial e_f}\frac{\partial e_f}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_f}=0 \quad (26)$$

implying:

$$p_e|_{cen}=\frac{\partial p_e}{\partial \overline{e}_d}\left(\frac{\partial D_d}{\partial e_d}\frac{\partial e_d}{\partial p_e}+\frac{\partial D_f}{\partial e_f}\frac{\partial e_f}{\partial p_e}\right)=\frac{\partial p_e}{\partial \overline{e}_f}\left(\frac{\partial D_d}{\partial e_d}\frac{\partial e_d}{\partial p_e}+\frac{\partial D_f}{\partial e_f}\frac{\partial e_f}{\partial p_e}\right). \quad (27)$$

Under the DETS, in the absence of any transboundary pollution, the two countries first order conditions can be rewritten as:

$$\frac{\partial W_d}{\partial \overline{e}_d} = \frac{\partial \Pi_d}{\partial \overline{e}_d} - \frac{\partial D_d}{\partial e_d}\frac{\partial e_d}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_d} = 0 \tag{28}$$

for the domestic country, that is,

$$p_e - \frac{\partial p_e}{\partial \overline{e}_d}(e_d - \overline{e}_d) - \frac{\partial D_d}{\partial e_d}\frac{\partial e_d}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_d} = 0 \tag{29}$$

and as:

$$\frac{\partial W_f}{\partial \overline{e}_f} = \frac{\partial \Pi_f}{\partial \overline{e}_f} - \frac{\partial D_f}{\partial e_f}\frac{\partial e_f}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_f} = 0 \tag{30}$$

for the foreign country, that is,

$$p_e - \frac{\partial p_e}{\partial \overline{e}_f}(e_f - \overline{e}_f) - \frac{\partial D_f}{\partial e_f}\frac{\partial e_f}{\partial p_e}\frac{\partial p_e}{\partial \overline{e}_f} = 0 \tag{31}$$

Following the same steps as in the proof of Lemma 1, it can be shown that (29) and (31) imply

$$p_e = \frac{1}{2}\frac{\partial p_e}{\partial \overline{e}_d}\left(\frac{\partial D_f}{\partial e_f}\frac{\partial e_f}{\partial p_e} + \frac{\partial D_d}{\partial e_d}\frac{\partial e_d}{\partial p_e}\right) \tag{32}$$

Again, we can use the expressions for equilibrium prices of permits under the two alternative regimes to characterize the optimal level of emissions chosen by the firms in the two countries both in the centralized and in the decentralized case. Namely, we get:

$$e_i|_{cen} : \frac{\partial \pi_i(e_i)}{\partial e_i} = \frac{\partial p_e}{\partial \overline{e}_d}\left(\frac{\partial D_f}{\partial e_f}\frac{\partial e_f}{\partial p_e} + \frac{\partial D_d}{\partial e_d}\frac{\partial e_d}{\partial p_e}\right) \tag{33}$$

under the CETS and

$$e_i|_{dec} : \frac{\partial \pi_i(e_i)}{\partial e_i} = \frac{1}{2}\frac{\partial p_e}{\partial \overline{e}_d}\left(\frac{\partial D_f}{\partial e_f}\frac{\partial e_f}{\partial p_e} + \frac{\partial D_d}{\partial e_d}\frac{\partial e_d}{\partial p_e}\right) \tag{34}$$

under the DETS. It is then possible to show, following the steps used in Appendix A, that $e_i|_{cen} < e_i|_{dec}$ for all i.

References

[1] Barrett S. (1994), "Strategic environmental policy and international trade", *Journal of Public Economics*, 54, 325-338.

[2] Böhringer C., Lange, A. (2005), "On the design of optimal grandfathering schemes for emission allowances", *European Economic Review*, 49, 2041-2055.

[3] Boom J.-T., Dijkstra B. (2006), "The effect of emissions trading on international environmental agreemets", Unpublished manuscript, University of Nottingham.

[4] Carbon Trust (2004), "*The European emissions trading scheme: implications for industrial competitiveness*", London, U.K.

[5] European Commission (2005), Further guidance on allocation plans for the 2008 to 2012 trading period of the EU Emission Trading Scheme, COM(2005) 703.

[6] Gilbert A., Bode J.W., Phylipsen D. (2004), "*Analysis of the National Allocation Plans for the EU Emissions Trading Scheme.*", Ecofys UK, London.

[7] Grubb M., Neuhoff K. (2006), "Allocation and competitiveness in the EU emissions trading scheme: policy overview", *Climate Policy* (Special Issue on *Allocation and competitiveness in the EU ETS*), 6, 7-30.

[8] Helm, C. (2003), "International emissions trading with endogenous allowance choices". *Journal of Public Economics*, 87, 2737-2747.

[9] Pratlong, F. J.-A. (2005). "International competitiveness and strategic distribution of emission permits", Manuscript presented at the *13th Annual Conference of EAERE*, Budapest, June 2004.

[10] Smale M., Hartley M., Hepburn C., Ward J., Grubb M. (2006), "The impact of CO_2 emissions trading on firm profits and market prices", *Climate Policy* (Special Issue on *Allocation and competitiveness in the EU ETS*), 6, 29-46.

[11] Ulph A. (1996), "Environmental policy and international trade when governments and producers act strategically", *Journal of Environmental Economics and Management*, 30, 265-281.

[12] Ulph A. (1998), "Political institutions and the design of environmental policy in a federal system with asymmetric information", *European Economic Review*, 42, 583-592.

[13] Ulph A. (2000), "Armonization and optimal environmental policy in a federal system with asymmetric information", *Journal of Environmental Economics and Management*, 39, 224-241.