ON EMISSIONS TRADING TAXATION AND MARKET POWER

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Abstract

Our paper addresses how market power and emissions trading taxation might affect the efficiency properties of an international emissions market. We consider I countries and I representative firms (one for each country). Each firm emits pollution and trades emissions permits on an international market. Firms are divided in two categories, according to whether they have market power in the permits market or not. We claim that the negative effect of market power can be compensated, or even completely neutralized, by the presence of taxation, and viceversa. More specifically, we show that if tax differentials among competitive countries/firms and strategists exist, cost effectiveness can be restored without necessarily driving dominant firm(s) net demand to zero. Also, we show that the presence of emissions trading taxation increases the firms' ability to affect the equilibrium price in the permits market, and can therefore have an impact on the degree of market power.

1 Introduction

In this paper we study how market power and emissions trading taxation affect the efficiency properties of an international emissions market. Indeed, since the seminal article of Montgomery (1972), an extensive literature has examined various aspects of the functioning of permit markets which are regarded as a cost-effective instrument for achieving abatement targets. However, such a confidence in emissions trading relies upon the somehow controversial hypotheses that permit markets are *i*) perfectly competitive and *ii*) outside of any fiscal regime. Even if there is no sufficient empirical evidence for or against the first hypothesis (Tietenberg, 2006), from a theoretical point of view it is well known that, if the assumption of perfect competition is relaxed, strategic sellers (buyers) can exploit their market power, decreasing supply (demand) and causing a greater aggregate abatement cost (Hahn, 1984; Westskog, 1996). As regards the second hypothesis, it is self-evident that emission permits are fiscally relevant and that the their fiscal treatment is a crucial issue, especially in international contexts where countries'laws differ in terms of the accounting nature of emission rights, the burden of initial allocation and transfer, the deductible character of penalties resulting from non-fulfilment of the delivery obligation and the tax breaks for emission rights transfers (Fisher, 2006). Nevertheless, most of the existing emissions trading systems, such as the EU ETS, have ignored for a long time the role of corporate/personal income tax and Value Added Tax (VAT), implicitly assuming that the impact of these taxes would be neutral. Recent contributions however contrast this implicit assumption and show that the tax treatment of tradeable emissions is likely to affect the permit market in terms of cost effectiveness, abatement decisions and welfare effects (see, for instance, Costantini et al., 2011). However, to the best of our knowledge, no paper has simultaneously addressed market power and emissions trading taxation yet.

To embody both market power and emissions trading taxation into the analysis, we adapt the classical theoretical model proposed by Hahn (1984), and extended by Westskog (1996) and Godal and Meland (2010). More specifically, we consider I countries and I representative firms (one for each country). Each firm emits pollution and trades emissions permits on an international market. Firms are divided in two categories, according to whether they have market power in the permits market or not. Each firm optimally chooses its level of emissions, given its initial endowment of permits and the tax rate applied in its own country to revenues or cost arising from its permit selling or buying behavior. Of course each firm decides whether to be a net seller or buyer of permits after comparing its cost of increasing/reducing emissions to the international price of permits which, however, is taken as exogenous or not according to whether the firm is price taker or has market power.

Our model provides some insightful results. First of all we can claim that, under some conditions, policies aimed at removing or reducing market power in the permits market can be detrimental. Indeed, if some form of taxation is charged on permits, the negative effect of market power can be compensated, or even completely neutralized, by the presence of taxation, and viceversa. Indeed, cost effectiveness, which is violated by both market power and permits taxation when they are considered separately, can be guaranteed in those settings where market power and permits taxation coexist. More specifically, in our model cost effectiveness is guaranteed by the presence of some tax rate differential, at least between countries hosting the competitive fringe and those countries hosting the set of dominant-strategists. This result contrasts with the cost effectiveness requirement implied by previous papers on emissions trading taxation (Kane, 2009; Costantini et al., 2011) where, given the competitive market of permits, it is necessary to have a homogeneous tax rate for all states. Finally, we show that the presence of emissions trading taxation increases the firms' ability to affect the equilibrium price in the permits market, and can therefore have an impact on the degree of market power.

