Società italiana di economia pubblica

XVII CONFERENZA

FINANZIAMENTO DEL SETTORE PUBBLICO

Pavia, Università, 15 - 16 settembre 2005

THE ALLOCATION OF TRADEABLE EMISSION PERMITS WITHIN ECONOMIC UNIONS: IS THERE ANY ROOM FOR ENVIRONMENTAL DUMPING?

STEFANO ALAIMO, ALESSIO D'AMATO AND EDILIO VALENTINI

pubblicazione internet realizzata con contributo della COMPAGNIA di San Paolo

The allocation of tradeable emission permits within Economic Unions: is there any room for environmental dumping? *

Stefano Alaimo

Gestore del Mercato Elettrico

Roma

Alessio D'Amato

Università di Roma

"Tor Vergata"

Edilio Valentini†

Università "G. D'Annunzio"

di Chieti-Pescara

(Provisional version. Please do not quote without authors' permission.)

*The authors wish to thank Laura Castellucci and the seminar audience at the 2004 SIEP for their useful comments

†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 deals with environmental dumping between national governments belonging to an Economic Union when the regulation of pollution takes place through emissions trading. This topic is addressed in a stylised model where allowances can be freely traded within the Economic Union and decisions on the amount of emission permits to be allocated to the polluting units may be either centralised or decentralised to the national governments. In a simple setup where the emission permits are traded in a perfectly competitive market and national governments act strategically, we show that the decentralised solution would not be efficient. We argue that this model may be used as a stylised framework to investigate the welfare properties of the EU emissions trading system (Directive 2003/87/CE).

(**JEL numbers:** L13, L50. **Keywords:** emission trading, environmental dumping)

1 Introduction

This paper deals with the possibility and consequences of environmental dumping between national governments belonging to an Economic Union when the regulation of pollution takes place through emissions trading. Indeed, in recent years environmental policy makers are increasingly substituting command and control pollution policies with incentive based ones and, among the latter type of policies, tradeable emission permits have been attracting greater and greater attention by environmental authorities. The most recent and important evidence of this trend is definitely the implementation by the European Union of a trading system for Greenhouse Gases (GHGs) emissions as a step towards the achievement of the Kyoto targets (Directive 2003/87/CE).

From a theoretical point of view, there are two main reasons supporting the choice of a system of tradeable emission permits, namely cost effectiveness and low informational requirement. Indeed, if permits can be exchanged in a perfectly competitive market, the emission permits will eventually go to the polluting sources that value them the most and a certain environmental quality target can be reached at minimum cost for society. Moreover, emissions trading (ET) allows cost effectiveness even if the environmental regulator does not have information on the regulated firms' marginal abatement cost curves[1].

Certainly, these theoretical findings have contributed to generate a large consensus on ET systems. On the other hand, the practice of ET systems provides a number of new theoretical (and empirical) issues. The EU Emission Trading Directive may represent, under this respect, a rich source of inspiration.

[1] Dales [3] is generally credited of having introduced the notion of emissions trading. The efficiency properties of emission permits where derived by Montgomery [5]. For a comparison of emission permits with other environmental policy instruments, see Tietenberg [7] or, at a more advanced level, Baumol and Oates [2] and Xepapadeas [9].

Indeed, according to the Directive, each EU country has to submit to the European Commission a National Allocation Plan (NAP), specifying:

- the total amount of permits to be allocated to each country in accordance with Kyoto targets and with the "burden sharing" agreement among European countries (Decision 2002/358/EC);

- how the amount of allowances each country receives are divided among the sectors subject to regulation, and among installations within each sector.

From a preliminary evaluation of the submitted NAPs and the assessments supplied from the Commission so far, a number of relevant economic issues arises. Indeed, since a discretionary power seems to be left to each country concerning the total amount of allowances, it appears evident that most of the NAPs set an emission cap above the one which would be consistent with the Kyoto target. Even if this turns out from the possibility of using instruments other than ET to achieve the Kyoto target (e.g. Joint Implementations, Clean Development Mechanisms or other national policies), for some of the NAPs (e.g. Austria, Denmark, Ireland) achieving the Kyoto target does not seem likely on the basis of the proposed complementary policies[2].

