STRATEGIC BEHAVIOUR OF POLLUTERS DURING THE TRANSITION FROM STANDARD-SETTING TO PERMITS TRADING

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Abstract

Grandfathering of emission permits creates a rent to incumbent firms since a valuable asset is freely distributed to them. In this paper, we examine the strategic behaviour of polluters that anticipate a change in environmental regulation from a standard-setting to tradeable emission permits with grandfathering. We focus on the impact of firms' rent-seeking activities on social welfare. We show that anticipation of the change in environmental regulation has two effects: a distributional effect which reduces, or completely eliminates, the distributional bias towards incumbent firms inherent to the grandfathering system and an efficiency effect resulting from the increase in aggregate output and emissions during the base period. Social welfare may increase as a result of the strategic manipulation of emissions.

I. Introduction

According to the theory of externalities, a proper policy should provide economic agents with adequate incentives to undertake the right amount of the externality creating activity. To the extent that public intervention is necessary, it can be done with price-based instruments such as Pigouvian taxes, or with quantity-based instruments such as tradeable emission permits. Under ideal conditions, these instruments are equivalent in that they both achieve the efficient distribution of emissions reduction effort among the regulated firms.[1] However, it has often been noted that the two instruments differ in distributional aspects: compliance costs could be lower under a tradeable emission permits regime to the extent that a portion (or totality) of the permits are initially given free of charge to existing regulated sources. Grandfathering of emission permits has most often been suggested for this particular reason. [2]

> "Polluters (that is, existing polluters), as well as regulators, are likely to prefer the permit approach because it can involve lower levels of compliance costs. .... the environmental authority can initiate the system with a one-time distribution of permits to existing sources free of charge." (Cropper and Oates, 1992, p.687)

If grandfathering reduces compliance costs, it has also been recognized that it favours incumbent firms over potential competition by the very fact that a valuable asset is freely distributed to them. Moreover, Fullerton and Metcalf (1996) have recently suggested that in the presence of existing distortionary labour tax, the rent created by the grandfathering of emission permits exacerbates the negative impact of existing distortions, thus, reducing further social

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1 However, in a policy setting, this equivalence may not hold. For an extensive discussion on the comparison between effluent taxation and tradeable emission permits, see Bahm and Russell (1985), Cropper and Oates (1992), OECD (1993) and Tietenberg (1991).

2 Lyon (1982) and Devlin and Grafton (1996) for example, recognize the additional financial burden that permits auctions impose on firms as a problem of implementing auctioning of permits.

welfare.[3] Hence, grandfathering may have efficiency as well as distributional impact.

However, it has not been fully recognized that if grandfathering creates a rent to incumbent firms, it may give rise to rent-seeking activities resulting from the anticipation of the regulatory change. When the allocation of emission permits is based on firms' emissions performance in a period in which the regulatory change is anticipated, firms will try to increase their emissions in the base period so as to capture a larger portion of the rent. Rent-seeking activities do not necessarily require the direct announcement of the policy change. Indeed, since permits trading policies have received great attention in the last decade, it may be assumed that firms in some sectors of the economy do anticipate a shift from the current standard setting to an emission permits system. For example, emission permits trading programs have been considered very seriously for many years in Canada and more recently in Europe. Moreover, as noted by Stavins (1995), "political barriers against permit auctions and political incentives in favour of all sorts of free distributions are likely to remain in place for the foreseeable future." (p. 146).[4]

In this paper, we examine the effects of an anticipated regulatory change from command and control to tradeable emission permits with grandfathering.[5] In the base period, firms' emissions are regulated under a command and control system where environmental standards are

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3 See also Bovenberg and Mooij (1994) and Bovenberg and Goulder (1996).

4 Rent-seeking activities may also have serious consequences on international emission permits trading. Chichilnisky, Heal and Starrett (1994) have noted that the "..introduction of a global permit market for CO_2 is firmly on the international agenda." (p.2). See also Chichilnisky and Heal (1993) and Grubb (1989). Thus, part of some countries' current behavior, including reluctancy to sign on international environmental agreements, might be better understood as rent-seeking behavior.