The majority of papers considering emissions trading jointly with taxation regards both of them as regulatory instruments and deals with the overlapping issues of these instruments rather than with the application of taxation on emissions trading (Böhringer et al., 2008; Borghesi, 2010; Brechet and Peralta, 2007; Eichner and Pethig, 2009; Johnstone, 2003). To the best of our knowledge only few contributions deal explicitly with emissions trading revenues taxation. Among them, Fischer (2006) investigates the interaction between multinational taxation and abatement in an international emissions trading scenario where the equilibrium permits price is exogenous. Kane (2009), instead, provides a descriptive analysis of the different fiscal treatments affecting the permits trading markets, claiming that heterogeneous tax regimes among firms or jurisdictions are very likely to affect allocative efficiency in a multi-periods context. In a more formal setting, Yale (2008) examines under what circumstances income taxation interferes with cap-and-trade environmental regulation. He reaches two opposite conclusions according to the time horizon under scrutiny: within a single tax period, taxing returns from permits does not distort firms' choices at the margin between using and selling permits or between buying permits and abating. On the opposite, when permits are provided for free and their value is excluded from taxable income, taxes may distort firms' decisions regarding whether and to what extent they find permit banking convenient. In this case, the permit price will rise up to the point where tax exemption is capitalized into the price of permits and, accordingly, the relative costs of abatement in present and future periods result to be distorted. Finally, Costantini et al, (2011) deal with a perfectly competitive international permit market where permit price as well as emissions abatement decisions are derived endogenously. They show through both a theoretical partial equilibrium model and a computable general equilibrium model that, differently from Yale (2008), emission trading taxation leads to distortions even in a static context.

A partially dissenting voice comes from a policy oriented report by Copenhagen Economics (2010). By dealing with cost distortions related to the existence of differentiated tax treatment of permits across member States in the EU, this report concludes that such distortions are not expected to be significant. By showing how the presence of market power can mitigate the adverse effect of a differentiated taxation of permits among states, our paper can provide a further support to the reassuring conclusions of Copenhagen Economics (2010).

The rest of the paper is organized as follows: Section 2 presents the theoretical model and the main results under very general hypothesis; Section 3 provides some additional result by resorting to a a specific example; finally, Section 4 concludes.

2 Model and general results

We consider I representative firms operating in I countries which are part of an international emission permits market. Each firm $i \in I$ is assumed to minimize emissions costs, taking into account the price of permits and the tax treatment of revenues and costs generated by its permit selling or buying behavior:

$$\min_{x_i} c(x_i) + p(1 - t_i)(x_i - e_i) \tag{1}$$

where the cost function $c(.)$ is decreasing and convex in firm's emissions (x_i), p is the equilibrium permits price, and e_i is the initial endowment of permits to firm i. The tax rate t_i is applied on revenues (or costs) generated by $(x_i - e_i)$, i.e. the amount of permits sold (when $x_i < e_i$) or bought (when $x_i > e_i$). Given the definition of t_i adopted in this paper, we do not need to specify further the nature of permit trading taxation which could be, for instance, the differentiated treatment among states of those transactions involved in markets for tradable emission permits in terms of either the application of (or exemption from) VAT, or corporate income tax.

Firms are divided in two categories, according to whether they have market power in the permits market or not. More specifically, firms can be part of a competitive fringe ($i \in F$) or can be part of a set of strategists ($i \in S$), where $F \cup S = I$ and $F \cap S = \emptyset$. We can represent our model as a two stage game: *in the first stage,* strategists set their emission quantities before the price takers firms clear the market *(the last stage).* The tax rate and the received amount of allowances are exogenously given for any firm $i \in I$.

Solving backward we look first at the optimal choices of the firms belonging to the competitive fringe. Given the permits price, each firm $i \in F$ chooses the level of emissions minimizing the net emission costs. The first order condition of this minimization problem is as follows:

$$c'(x_i) + p(1 - t_i) = 0 \tag{2}$$

In the first stage, when the strategists decide their optimal levels of emissions, they anticipate how the fringe will react to their choices and, consequently, the equilibrium price of permits; the first order condition of their minimization problems is:

$$c'(x_i) + p(1 - t_i) + \frac{\partial p}{\partial x_i}(1 - t_i)(x_i - e_i) = 0 \tag{3}$$

for every $i \in S$.

