Tradable Quotas Taxation and Market Power *

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Abstract

We show how *corrective* taxation can improve the efficiency properties of tradable quotas systems affected by market power. Indeed, when only a subset of firms are price takers while the remaining firms enjoy market power, we show that, if the regulator sets an *ad hoc* taxation on firms' traded quotas, cost effectiveness can be restored without necessarily driving dominant firm(s) net demand to zero. Cost effectiveness with market power and quotas taxation implies some cost in terms of tax revenue that, however, can be justified from a social welfare perspective. Moreover, all firms may result to be better off when the corrective taxation is implemented.

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1 Introduction

In recent years, environmental policies have been characterized by a remarkable increase in the adoption of marketable permit instruments, where price signals to regulated agents arise from emissions quantity restrictions coupled with trading schemes (Hepburn, 2006). Several types of green markets have been put in place. Markets for tradeable pollution permits, for instance, have been established to control SO2 emissions and other air pollutants in the US, as well as to cut CO2 emissions in the EU; further, the development of an international permit market for CO2 emissions has been one of the cornerstones of the flexibility mechanisms under the Kyoto Protocol. Markets for tradable certificates have been introduced also to stimulate investments in energy efficiency and in electricity generation from renewable energy sources. The functioning of these tradeable quotas (TQ) systems has been investigated extensively by the literature, starting from the seminal article by Montgomery (1972), as, in some cases, they have the potential to attain environmental policy targets cost-effectively, i.e. at the minimum aggregate cost. The property of cost effectiveness, however, relies upon the somehow controversial hypothesis that TQ are traded in perfectly competitive markets. When the assumption of perfect competition is relaxed, strategic players can exploit their market power by decreasing TQ supply/demand, leading to larger total abatement costs (Hahn, 1984; Westskog, 1996). While the presence of market power is empirically debated in the practice of emissions trading (Tietenberg, 2006) and its relevance should be probably assessed case by case (Sturn, 2008), it has been recognized to be a potential problem in the case of a hypothetical Kyoto-like international emissions trading system (Alvarez and Andrè, 2015), as well as a source of concern in local or nationwide carbon markets. This is testified, for instance, by the different ways in which pilot carbon trading schemes introduced in China are trying to prevent, or at least reduce, market power (Zhang, 2015), or by the attention devoted to the emergence of strategic behaviors in other TQ systems, such as the Scandinavian market for renewable energy certificates (Amundsen and Bergman, 2012).

The analysis of the effects of market power on the economic performance of TQ systems is also a thought provoking research question, as it is shown by the large theoretical literature that has followed the seminal article by Hahn (1984) (see, for instance, Eshel, 2005; Hagem and Westkog, 2009; Montero, 2009; Godal and Meland, 2010; Hintermann, 2011; Liski and Montero, 2011; and Haita, 2014). In some cases, authors provide policy suggestions to address inefficiencies that might arise when TQ markets are not perfectly competitive. Hahn (1984), for instance, suggests that a possible way to eliminate market power in TQ systems is through an ad hoc, cost-effective initial allocation of TQ. However, there are situations where the regulator cannot control the initial allocation of TQ to each emission source. This can happen, for instance, in the case of energy efficiency and renewable energy certificates typically based on baseline and credit mechanisms, which do not allow any ex-ante decision on the number of TQ to be assigned to the regulated firms. Further, as it is emphasized by Hagem and Westkog (2009), the environmental authority could be not aware of the presence of market power when the initial distribution of permits is realized, while she could observe and regulate it only ex-post.

In this paper we put forward an alternative proposal to the efficient allocation of TQ discussed by Hanh (1984). Namely, we investigate the possibility of restoring cost effectiveness through an *ad hoc* differentiation of prices faced by each firm in the TQ market. We show that the task of differentiating prices can be assigned to a system of taxes and subsidies that would allow the regulator to tackle market power even under a baseline and credit mechanism. We derive the conditions required by an optimal tax/rebate rule to restore cost effectiveness in TQ markets where some firms have the possibility to affect the equilibrium price. For the sake of simplicity, we focus on a theoretical model dealing with emissions trading, but results could be easily replicated in an alternative model where TQ are either energy saving certificates or renewable energy certificates[1].