5 Rent seeking behaviour will also exist in the case that permits trading with grandfathering is implemented in a previously unregulated industry. In the present paper we examine the more realistic case of an industry whose emissions are already regulated under a command and control regulation, because is more realistic.

defined in terms of emissions per unit of output.[6] If the emission permits market is competitive, strategic manipulation of emissions affects equilibrium only in the base period. The effect of firms' strategic action on social welfare then solely depends on the relative magnitude of the output and emissions effects. However, if power exists in the permits market, the second period equilibrium is also affected. Therefore, welfare in this case also depends on the nature of the market power in the permits market, as well as on the technological structure of the industry.

The idea that tradeable emission permits regulation may induce strategic behaviour on the part of incumbent firms is not entirely new. Indeed, numerous authors have suggested that a firm could use the emission permits market to raise rivals' costs. *"Firms may even be able to buy permits in excess of their own needs as a strategic device to increase the costs of potential competitors."* (OECD, 1993, p.27).[7] However, the nature of the strategic behaviour analysed in the present paper is of a different nature. In the anticipation of the rent, firms will behave strategically for the sole purpose of capturing a greater portion of the rent. To the best of our knowledge, this has not been fully recognized and may have important policy implications.[8]

The model is presented in Section II. In Section III we analyse the situation where the permits market is competitive, and in Section IV the case that permits market is not competitive. We conclude in Section V.

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6 In circumstances where emissions standards are concentration-based (e.g. mg/liter of water), the gains obtained from a strategic manipulation of emissions for the purpose of rent-seeking would be traded-off against the expected penalty the polluter would be facing in violating the standard.

7 There are a number of ways in which power in the permits market has been modeled. See Hahn (1984), Tietenberg (1985), Misiolek and Elder (1987), Sartzetakis (1994) and (1996), von der Ferh (1994) and Fershtman and de Zeeuw (1996).

8 In a different context, Misiolek (1988) shows that the optimal pollution tax in presence of a monopoly is higher when the monopolist is rent-seeking than when it is not.

II. The model

Assume a two sector economy; the first is a competitive numeraire sector, the other is a homogeneous duopoly. Production in both sectors generates emissions of the same pollutant. Consumer preferences are given by a utility function which is separable in the numeraire good,

$$U = u(q^1, q^2, E) + m \,, \qquad (1)$$

where q^i, $i=1,2$ is the output of firms in the differentiated sector, E is the aggregate level of emissions and m is expenditure on the numeraire good.

On the production side, we assume that firms can reduce emissions by either reducing output or controlling emissions by engaging in abatement. Firms in the competitive sector have identical production and abatement technologies and do not act strategically in anticipation of the regulatory change. Since we focus on the oligopolistic sector, we define firms' technology in this sector. Emissions per unit of output are a function of abatement expenses per unit of output, $e^i=e^i(\alpha^i)$, where e^i is emissions per unit of output, and α^i abatement expenses per unit of output for firm i, with $e^i_i<0$ and $e^i_{ii}>0$. Total cost is a function of output and abatement expenses per unit of output, $C^i = C^I(q_i,\alpha^i)$, which is non decreasing and convex in both its elements.

Let $\partial u/\partial q^i = p^i(q^1, q^2, E)$ be the inverse demand, and $R^i(q^1,q^2)=p^i q^i$ the total revenue for the ith firm. We assume that q^1 and q^2 are substitutes in the sense that increasing the output of good j decreases the total and marginal revenue of firm i, $R^i_j < 0$, $R^i_{ij} < 0$. The two firms in the oligopolistic sector set output and abatement per unit of output on the assumption that the other firm holds output fixed, which results in the standard Cournot equilibrium.

Initially emissions are subject to a technology standard by which the policy maker sets a maximum allowable level of emissions per unit of output $\hat{e}$, the same for all firms.[9] Under permits trading, the policy maker issues a number of permits, each allowing the discharge of one unit of pollutant, and distributes them free of charge to the polluting sources. In order to isolate the effects of the anticipation of the regulatory change to the oligopolistic sector, we assume that the policy maker first determines a number of permits to be distributed to each of the two sectors. Let $\bar{E}$ denote the number of permits distributed to the oligopolistic sector. Second, the policy maker distributes emission permits to the firms of the oligopolistic sector as a function of their share of the industry's emissions during a base period *t*; each firm receives $\bar{E}^i = g(e^{it}(\alpha^{it})q^{it})$ permits, with $g_{q^{it}} > 0$, $g_{\alpha^{it}} < 0$, and $\bar{E}^1 + \bar{E}^2 = \bar{E}$. After the initial distribution of permits, firms can trade permits. The market for emission permits is competitive since firms from the competitive (numeraire) sector participate in the permits market.