From (2) to (3) we can infer the joint effects of permits taxation and market power on cost effectiveness.

Proposition 1 *If both F and S are nonempty sets, cost effectiveness requires that all the following conditions holds*

1. $t_i = t_j$ *for any possible pair of countries* $i, j \in F$*;*
2. $p(t_j - t_i) = \frac{\partial p}{\partial x_j}(1 - t_j)(x_j - e_j)$ *for any possible pair of countries* i *and* j*,* $i \in F$ *and* $j \in S$*;*
3. $p(t_j - t_i) = \frac{\partial p}{\partial x_j}(1 - t_j)(x_j - e_j) - \frac{\partial p}{\partial x_i}(1 - t_i)(x_i - e_i)$ *for any possible pair of countries* $i, j \in S$*.*

Proof. By a simple inspection of the first order conditions we have that (2) can be rewritten as follows

$$-c'(x_i) = p(1 - t_i) \tag{4}$$

for any $i \in F$, and (3) can be rewritten as

$$-c'(x_i) = p(1 - t_i) + \frac{\partial p}{\partial x_i}(1 - t_i)(x_i - e_i) \tag{5}$$

for any $i \in S$. Since cost effectiveness implies that $-c'(x_i) = -c'(x_j)$ for any $i, j \in I$ and since $I = \{F, S\}$, the proof is straightforward. ■

Proposition 1 brings about an important policy implication: policies aimed at removing or reducing market power in the permits market must be carefully evaluated when some form of taxation is charged on permits. Indeed, when the conditions listed in Proposition 1 hold simultaneously, the negative effect of market power, which is a typical source of inefficiency in the emissions trading markets (Hahn, 1984), is completely neutralized by the presence of another source of inefficiency, i.e. taxation, and viceversa.

Proposition 1 also provides some insights on a possible more efficient use of permits taxation at the international level. First of all cost effectiveness cannot be ensured whenever $t_i \neq t_j$ for at least a pair $i, j \in F$. This partly confirms the result by Costantini et al. (2011) dealing with permits taxation in a perfectly competitive permits market. It can easily be shown that our analysis tends to collapse to the model presented in Costantini et al. (2011), whenever S, the set of strategists, is empty. Differently from Costantini et al (2011), where cost effectiveness is ensured when tax rates are homogeneous in all countries, however, in our model the possibility of market power in the permits market complicates the results. Specifically, homogeneity in the tax rates can be required only for countries belonging to the competitive fringe. But even having $t_i = t_j$ for any possible pair of countries $i, j \in F$, $i \neq j$, is not sufficient for having cost effectiveness in the permits, as stated in Proposition 1.

Further, it is worth to note that in our framework, having $t_i = t_j$ for any possible pair of countries $i, j \in I$, $i \neq j$, is never optimal when market power is accounted for. Indeed, we can easily note that condition 2 in Proposition 1 is never satisfied for $t_i = t_j$, when $i \in F$ and $j \in S$. In other words, having assumed the co-presence of price takers and price makers firms in the permits market implies that some heterogeneity in the tax rates (at least between firms with market power and the competitive fringe) must be required. The following lemma defines better the terms of such heterogeneity.

Lemma 2 *If both F and S are nonempty sets, cost effectiveness needs that*

1. *the tax rate differential between any country $j \in S$ and all countries in F*

must be positive (negative) if the strategist is a net buyer (seller) in the permits market;

2. *the greater the impact of strategists' emissions on equilibrium price, the greater the tax rate differential between strategists' countries and any country $i \in F$ in absolute terms.*

Proof. The proof derives by simply noting that i) the signs of the left hand side and the right hand side of the equation defined by the second condition of Proposition 1 depend on the signs of $(t_j - t_i)$ and $(x_j - e_j)$, respectively; and ii) the magnitude, in absolute terms, of the right hand side of the equation defined by condition 2 of Proposition 1 depends on the magnitude of $\frac{\partial p}{\partial x_j}$. ■

Lemma 2 provides information on the relative magnitude of the tax rates required to get cost effectiveness. One determinant of the relative ranking of the different tax rates is the magnitude of $\frac{\partial p}{\partial x_j}$, that is the impact of emissions of strategist j on the equilibrium price. Under this respect it is interesting to note that the magnitude of $\frac{\partial p}{\partial x_j}$ is endogenously determined by the tax rates. The following proposition clarifies this point.