[1] Supplementary material showing how the model presented in this paper can be interpreted in terms of energy saving certificates and renewable energy certificates, is available at

Specifically, we consider I firms emitting pollution. 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; we assume that a system of firm-specific taxes (rebates) can be applied to revenues (costs) arising from permit selling (buying) behavior. Each firm decides whether to be a net seller or buyer of permits by comparing its cost of increasing/reducing emissions and the price of permits, which is exogenous when the firm is price taker and endogenous when the firm is a price maker strategist.

We find that an optimal corrective taxation implies that net seller firms should be taxed, while net buyers should be subsidized. Further, the tax rate of net seller strategists should be lower than the rebate rate applied to net buyer firms. The difference between the tax rate on sellers and the rebate rate on buyers brings about that restoring cost effectiveness comes at the cost of an additional public expenditure. As this expenditure is a net transfer from taxpayers to the TQ market, it can be justified from a social welfare perspective as long as the benefit of restoring cost effectiveness is larger than the deadweight loss of the required tax revenue. Moreover, we show that, under market power, all firms may result to be better off if an ad hoc corrective tax rule is implemented.

This is not the first paper dealing with TQ taxation. Fischer (2006), for instance, investigates the interaction between multinational taxation and abatement in an international emissions trading scenario where the equilibrium permits price is exogenous, while Yale (2008) examines under what circumstances income taxation interferes with cap-and-trade environmental regulation. Both Fischer (2006) and Yale (2008), however, deal with a comprehensive corporate income taxation which taxes both profits (net of abatement costs) and permits' revenues/costs by the same tax rate. Costantini et al. (2013), instead, isolate the specific impact of permits taxation in an international emissions trading market where no other taxes are taken into account. In this way they elicit the impact of permits taxation within an emissions trading scheme that would

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perform in a cost effective way without this type of taxation[2]. None of these papers, however, consider market power or the possibility that TQ taxation can be used as corrective regulatory tool.

The rest of the paper is organized as follows: Section 2 presents the theoretical model and the main results under very general hypotheses; Section 3 provides some additional results; finally, Section 4 concludes.

2 Theoretical model and results

We assume a market featuring I firms; each firm $i \in I$ minimizes net emissions' cost $c_i(x_i)+p(x_i-e_i)$, where x_i and e_i are, respectively, the amount of pollution emitted by firm i and the initial endowment of permits which is exogenously allocated to firm i, $c_i(x_i)$ is the (gross) cost of pollution (with $c_i' < 0$ and $c_i'' \geq 0$), $p(x_i - e_i)$ is the cost (revenue) of buying (selling) permits and p is the equilibrium permits price.

Firms are divided in two categories: they can be part of a competitive fringe F or can be part of a set of strategists S, where $F \cup S = I$ and $F \cap S = \emptyset$. We can represent this model as a two stage game where, in *the first stage* strategists set their emission quantities before the price takers firms clear the market *(the second stage)*.

More specifically, given the permits price which arises from the after-trade market clearing condition $\sum_{i=1}^{I} x_i = \sum_{i=1}^{I} e_i$, in the second stage each firm $f \in F$ chooses the level of emissions minimizing the net emission cost. The first order condition of this minimization problem is as follows:

$$c_f'(\hat{x}_f) + p = 0 \tag{1}$$

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

[2] Another paper on this stream of literature is Kane (2009) who provides a descriptive analysis of the different fiscal treatments affecting the permits trading markets.

problems is:

$$c_s'(\hat{x}_s) + p + \frac{\partial p}{\partial x_s}(\hat{x}_s - e_s) = 0 \tag{2}$$

for every $s \in S$, where $\frac{\partial p}{\partial x_s}(\hat{x}_s - e_s)$, that is the marginal effect on permits price of polluting decisions of firm s times the size of firm s in the permits market, captures the degree of market power enjoyed by firm s. Note that a cost effective solution can be achieved if any strategist receives an amount of permits equal to the emissions' level that it would choose in equilibrium (Hahn, 1984), i.e. if $\hat{x}_s = e_s$ for any $s \in S$.

2.1 Cost effectiveness and quota taxation

Differently from Hahn (1984) we define a corrective taxation that allows for cost effectiveness also in cases when strategists trade in the permits market.