III. Regulatory change with competitive permits market

III.1. Unanticipated regulatory change

Let us assume first that the regulatory change from command and control to tradeable permits is not anticipated by the firms (or that the initial distribution of permits is a function of variables that an individual firm cannot influence). The equilibrium during the base period *t* and the subsequent period *t+1* (during which permits are introduced) are then independent from one

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[9] Most environmental regulation aimed at controlling industrial emissions set standards in terms of emissions per unit of output. For more details, for example, on the effluent regulation for the pulp and paper industry in the United States or Canada, see Magat and Viscusi (1990), and Laplante and Rilstone (1996).

another. During the base period *t*, firm *i*'s constrained profit maximization problem is,[10]

$$\max_{q^{it},\alpha^{it}} \quad \pi^{it}(q^{1t},q^{2t},\alpha^{it}) = R^{it}(q^{1t},q^{2t},E) - C^{it}(q^{it},\alpha^{it}) \tag{2}$$
$$subject \quad to: \quad e^{it}(\alpha^{it}) \leq \hat{e} \ ,$$

where the first part of the double superscript denotes the firm in the industry, with *i=1,2* and the second part denotes the time period.

The Cournot equilibrium is characterized by the following first order conditions,

$$\pi^{it}{}_{i} \equiv \frac{\partial \pi^{it}}{\partial q^{it}} = R_i^{it}(q^{1t},q^{2t},E) - C_{q^{it}}^{it} = 0 \ , \tag{3a}$$

$$\pi_{\alpha_{it}}^{it} - \lambda^i e_i^{it}(\alpha^{it}) = -C_{\alpha_{it}}^{it} - \lambda^i e_i^{it}(\alpha^{it}) = 0 \ , \tag{3b}$$

$$\lambda^i(\hat{e} - e^{it}(\alpha^{it})) = 0 \ , \quad \lambda^i \geq 0 \ , \quad \hat{e} - e^{it}(\alpha^{it}) \geq 0 \ , \tag{3c}$$

where λ^i is the Lagrange multiplier of firm *i*'s constrained maximization problem, i.e. the shadow value of its emissions constraint. The second order conditions are, $\pi_{ii}^{it} \equiv R_{ii}^{it} < 0$. Assume that the constraint is effective at the equilibrium, and the second order conditions hold for a maximum. The system of equations (3) for *i=1,2* can be solved for the equilibrium values of the firms' choice variables and the Lagrange multipliers.

In the next period *t+1*, the regulatory system changes to emission permits trading with grandfathering. According to the grandfathering scheme, each firm receives at the beginning of

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10 In this paper we do not allow firms to violate the standards and face an expected penalty for doing so. Allowing for this possibility would add complexity to our mathematical expressions without any further insight. The profitability of engaging into rent-seeking activities would simply be enhanced.

period $t+1$, $\bar{E}^i = g\left(e^{it}\left(\alpha^{it}\right)q^{it}\right)$ permits. We assume that firms do not anticipate the regulatory change so $\bar{E}^i$ is an exogenous parameter. Under the new regulation firm *i*'s profit maximization problem is,

$$\max_{q^{it+1},\,\alpha^{it+1}} \pi^{it+1} = R^{it+1}\left(q^{1t+1}, q^{2t+1}, E\right) - C^{it+1}\left(q^{it+1} + \alpha^{it+1}\right) - P\left[e^{it+1}\left(\alpha^{it+1}\right)q^{it+1} - \bar{E}^i\right], \qquad (4)$$

where P is the price of permits determined in a market in which all firms, including the Cournot players are price takers. The first order conditions are,

$$R_i^{it+1} - C_{q^{it+1}}^{it+1} - Pe^{it+1}\left(\alpha^{it+1}\right) = 0\ , \qquad (5a)$$

$$-C_{\alpha^{it+1}}^{it+1} - Pe_i^{it+1}\left(\alpha^{it+1}\right)q^{it+1} = 0\ . \qquad (5b)$$

The permit price is defined through the permit market clearing condition. Assuming that the second order conditions $\pi_{ii}^{it+1} \equiv R_{ii}^{it+1} < 0$ hold for a maximum, the system of equations (5) for $i=1,2$ can be solved for firms' equilibrium output and abatement expenses.