We argue that this situation may be rationalised within a stylised model representing an Economic Union (we could alternatively think about a Federal State), where allowances can be freely traded within the Union and decisions on the amount of emission permits to be allocated to the polluting units may be either centralised or decentralised to the national (or regional) governments. In a simple setup where the emission permits are traded in a perfectly competitive market, we show that the decentralised solution would not be efficient. Our result partly hinges on standard international externality considerations. However, another effect must be accounted for: indeed, in a decentralised setting, national govern-

[2]See, under this respect, Gilbert, Bode and Phylipsen [4].

ments act strategically in order to secure competitive advantages to their domestic firms by engaging in environmental dumping *via* the price of allowances. More specifically, if countries' share in total emissions is large enough, then each government will be able to affect the equilibrium permits price and generate profit advantages for its firms.

The setup of our model is closely related to the standard *ecological dumping* literature. As in Barrett [1] and Ulph [8], we use a two stage game played by two governments and their respective identical industries producing a homogeneous output that is sold in a third country. Governments move first but, differently from Barrett [1] and Ulph [8], they choose the amount of permits to be provided to firms operating within their borders. In the second stage each firm observes the amount of permits that have been assigned to it and chooses the level of output to produce. At this stage, we can remark another difference between this paper and the main related literature on environmental dumping because, to obtain our results, we do not need to assume any imperfect competition in the output market. Finally, we also differentiate from Barrett [1] and Ulph [8] as we focus on a problem of *transboundary pollution*, which is more suitable to illustrate the case of GHG emissions.

The paper is organised as follows. In section 2 we present the main features of the model; section 3 derives results for the centralised case, while section 4 analyses the case when governments act strategically. Section 5 compares results gained under the two possible institutional settings, leading to the main contribution of the paper. Finally, section 6 concludes.

2 The model

We analyse transboundary pollution regulation in an Economic Union through an emission trading system using the following two stage game. In the first stage, there are two national governments (a domestic one, labelled as d, and a foreign one, labelled as f) that choose the amount of permits to be issued. We consider two alternative institutional frameworks, namely a *centralised* one, where the two governments act as a single entity, and a *decentralised* one, where each government chooses the amount of permits to be issued to the firm(s) located within its borders and takes other government's choices as given.

In both countries an identical (and large) number of firms produces a homogeneous output q which is sold in a competitive output market located in a third country[3]. Without loss of generality, we can normalize to 1 the number of firms in each country, so that there will be one "representative" firm in the domestic country and one in the foreign country.

The amount of permits allocated to domestic and foreign firms in the first stage of the game is defined, respectively, by $\overline{e}_d$ and $\overline{e}_f$. Given $\overline{e}_d$ and $\overline{e}_f$, in the second stage the two firms choose their output levels (q_d and q_f respectively) in order to maximize their profits. Permits are then freely exchanged within the Economic Union in a perfectly competitive market.

The profits of country i firm (or firm i, as we will call it in what follows) $(i = d, f)$ can be written as:

$$\Pi_i = p_q q_i - \frac{\alpha q_i^2}{2} - p_e(e_i - \overline{e}_i)$$

where p_q is the output price, $\frac{\alpha q_i^2}{2}$ are production costs, which are identical across firms, α is an exogenous parameter[4], p_e is the permits price, while e_i is the level of emissions caused by firm i $(i = d, f)$. The last term of the profit function is the amount of money the firm spends (earns) if it is a net buyer (seller) of

[3] By this assumption we follow standard environmental dumping literature which excludes consumers' surplus from the analysis.

[4] In order to guarantee that output levels, emissions and initial endowments are always positive, it is necessary to assume $\alpha > 4$.

permits. To keep matters as simple as possible, we assume that there is a one to one relationship among output and emissions and the only way to reduce emissions is by reducing output, that implies $e_i = q_i$.

In the following two sections we derive our results solving the two stage game backward.