Specifically, assume that a tax rate $t_i \in (0, 1)$ is applied on permits revenues/costs. Therefore, for any firm $i \in I$, the minimization problem becomes

$$\min_{x_i} c_i(x_i) + p(1 - t_i)(x_i - e_i). \tag{3}$$

According to (3), $pt_i(x_i - e_i)$ is the tax payed by firms when they are net sellers (i.e. when $x_i < e_i$) while, in the case of net buyers (i.e. when $x_i > e_i$), it represents either a subsidy to the firm or a tax credit (a rebate) on its profit tax. Under this specification the first order conditions for the fringe and the strategists become, respectively,

$$c_f'(x_f^*) + p(1 - t_f) = 0 \tag{4}$$

and

$$c_s'(x_s^*) + p(1 - t_s) + \frac{\partial p}{\partial x_s}(1 - t_s)(x_s^* - e_s) = 0. \tag{5}$$

The following proposition defines a set of conditions for cost effectiveness under market power and permits taxation.

Proposition 1 *Tradable quotas taxation can restore cost effectiveness without driving net demand by strategists to 0, if:*

(a) *all firms belonging to the competitive fringe are taxed/subsidized by the same rate;*

(b) *net seller (buyer) strategists are taxed by a rate which is lower (greater) than the rate applied to the competitive fringe;*

(c) *net seller strategists are taxed with a rate which is lower than the rate applied to net buyer strategists.*

Proof.

From (4) and (5), the cost effectiveness condition $-c_i'(x_i^*) = -c_j'(x_j^*)$ for any $i, j \in I$, requires that:

1. $t_f = t_g$ for any possible pair of firms f, $g \in F$,
2. $p(t_s - t_f) = \frac{\partial p}{\partial x_s}(1 - t_s)(x_s^* - e_s)$ for any possible pair of firms f and s, such that $f \in F$ and $s \in S$,
3. $p(t_r - t_s) = \frac{\partial p}{\partial x_r}(1 - t_r)(x_r^* - e_r) - \frac{\partial p}{\partial x_s}(1 - t_s)(x_s^* - e_s)$ for any $r, s \in S$.

Specifically, point 1 comes from equalizing the marginal abatement costs in (4) for any pair of firms f and $g \in F$ and it is a formal restatement of enunciate (a). Point 2 comes from equalizing the marginal abatement costs in (4) and (5) for any pair of firms $f \in F$ and $s \in S$ which implies that $t_s \gtreqless t_f$ as long as $x_s^* \gtreqless e_s$ as it is enunciated in (b). Concerning point 3, it comes from equalizing the marginal abatement costs in (5) for any pair of firms r and $s \in S$. Therefore, let s be a net seller and r a net buyer, then cost effectiveness requires that $t_r > t_s$ as it is stated in enunciate (c) and coherently with enunciate (b). To conclude the proof, notice that the conditions reported in points 2 and 3 can indeed hold for $(x_s^* - e_s) \neq 0$ $(s \in S)$ for an appropriately chosen set of tax rates. ■

The above analysis suggests that in a TQ system with market power cost effectiveness can be restored without the need of reallocating emission targets across firms. As a matter of fact, the tax rate structure suggested in Proposition

1 affects the trading incentive and brings about a final allocation of permits counteracting the impact of market power. Such final allocation, however, is not directly commanded by the regulator, as in Hahn (1984), since it is obtained by means of price-type economic incentives. Therefore, since taxes can be used to restore cost effectiveness as alternative to direct reallocation of permits, an important issue arises in terms of differences - if any - between these two options. An important difference, for instance, concerns the effects of corrective taxation on public revenue. We discuss this effect in the following section.

3 Tax revenue and distributional implications

The equivalence between quantity and price instruments requires a number of demanding assumptions (Hepburn, 2006). Even in the case of perfect information, an important difference between quantity and price instruments is due to the fact that the former does not imply any variation in the public budget (apart from the implementation costs), while the latter may imply an increase (in the case of taxes) or a decrease (in the case of subsidies) in the public budget. The tax structure analyzed in this paper implies a public revenue from permits sellers that needs to be compared with the public budget finalized to refund permits buyers. The following Corollary, which comes from conditions (b) and (c) of Proposition 1, tells us that there is a cost in terms of public budget when we use permits taxation to achieve cost effectiveness in a permits market with market power.