III.2 Anticipated regulatory change

Assume now that firms in the oligopolistic sector anticipate the regulatory change. Firm *i*'s endowment of permits in period $t+1$ now depends on its actions in period t. In period t, firm i maximizes the discounted stream of profits over the two periods,

$$\begin{aligned} &\max_{q^{it},\,q^{1t+1},\,\alpha^{it},\,\alpha^{it+1}} \pi^{it} + \delta\,\pi^{it+1} \\ &subject\quad to: \quad e\left(\alpha^{it}\right) \leq \hat{e}\ , \end{aligned} \qquad (6)$$

where δ is the discount rate, and profits in the two periods are given by equations (2) and (4).

Note however that in (4), $\bar{E}$ is no more exogenous but is instead a function of α^{it} and q^{it}.

The equilibrium of the oligopolistic industry is characterized by first order conditions,

$$R_i^{it} - C_{q^{it}}^{it} + \delta P g_{q^{it}}\left(e^{it}(\alpha^{it}) q^{it}\right) = 0 \ , \tag{7a}$$

$$-C_{\alpha^{it}}^{it} - \lambda^i g_{\alpha^{it}}\left(e^{it}(\alpha^{it}) q^{it}\right) + \delta P g_{\alpha^{it}}\left(e^{it}(\alpha^{it}) q^{it}\right) \ , \tag{7b}$$

$$\lambda^i \geq 0 \ , \quad \hat{e} - e^{it}(\alpha^{it}) \geq 0 \ , \tag{7c}$$

$$R_i^{it+1} - C_{q^{it+1}}^{it+1} - P e^{it+1}(\alpha^{it+1}) = 0 \ , \tag{7d}$$

$$-C_{\alpha^{it+1}}^{it+1} - P e_i^{it+1}(\alpha^{it+1}) q^{it+1} = 0 \ . \tag{7e}$$

Assuming that the second order conditions hold, the equilibrium values of the choice variables of the two Cournot players can be derived by solving the system of equations (7) for $i=1,2$.

The permits trading equilibrium is not affected by the strategic manipulation of firms' emissions, as comparison of conditions (7d) and (7e) to conditions (5a) and (5b) show. This is a direct consequence of the price taking behaviour of the two firms in the permits market. Condition (7a) shows that in anticipation of the rent, firms increase their output relative to the case that the regulatory change is not anticipated. Since we assume that the policy constraint in period *t* is biding, $\lambda^i > 0$, firms do not decrease their abatement per unit of output, $e^{it}(\alpha^{it}) = \hat{e}$. Therefore, when the change in the environmental policy is anticipated at the base period, firms exhaust the potential rents of grandfathering by engaging in rent seeking activities that take the form of increased production at the base period. Thus, anticipation of the regulatory change eliminates any advantage that grandfathering gives to incumbent firms over potential entrants.

This result contradicts the view that grandfathering of emission permits may yield undue advantage to existing firms (as opposed to potential entrants) by yielding them a valuable asset: firms will engage into rent-seeking activities until the marginal net benefit of doing so is zero. Most if not all of the rents may then be dissipated. Moreover, if existing distortionary labour taxes are considered, environmental regulations exacerbate these distortions by increasing prices and thus decreasing real wages. When environmental regulations, such as pollution taxes and auctioned permits, yield public revenues, these revenues can be used to offset additional distortions. However, when environmental regulations, such as grandfathered permits, transfer all rents to the private sector in a lump-sum fashion, existing distortions are worsen.[11] Rent-seeking activities do not transfer rents to the public sector, and thus they do not offer any offset of additional distortions at time *t+1*. However, as we show above, rent-seeking yields lower prices at time *t*, and thus, existing distortions at time *t* are reduced. The partial equilibrium framework of our analysis does not allow for any indication of the direction of the total effect. In this paper, we can only identify the above two effects associated with rent-seeking activities.