3 Second stage: the firms

Firm $i's$ problem can be re-written as follows:

$$\max_{q_i} \Pi_i = p_q q_i - \frac{\alpha q_i^2}{2} - p_e(q_i - \overline{e}_i). \tag{1}$$

As it is clear, profit functions of the two firms are identical. Our results, therefore, do not rely on asymmetries across countries. Assuming interior solutions, the first order conditions are[5]:

$$\frac{\partial \Pi_i}{\partial q_i} = p_q - \alpha q_i - p_e = 0 \tag{2}$$

Solving for q_i we get:

$$q_i = \frac{p_q - p_e}{\alpha} \tag{3}$$

The equilibrium in the permits' market requires that the total amount of emissions by the two firms equal the total amount of permits issued by the governments of the two countries, that is:

$$q_d + q_f = \overline{e}_d + \overline{e}_f$$

Solving this condition for p_e we get the equilibrium price of permits as a function of the amount of permits issued to the two firms.

$$p_e\left(\overline{e}_d, \overline{e}_f\right) = p_q - \frac{1}{2}\alpha\overline{e}_d - \frac{1}{2}\alpha\overline{e}_f \tag{4}$$

[5] Second order sufficient conditions for an optimum are clearly satisfied, as $\frac{\partial^2 \Pi}{\partial q_i^2} = -\alpha < 0$.

Substituting in (3) we get the equilibrium value of emissions (and output) for the domestic and foreign firms:

$$e_d\left(\overline{e}_d, \overline{e}_f\right) = \frac{1}{2}\overline{e}_d + \frac{1}{2}\overline{e}_f = e_f\left(\overline{e}_d, \overline{e}_f\right) \tag{5}$$

As we could expect, the symmetry of firms' maximization problems leads to identical equilibrium output and emission levels.

Substituting these values back in the domestic and foreign firms' profit functions, we get equilibrium profits as a function of the amount of permits issued in each country, that is $\Pi_d\left(\overline{e}_d, \overline{e}_f\right)$ and $\Pi_f\left(\overline{e}_d, \overline{e}_f\right)$.

4 First stage: the governments

In the first stage of our "emissions trading game" the two governments choose the amount of permits to be issued, $\overline{e}_d$ and $\overline{e}_f$, taking into account how firms' react to their choices.

4.1 The centralised case

We now derive the amount of permits issued when the two governments act as if they were a single "supranational" government at the Economic Union level. We can think of this case as a benchmark to evaluate the consequences of the strategic behavior among government in a decentralised setting.

The supranational government chooses the amount of emission permits to be issued in both countries in order to maximize a social welfare function which is given by the sum of the profits of the two firms and the damages related to pollution. We assume that the damage cost function is quadratic, that is $D(q_d + q_f) = (q_d + q_f)^2$; coherently with standard environmental policy literature, it is therefore increasing and convex in total pollution; notice also that the damage function captures the problem of *transboundary pollution*, as it is the case of GHG emissions[6]. The objective function of the Economic Union government is, then:

$$W = \Pi_d(\bar{e}_d, \bar{e}_f) + \Pi_f(\bar{e}_d, \bar{e}_f) - (q_d(\bar{e}_d, \bar{e}_f) + q_f(\bar{e}_d, \bar{e}_f))^2$$

and, given our assumptions concerning functional forms and the solutions in the previous section, the centralized government problem can be written as follows:

$$\max_{\overline{E}} W = p_q\overline{E} - \frac{1}{4}\alpha\overline{E}^2 - \overline{E}^2 \tag{6}$$

where $\overline{E} = \bar{e}_d + \bar{e}_f$ is the total amount of permits issued. We get, then, to the following proposition:

Proposition 1. *In the centralised case, social welfare maximization leads to an aggregate emissions standard* $\overline{E} = 2\frac{p_q}{\alpha+4}$ *and to an equilibrium permits price* $p_e^C = 4\frac{p_q}{\alpha+4}$.

Proof. First order conditions for problem (6) are [7]:

$$p_q - \frac{1}{2}\alpha\overline{E} - 2\overline{E} = 0$$

and, solving for $\overline{E}$

$$\overline{E} = 2\frac{p_q}{\alpha+4} \tag{7}$$

Output levels of firms d and f will be therefore:

$$q_d^C = q_f^C = \frac{p_q}{\alpha+4}. \tag{8}$$

Finally, substituting (8) into (4), the equilibrium price of permits is:

$$p_e^C = 4\frac{p_q}{\alpha+4} \tag{9}$$

□

[6]It can be shown, nonetheless, that our results extend to the case when emissions in one country only affect welfare in the same country. Proofs are available from the authors upon request.

[7]Also in this case, second order conditions are easily shown to be verified.