Proposition 3 *The impact of an increase in emissions by any firm $j \in S$ on the equilibrium price is increasing in the tax rate of any country $i \in F$.*

Proof. Market clearing requires that demand by the fringe equals the overall cap, i.e. $E = \sum_{i \in I} e_i$, minus the demand from strategists:

$$\sum_{i \in F} x_i(p) = \sum_{i \in I} e_i - \sum_{i \in S} x_i \tag{6}$$

Differentiating (6) with respect to the emissions quantity x_j of firm $j \in S$, and taking into account that comparative statics of (2) imply:

$$c''(x_i)dx_i + dp(1 - t_i) = 0$$

i.e.

$$\left.\frac{dx_i}{dp}\right|_{i \in F} = -\frac{(1 - t_i)}{c''(x_i)} < 0, \tag{7}$$

we get:

$$\left.\frac{\partial p}{\partial x_j}\right|_{j\in S} = \frac{1}{\sum_{i\in F}\frac{(1-t_i)}{c''(x_i)}} > 0$$

which is increasing in t_i. ■

Proposition 3 tells us that the impact of an increase in emissions by a strategist on the equilibrium price is greater when we take emissions trading taxation into account $\left(\frac{1}{\sum_{i\in F}\frac{(1-t_i)}{c''(x_i)}} > \frac{1}{\sum_{i\in F}\frac{1}{c''(x_i)}}\right)$ and suggests a channel through which emissions trading taxation can affect the degree of market power. From (7) we can see that, for any $i \in F$, when p increases, x_i decreases because the net benefit of polluting decreases, i.e. buying (selling) permits becomes more expensive (remunerative). Nevertheless, the higher t_i, the lighter the effect of p on x_i. As a consequence, if a strategist increases its emissions, i.e. increases (decreases) its demand (supply) of permits, it is necessary a higher increase in the equilibrium price to induce the fringe to clear the market.

3 A specific example with a single dominant firm

In order to achieve some additional readable insights, we revert to specific functional forms and to some intuitive normalization. More specifically, we assume the following shape for the cost function:

$$c(x_i) = \frac{1}{2b}\left(bx_i - a_i\right)^2$$

Notice that symmetry is introduced concerning the parameter b, while a_i is allowed to vary across firms/countries, in order to have asymmetric business as usual emissions. Such emissions level is defined as the level that minimizes unregulated costs $c(.)$, that is:

$$x_i^B = \frac{a_i}{b}$$

We further assume that the set of strategists is made by a single dominant firm, while a representative competitive fringe firm is also accounted for. As a result, we have a dominant firm, labelled as S and a competitive fringe representative firm, labelled as F. Finally, we assume $b = 1$, so that business as ususal emissions by firm $i = S, F$ are given by a_i. While the last assumption does not imply any loss of generality, the kind of asymmetry assumed and, above all, the single dominant firm assumption are likely to affect results. We aim, however, at focusing on the simplest possible market power setting, to achieve understandable conclusions.