The welfare effect of firms' rent seeking activities is, in general, ambiguous. Social welfare is of the usual type, namely the sum of consumer surplus and firms' profits,

$$W = \sum_{v=t}^{t+1} \left[u^{v}\left(q^{1v}, q^{2v}, E\right) - \sum_{i=1}^{2} C^{iv}\left(q^{iv}, \alpha^{iv}\right)\right]. \qquad (8)$$

Under competitive permits market, the equilibrium at period *t+1* is independent of whether firms anticipate the regulatory change. Welfare impact is therefore a function of the behaviour at the

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[11] Goulder (1995) offers an excellent review and evaluation of the literature.

base period. While the increase in output increases consumer surplus, it reduces aggregate profits and results in higher pollution level. As an illustration consider the case of technological symmetry (same marginal cost of production), in which both firms increase output by the same amount. Under the assumption of Cournot competition, a symmetric increase in both firms output implies an increase in social welfare net of the negative effect of the additional pollution.[12] In this case, the effect of the strategic manipulation of emissions will depend on the functional form of the utility function. If the valuation of pollution is very high, marginal increases in pollution may not be compensated by even a large increase in output. On the other hand, if the marginal evaluation of pollution damage is low, an increase in output (and emissions) might be welfare increasing.

In the case of technological asymmetry, the welfare effect is more complicated. First, note that since the regulation imposes technology standards at the base period, firms' rate of emissions is the same. For simplicity, assume that firms' endowment of permits is a fraction of their base period's emissions, $g\left(e^{it}\left(\alpha^{it}\right)q^{it}\right) = \psi e^{it}\left(\alpha^{it}\right)q^{it}$, $0<\psi<1$. Then, according to condition (7a), both firms increase their output by the same amount regardless of their technological differences. Thus, the product market share of the less efficient in abatement firm increases, which has a negative effect on welfare. This negative "business stealing" effect is augmented in the case that a firm is less efficient in both abatement and production. This implies that in the case of asymmetric firms the welfare effect of the strategic manipulation of emission depends on the firms' cost structure in addition to the marginal evaluation of pollution damage.

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[12] Both firms will always price above marginal cost. An increase in aggregate output reduces the size of the price-marginal cost margin, resulting in higher welfare.

IV. Regulatory change with strategic manipulation of permits market

In the preceding discussion we assumed the absence of any type of strategic action in the permits market. However, when the number of participants in the permits market is small, strategic interaction may be present. Hahn (1984) has noted that a firm with power in the permits market does not trade the cost-minimizing number of permits. Instead, it buys or sells permits acting as monopsonist or monopolist respectively.[13] The initial allocation of permits determines the extent of market power and thus, the diversion from the cost-minimizing allocation of abatement efforts. A number of subsequent studies have examined different formulations of strategic manipulation of permits markets, emphasizing the link between permits and product market. These studies have one common result, namely that the initial permits distribution plays an important role in determining the trading equilibrium and/or firms's profits.[14] Thus, the rents associated with permits differ from the price-taking case, and thus, rent-seeking activities differ.

To demonstrate the effect that strategic interaction in the permits market has on rent-seeking activities we examine the simplest form of strategic interaction. We assume that one of the Cournot players (hereafter called the leader) has price setting power in the permits market.

IV.1. Unanticipated regulatory change

The case of leadership in the permits market is modelled as a two stage game. In the first stage, the leader chooses the permit price that maximizes its profit. In the second stage, both firms make their output and abatement decisions taking the permit price as given. To determine

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13 Hahn(1984) assumes that there are no links between the product and the permits market.

14 See Misiolek and Elder (1985), von der Ferh (1994) and Sartzetakis (1994) and (1996). In the case that firms use the permits market to strengthen collusive agreements (Fershtman and de Zeeuw (1996) and Requate (1993a) and (1993b)) the initial permits distribution does not affect the equilibrium, but only firms' profits. For a review of the literature see Sartzetakis and McFetridge (1996).

the subgame perfect equilibrium we begin by solving the second stage of the game first. In the second stage, firm 2 is a price taker and thus, its profit maximization is given by equation (4). The leader, firm 1, has to adjust its choice variables such that the permits market clears at the permit price it has committed to at the first stage of the game. The Lagrange function for the leader's constrained profit maximization problem is:

$$L_1 = \pi^{1t+1} + \lambda^m \left[\bar{E} - \sum_{i=1}^{2} e^{it+1}\left(\alpha^{it+1}\right) q^{it+1} \right], \tag{9}$$

where π^{1t+1} is defined by equation (4) and λ^m is the Lagrange multiplier of the maximization problem.