Corollary 1 *In a tradable quota market affected by market power, taxation restoring cost effectiveness implies that the revenue raised from net sellers is smaller than the lost revenue from net buyers.*

In fact, the revenue generated from the emissions trading taxation is $R = \sum_i^I t_i(e_i - x_i)$. Given the market clearing condition $\sum_i^I (e_i - x_i) = 0$, when the permits market is perfectly competitive, Proposition 1 requires that $t_i = t_j$ for any $i, j \in I$ implying $R = 0$, i.e. that the total tax payed by net sellers is exactly equal to the total tax credit refunded to net buyers. Differently, as we introduce some degree of market power, Proposition 1 tells us that we need to differentiate the tax rates between strategists, s, and fringe, f, as well as between net selling and net buying strategists. Specifically, Proposition 1 implies $t_s > t_f$, when strategist s is a net buyer, and $t_s < t_f$, when strategist s is a net seller. Consequently, the presence of strategists brings about a loss in public revenue with respect to the case without market power, i.e. $R < 0$. This is due both to the tax credit recognized to the net buyer strategist(s), which is greater than the tax credit to net buyers belonging to the fringe, and to the unit tax on permits to be payed by net seller strategists, which is less than the equivalent unit tax on net sellers belonging to the fringe.

It should be noted that, given the overall cap on emissions and the non competitive nature of the market, pollution is a strategic substitute, that is any increase in $x_s, \;\; s \in S$, must be coupled with a reduction of x_i in at least another firm $i \in I$, $i \neq s$, with a final effect on p which is undeterminate[3]. Moreover, variations of p affect the net emissions costs bringing about a redistribution of the total abatement costs across firms. This point is addressed by the following proposition.

Proposition 2 *A corrective taxation, as defined by Proposition 1, restores cost effectiveness bringing about a redistribution of net emissions' costs that can be beneficial for all firms.*

Proof. See the Appendix ■

To prove Proposition 2 we provide a simplified case that, albeit specific, is sufficient to show that restoring cost effectiveness through tradable quotas taxation may generate net gains for all involved firms (being them dominant or not). In such a case, we can expect no hold up from regulated firms if the business as usual scenario is one featuring market power. Of course, and as already clarified in Corollary 1, this comes at a cost in terms of aggregate

[3]See also Godal and Meland (2010) who show how strategic substitution characterizes an emissions trading system with market power (but without taxation).

public revenue.

4 Discussion and Concluding Remarks

This paper provides a new perspective on the use of corrective taxation to deal with market power inefficiencies in TQ markets. In a very simple setting, we have introduced the possibility of affecting the prices faced by each firm in the TQ market through a corrective taxation, which taxes the revenues generated by selling TQ and subsidizes the costs of buying TQ. Moreover, we have derived conditions under which tax rates guarantee that the impact of market power on total compliance costs is neutralized, by showing their effects on tax revenues. The implementation of the corrective taxation clearly implies a loss of public revenue, which should be compensated through other types of taxation. Nevertheless, if it does not imply introducing large distortions in the taxation system, then quotas taxation can be justified in terms of social welfare, considering the gains related to have cost effectiveness restored. Hence we have provided a theoretical case showing how restoring cost effectiveness may be beneficial for all regulated firms. It is worth mentioning that all results do not imply the need to drive the net demand of permits of the dominant firm(s) to 0. This makes our mechanism a viable option when an efficient distribution of permits across regulated firms is not possible or too costly to be performed.

A first question arising from our analysis concerns the effective relevance of our results for policy. The answer to this question is twofold. First of all, in real life there are relevant cases where reallocating permits across sources is severely limited or impossible. Secondly, tradable quotas markets exist where no proper initial distribution phase takes place (e.g. green certificates, that rely on a baseline and credit market), so that each firm sells or buys permits if it performs better or worse than a predetermined threshold. In all these cases, the possibility for regulators to affect the initial distribution in order to neutralize market power is very limited.

A second natural issue raised by our analysis is the informative requirement of our corrective taxation scheme. Indeed, the implementation of cost effective tax rates would imply a perfect knowledge of the cost structure of regulated firms. Our theoretical conclusions, however, are useful in directing regulatory authorities in the presence of market power. Proposition 1 indeed suggests that the observation of the reactivity of the price to changes in emissions, together with the equilibrium price and net position on the market (which are easily available) could be used to infer the direction of the needed tax rate correction, or (seeing it the other way round) could be informative on the potential role of existing tax rates differentials in reducing the impact of market power on cost effectiveness. Therefore, observing a relatively small demand elasticity and a net selling position by a dominant firm, for instance, the regulator could infer the need to reduce the tax rate on the dominant firm and/or to increase the one on competitive firms.