4.2 The decentralized case

We now analyse the case when the domestic and foreign governments choose the amount of permits to be issued in a decentralized way. We assume that each of the two governments realizes that the equilibrium price on the permits market can be influenced by their choice of $\overline{e}_i$ $(i = d, f)$. Each government chooses its emissions standard taking the other government's choice as given.

Government d maximizes domestic firms profits less the damage born by domestic citizens, which is a fraction $\beta \in [0, 1]$ of total damages. Such fraction may be determined, for example, by geographical and/or meteorological reasons. The objective function of government d can be written as:

$$W_d = \Pi_d\left(\overline{e}_d, \overline{e}_f\right) - \beta\left(q_d\left(\overline{e}_d, \overline{e}_f\right) + q_f\left(\overline{e}_d, \overline{e}_f\right)\right)^2 \tag{10}$$

The corresponding objective function of the foreign government is:

$$W_f = \Pi_f\left(\overline{e}_d, \overline{e}_f\right) - (1-\beta)\left(q_d\left(\overline{e}_d, \overline{e}_f\right) + q_f\left(\overline{e}_d, \overline{e}_f\right)\right)^2 \tag{11}$$

The features of the decentralized solution are summed up in the following Proposition:

Proposition 2. *The equilibrium in the decentralized case is characterized by an amount of permits issued equal to* $\overline{e}_d^D = \frac{p_q}{\alpha(\alpha+2)}\left(\alpha + 4(1-2\beta)\right)$ *for the domestic country and* $\overline{e}_f^D = \frac{p_q}{\alpha(\alpha+2)}\left(\alpha - 4(1-2\beta)\right)$ *for the foreign country. The equilibrium permits price is:* $p_e^D = 2\frac{p_q}{\alpha+2}$.

Proof. Substituting from (5) and (4), the objective function of the domestic government given in (10) can be written as:

$$W_d = p_q\overline{e}_d - \frac{3}{8}\alpha\overline{e}_d^2 - \frac{1}{4}\alpha\overline{e}_d\overline{e}_f + \frac{1}{8}\alpha\overline{e}_f^2 - \beta\overline{e}_d^2 - 2\beta\overline{e}_d\overline{e}_f - \beta\overline{e}_f^2$$

The first order conditions with respect to $\overline{e}_d$ are[8]:

$$p_q - \frac{3}{4}\alpha\overline{e}_d - \frac{1}{4}\alpha\overline{e}_f - 2\beta\overline{e}_d - 2\beta\overline{e}_f = 0 \tag{12}$$

Condition (12) implicitly defines a reaction function of the domestic government to any possible amount of permits issued by the foreign government:

$$\overline{e}_d(\overline{e}_f) = \frac{4p_q - \overline{e}_f\alpha - 8\beta\overline{e}_f}{3\alpha + 8\beta} \tag{13}$$

Following the same steps, from the maximization of (11) we get a reaction function of the foreign government to any possible amount of permits issued by the domestic one:

$$\overline{e}_f(\overline{e}_d) = \frac{4p_q - \overline{e}_d\alpha - 8\overline{e}_d(1-\beta)}{3\alpha + 8(1-\beta)}.$$

Given the assumptions concerning cost and pollution damage functions, the two reaction functions are downward sloping; indeed,

$$\frac{\partial\overline{e}_d(\cdot)}{\partial\overline{e}_f} = -\frac{\alpha + 8\beta}{3\alpha + 8\beta} < 0$$

$$\frac{\partial\overline{e}_f(\cdot)}{\partial\overline{e}_d} = -\frac{\alpha + 8(1-\beta)}{3\alpha + 8(1-\beta)} < 0.$$

Further, the Nash solution is stable if

$$\frac{\partial^2 W_d}{\partial\overline{e}_d{}^2} - \frac{\partial^2 W_f}{\partial\overline{e}_f{}^2} > \frac{\partial^2 W_d}{\partial\overline{e}_d\partial\overline{e}_f} - \frac{\partial^2 W_f}{\partial\overline{e}_d\partial\overline{e}_f}$$

which always holds in our setting. The Nash equilibrium in the decentralized case is then:

$$\overline{e}_d^D = \frac{p_q}{\alpha(\alpha+2)}(\alpha + 4(1-2\beta)) \tag{14}$$

$$\overline{e}_f^D = \frac{p_q}{\alpha(\alpha+2)}(\alpha - 4(1-2\beta)); \tag{15}$$

substituting in (5), we get output (and emission) levels:

$$e_d^D = q_d^D = \frac{p_q}{\alpha(\alpha+2)}(\alpha + 4(1-2\beta))$$

[8]It is easily shown that second order conditions for both governments are satisfied.