From (2), the first order conditions for the fringe can be rewritten as follows:

$$(x_F - a_F) + p(1 - t_F) = 0$$

impliying that emissions by the competitive fringe representative firm are:

$$x_F = a_F - p\,(1 - t_F) \tag{8}$$

The equilibrium on the permits market requires, in our setting:

$$x_S + x_F = E$$

so that the equilibrium permits price as a function of the dominant firm's emissions is as follows:

$$p = \frac{1}{1 - t_F}\,(a_F + x_S - E) \tag{9}$$

Notice that also in our explicit functional form setting an increase in t_F implies, ceteris paribus, a larger impact of a change in x_S on p. From (3), the first order conditions for the dominant firm are:

$$(x_S - a_S) + p(1 - t_S) + \frac{\partial p}{\partial x_S}(1 - t_S)(x_S - (E - e_F)) = 0$$

so that equilibrium permits demand by the strategist is:

$$x_S = \frac{(2E - e_F - a_F + a_S) - a_S t_F - (2E - e_F - a_F)\,t_S}{3 - t_F - 2t_S}. \tag{10}$$

The corresponding level for the equilibrium price and emissions by the fringe are:

$$p = \frac{(E - a_F - a_S)\,t_F + (e_F - a_F)\,t_S - (E + e_F - 2a_F - a_S)}{(1 - t_F)\,(3 - t_F - 2t_S)} \tag{11}$$

and

$$x_F = \frac{(a_S - E)\,t_F + (E + e_F + a_F - a_S) - (e_F + a_F)\,t_S}{3 - t_F - 2t_S} \tag{12}$$

A positive equilibrium permits price requires:

$$(t_F - 1) E + (2a_F - e_F + a_S - t_F (a_F + a_S) + t_S (e_F - a_F)) > 0$$

that is,

$$E < E_h = \frac{(e_F - a_F) t_S - (a_F + a_S) t_F + (2a_F - e_F + a_S)}{1 - t_F}$$

Turning to some comparative statics, we easily get:

$$\frac{\partial x_S}{\partial t_F} = (1 - t_S) \frac{2E - e_F - a_F - 2a_S}{(t_F + 2t_S - 3)^2}$$

which is positive if $E > E_t = \frac{1}{2}e_F + \frac{1}{2}a_F + a_S < E_h$. However, we must make sure that equilibrium emissions by the dominant firm are strictly lower than business as usual emissions, that is:

$$x_S - a_S = \frac{1 - t_S}{3 - t_F - 2t_S} (2E - e_F - a_F - 2a_S) < 0$$

requiring $E < E_t < E_h$. As a result, the gross (and net) demand of permits by the monopolist decreases with t_F.

$$\frac{\partial x_S}{\partial t_S} = \frac{1 - t_F}{(t_F + 2t_S - 3)^2} (e_F - 2E + a_F + 2a_S)$$

which has opposite sign with respect to $\frac{\partial x_S}{\partial t_F}$. Turning to the competitive fringe, it is easily shown that:

$$\frac{\partial x_F}{\partial t_F} = \frac{1 - t_S}{(t_F + 2t_S - 3)^2} (e_F - 2E + a_F + 2a_S)$$

which is positive, under the assumption that $E < E_t$, and

$$\frac{\partial x_F}{\partial t_S} = \frac{t_F - 1}{(t_F + 2t_S - 3)^2} (e_F - 2E + a_F + 2a_S)$$

which has opposite sign with respect to $\frac{\partial x_F}{\partial t_F}$.

We get therefore to the following result:

Proposition 4 *The demand of permits by the dominant firm decreases with the fringe tax rate and increases with own tax rate. The comparative statics signs are reversed with respect to the competitive fringe.*

The intuition for this result is as follows. An increase in t_F increases demand from the fringe, leading ceteris paribus to a decrease in demand from the dominant firm to keep the equilibrium on the permits market. An indirect impact through the permits price also takes place, but it is an equilibrium effect, which is dominated by the direct effect of t_F on x_F (and therefore on x_S). Interestingly, the price of permits might change, in equilibrium, due to the reallocation between the fringe and the strategist. This is coherent with the standard literature on emissions trading under market power. More specifically, it can be shown that $\frac{\partial p}{\partial t_F} > 0$ if $E < E_p$[1].