The very simple structure of our setting allows us to derive neat results, and leaves room for additional research. A first direction of research is related to the explicit inclusion of output market considerations, which are at the moment left out of the analysis; this would imply an extension of our model along the lines of Sartzetakis (1997), Disegni Eshel (2005) and Hintermann (2011), among others. Another promising extension is linked to the second point made above, and concerns the design of realistic implementation tools to apply our corrective taxation approach to existing tradable quota markets. In other words, although our suggested measure is quite abstract, it could be implemented through a trial and error process that could reduce total compliance costs.

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Appendix

For the aim of this proof we focus on a simplified case, featuring one representative price taker firms, f and one strategist, s. Further, we assume that permits endowments are $e_f = 1-\alpha$, and $e_s = \alpha$, and the cost functions of all firms i $(i = f, s)$ are

$$c_i(x_i) = \frac{1}{2}\left(1 - x_i\right)^2.$$

In order to have a binding cap on emissions we assume that $0 < \alpha < 1$ (emissions are lower than BAU for the strategist), so that also $0 < 1-\alpha < 1$ (same condition holds for the fringe). As a result, total permits endowment is lower than overall BAU emissions. From (4) we get

$$x_f = 1 - p(1 - t_f)$$

that, given the equilibrium on the permits market,

$$x_f + x_s = 1$$

implies the equilibrium price as a function of the dominant firm's emissions

$$p_t = \frac{x_s}{1 - t_f}. \tag{6}$$

By substituting (6) back into strategist's first order condition (5) we can derive through simple algebra the strategist's emissions level

$$x_s^* = \frac{\alpha(1 - t_s) + 1 - t_f}{3 - t_f - 2t_s}, \tag{7}$$

so that

$$p^* = \frac{(1 - t_s)\alpha + (1 - t_f)}{(1 - t_f)(3 - t_f - 2t_s)}$$

and

$$x_f^* = \frac{(1 - t_s)(1 - \alpha) + (1 - t_s)}{3 - t_f - 2t_s}.$$

According to the conditions required by Proposition 1, the dominant firm's tax rate must be set in such a way to satisfy

$$p^*(t_s - t_f) = \frac{1 - t_s}{1 - t_f}(x_s^* - e_s)$$

that, under the current specification, implies

$$t_s^* = \frac{1 - 2\alpha + t_f}{2(1 - \alpha)} < 1. \tag{8}$$

Notice also that $t_s^* > 0$ always holds when $\alpha < \frac{1}{2}$, as $t_f > 0$; on the other hand, we have to assume $t_f > 2\alpha - 1$ when the strategist is a permits seller under perfect competition (i.e. if $\alpha > \frac{1}{2}$).

If the tax rate is set according to (8) then:

$$p_t^* = \frac{1}{2(1-t_f)}$$

while the strategist and fringe emissions are, respectively:

$$x_{s\ t}^* = \frac{1}{2}$$

and

$$x_{f\ t}^* = \frac{1}{2}$$

that are both equal to the emissions that would be chosen under perfect competition (without taxation).

Under market power without corrective taxation we simply set $t_s = 0$ and $t_f = 0$, so that p^* becomes

$$p_m^* = \frac{1}{3}(\alpha + 1),$$

and the optimal level of emissions chosen by the fringe and the strategist are, respectively,

$$x_{f\ m}^* = \frac{1}{3}(2 - \alpha)$$

and

$$x_{s\ m}^* = \frac{1}{3}(\alpha + 1).$$

Comparing each firm's costs under market power and corrective taxation with those arising under market power without corrective taxation, we get

$$c_f(x_{f\ t}^*)+p_t^*(1-t_f)(x_{f\ t}^*-e_f)-\left(c_f(x_{f\ m}^*)+p_m^*(x_{f\ m}^*-e_f)\right) = -\frac{5}{72}(2\alpha-1)^2 < 0,$$

and

$$c_s(x_{s\ t}^*)+p_t^*(1-t_s^*)(x_{s\ t}^*-e_s)-(c_s(x_{s\ m}^*)+p_m^*(x_{s\ m}^*-e_s)) = \frac{1}{24}(\alpha+2)\frac{(2\alpha-1)^2}{\alpha-1} < 0$$

implying that both the fringe and the strategist are better off under corrective taxation.