$$e_f^D = q_f^D = \frac{p_q}{\alpha\left(\alpha+2\right)}\left(\alpha - 4(1-2\beta)\right)$$

The corresponding equilibrium permits price is:

$$p_e^D = 2\frac{p_q}{\alpha+2} \tag{16}$$

□

5 Centralised vs. decentralised case

From the comparison of emissions and output levels arising in the decentralized case with those that would be chosen by a supranational welfare maximizing government, we get the following Proposition:

Proposition 3. *The aggregate standard when the governments choose emission levels in a decentralized way is less stringent than the one arising in the centralised case. The resulting equilibrium permits price is strictly lower in a decentralized setting.*

Proof. From (7), (14) and (15) we get:

$$\overline{e}_d^D + \overline{e}_f^D - \overline{E} = 4\frac{p_q}{\left(\alpha+2\right)\left(\alpha+4\right)}$$

which is always positive. Comparing the equilibrium permits prices, from (16) and (9) respectively, we get:

$$p_e^D - p_e^C = -2\alpha\frac{p_q}{\left(\alpha+2\right)\left(\alpha+4\right)}$$

which, given $\alpha > 0$, is always negative[9]. □

Proposition 3 shows that, even in the absence of any market power in the output and/or in the permits market, the decentralised choice of emissions standards by governments leads to a distortion with respect to the centralised case. The

[9] In our setting this condition always holds: see footnote 4

intuition for this result is as follows: first, there is an international externality that is not taken into account by governments when acting in a decentralised way; second if the domestic (foreign) government perceives that he can influence the equilibrium price of permits through his choice of $\overline{e_d}$ ($\overline{e_f}$), then he exploits this "power" to increase profits of firms located within his borders.

6 Conclusion

Drawing inspiration from the recent EU emissions trading Directive, we have addressed the problem of *environmental dumping* between national governments belonging to an Economic Union when the regulation of transboundary pollution takes place through emissions trading. Specifically, we have analysed a two stage game where governments move first setting the amount of permits to be issued. They can do this acting as a single entity or in a decentralised way. In the second stage each firm observes the amount of permits that have been assigned to it and chooses the level of output and emissions. Emission permits are then traded in a perfectly competitive market.

In this theoretical framework we have shown that the decentralised solution is not efficient, as national governments have incentives to act strategically if they perceive that they can influence the equilibrium permits' price through their choice concerning national environmental standards. As a result, a setting where the aggregate environmental standard is the result of a decentralised decision making, as it is the case of the EU emissions trading system, is likely to lead to distortions with respect to the ideal (centralised) case.

A first direction for further research is the investigation of the robustness of our results in a more general analytical setting: indeed, though the distortion of the decentralised solution with respect to the centralised one is likely to keep its validity, the impact of this distortion on the total amount of permits issued by the two governments is likely to be affected if we remove some simplifying assumptions, as that of symmetry among countries and firms. Another possible generalization concerns the explicit consideration of consumers' surplus in the governments' objective function, introducing in our setting another specificity with respect to the standard environmental dumping literature.

References

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

[2] Baumol, W.J., Oates, W.E. (1988), *The theory of Environmental Policy*, Cambridge University Press.

[3] Dales, J.H. (1968), "*Pollution, Property and Price*", University Press, Toronto.

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

[5] Montgomery, W.D. (1972), "Markets in licenses and Efficient Pollution Control Programs", *Journal of Economic Theory*, 5, 395-418.

[6] Tietenberg, T.H. (1985), *Emissions Trading, an Exercise in Reforming Pollution Policy*, Resources For the Future, Washington D.C.

[7] Tietenberg T.H. (2004), *Environmental Economics and Policy*, Addison Wesley Longman, 4th edition.

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

[9] Xepapadeas, A. (1997), *Advanced principles in environmental policy*, Cheltenham, UK-Northampton, MA, USA, Edward Elgar.