As

$$E_p - E_t = -\frac{1}{2}\left(t_F + 2t_S - 3\right)^2 \frac{e_F - a_F}{\left(t_F - 1\right)^2} > 0$$

then it is always $E < E_p$, so that $\frac{\partial p}{\partial t_F} > 0$. On the other hand, $\frac{\partial p}{\partial t_F} > 1$ if $E < E_\pi$[2]. As

$$E_\pi - E_t = -\frac{1}{2}\left(t_F + 2t_S - 3\right)^2 \frac{e_F - a_F + 2\left(t_F - 1\right)^2}{\left(t_F - 1\right)^2}$$

then $E_\pi - E_t < 0$ if $e_F - a_F + 2\left(t_F - 1\right)^2 > 0$, that is if $e_F > a_F - 2\left(t_F - 1\right)^2$ and vice versa. So, the impact of a change in the fringe tax rate on price is more than proportional to the change in t_F if $e_F > a_F - 2\left(t_F - 1\right)^2$, i.e. the the endowment of the fringe is sufficiently large, and $E < E_\pi$, while it is less than proportional in all other cases.

Results are easier with respect to the impact of a change in t_S on the equilibrium price of permits. Indeed:

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[1] It is easily shown that

$\frac{\partial p}{\partial t_F} = -\frac{(t_F-1)^2(E-a_S)+2t_Ft_S(e_F-a_F)-a_F(t_F-2)^2-a_F-2a_Ft_S^2+4a_Ft_S+2a_Ft_S-2e_F\left(t_F+3t_S-t_S^2-2\right)}{(t_F-1)^2(t_F+2t_S-3)^2}$

and

$E_p = \frac{1}{(t_F-1)^2}\left(a_F + 2a_Ft_S^2 + a_F\left(t_F-2\right)^2 + a_S\left(t_F-1\right)^2 - 6a_Ft_S + 2e_F\left(t_F + 3t_S - t_S^2 - 2\right) - 2t_Ft_S\left(e_F - a_F\right)\right).$

[2] Note that

$E_\pi = \frac{S}{(t_F-1)^2}$, and

$S = -4e_F + 5a_F + a_S + 24t_F + 12t_S - 2e_Ft_S^2 + a_Ft_F^2 +$

$+2a_Ft_S^2 + a_St_F^2 + 8t_Ft_S^2 + 20t_F^2t_S - 4t_F^3t_S - 22t_F^2 +$

$+8t_F^3 - t_F^4 - 4t_S^2 - 4t_F^2t_S^2 + 2e_Ft_F + 6e_Ft_S - 4a_Ft_F +$

$-6a_Ft_S - 2a_St_F - 28t_Ft_S - 2e_Ft_Ft_S + 2a_Ft_Ft_S - 9$

$$\frac{\partial p}{\partial t_S} = -\frac{2E - e_F - a_F - 2a_S}{\left(t_F + 2t_S - 3\right)^2} > 0.$$

Also, it is easily shown that $\frac{\partial p}{\partial t_S} > 1$ if $E < E_\beta = \frac{1}{2}e_F + \frac{1}{2}a_F + a_S - 2t_S\left(t_F + t_S - 3\right) - \frac{1}{2}\left(t_F - 3\right)^2$. Notice that

$$E_\beta - E_t = -\frac{1}{2}\left(t_F + 2t_S - 3\right)^2 < 0$$

so that $\frac{\partial p}{\partial t_S} > (<) 1$ if $E < E_\beta$ $(E > E_\beta)$. We can therefore conclude that an increase in any of the tax rates generates an increase in the equilibrium price, and such increase is more or less than proportional than the change in the tax rate, depending on the total cap and on endowment distribution.

4 Conclusions

In this paper we have studied how market power and emissions trading taxation affect the efficiency properties of an international emissions market. We have seen that, in the presence of an ad valorem taxation on the permits exchanged in the market, it is possible to have cost effectiveness even without driving dominant firm(s) net demand to zero. We have also been able to define the necessary conditions guaranteeing cost effectiveness, showing that it is guaranteed by the presence of some tax rate differential among states, at least between states hosting the competitive fringe and states hosting the dominant-strategists. This result contrasts with the cost effectiveness requirement implied by previous literature on emissions trading taxation that, because of the assumed perfect competitiveness in the permits market, requires a homogeneous tax rate for all states. Finally, we have shown that the presence of emissions trading taxation can have an impact on the degree of market power since it increases the firms' ability to affect the equilibrium price in the permits market.

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