The first order conditions are,

$$\pi^{1t+1}_{q^{1t+1}} - \lambda^m e^{1t+1}\left(\alpha^{1t+1}\right) = 0 \;\Rightarrow\; R_1^{1t+1} - C^{1t+1}_{q^{1t+1}} - \left[P^m + \lambda^m\right] e^{1t+1}\left(\alpha^{1t+1}\right) = 0 \,, \tag{10a}$$

$$\pi^{1t+1}_{\alpha^{1t+1}} - \lambda^m e_1^{1t+1}\left(\alpha^{1t+1}\right) q^{1t+1} = 0 \;\Rightarrow\; -C^{1t+1}_{\alpha^{1t+1}} - \left[P^m + \lambda^m\right] e_1^{1t+1}\left(\alpha^{1t+1}\right) q^{1t+1} = 0 \,, \tag{10b}$$

$$\sum_{i=1}^{2} e^{it+1}\left(\alpha^{it+1}\right) q^{it+1} = \bar{E} \,, \quad \lambda^m > 0 \,, \tag{10c}$$

where P^m is the permit price in the case of leadership in the permits market. Comparison of (5b) with (10b) reveals that the leader does not operate anymore at the point where marginal cost of abatement is equal to the permits price. The leader's marginal cost of an extra permit differs from the permit price by the value of the Lagrange multiplier.

In the first stage, the leader chooses the permit price that maximizes its profits, taking into account the Nash equilibria of the second stage. Equations (10a)-(10c) for i,j=1,2 can be solved for firms' choice variables as functions of the permit price. Thus, the leader's profit maximization problem is,

$$\max_{P^m} \quad \pi^{it+1}\left[q^{it+1}(P^m), q^{jt+1}(P^m), \alpha^{it+1}(P^m), P^m\right]. \tag{11}$$

The first order condition is,

$$\pi^{it+1}_{q^{it+1}} q^{it+1}_{P^m} + \pi^{it+1}_{q^{jt+1}} q^{jt+1}_{P^m} + \pi^{it+1}_{\alpha^{it+1}} \alpha^{it+1}_{P^m} + \pi^{it+1}_{P^m} = 0 . \tag{12}$$

Using the first order conditions of the second stage profit maximization problem and the structure of the leader's profit function, we can rewrite the above condition as,

$$\lambda^m e^{it+1}(\alpha^{it+1}) q^{it+1}_{P^m} + R_j^{\,i} q^{jt+1}_{P^m} + \lambda^m e_i^{it+1}(\alpha^{it+1}) q^{it+1} \alpha^{it+1}_{P^m} + e_i^{it+1}(\alpha^{it+1}) q^{it+1} - \overline{E}^i = 0 . \tag{13}$$

Equation (13) shows that the permit price and subsequently the firms' choice variables are functions of the leader's initial endowment of permits. Leadership in the permits market results in a permits price higher than the competitive. The leader raises the permit price above the competitive level in order to raise its rival's costs and gain market share in the product market.

IV.2. Anticipated regulatory change

If the case that the change in regulation from command and control to tradeable emission permits is anticipated, the problem is solved as a two stage game. In the first stage the leader selects the permit price. In the second stage, both firms make their choices by maximizing the discounted stream of profits over the two periods. Because of the complexity of the results, we discuss the consequences of regulatory anticipation without the use of any further calculations.

The first, immediate consequence is an intensification of rent-seeking activities by both firms, since the rent (the permit price) ascribed to a permit increases. *Ex ante* of trading, the value that each firm attributes to a permit is different. For the price taker it is equal to the prevailing permit price. For the leader permits have an additional value. This is because the larger its endowment of permits, the lower its cost of raising the permit price, and thus, the higher its gain in product market share. This difference is demonstrated using condition (7a). The price taker increases its level of output at period *t* by $\delta P^{m} g_{q^{it}}\left(e^{it}\left(\alpha^{it}\right)q^{it}\right)$ as a result of anticipating the regulatory change. It follows from the structure of the leader's profit in the second stage of the game, equation (9), that the increase in leader's output in anticipation of the regulatory change is, $\delta\left[P^{m} + \lambda^{m}\right] g_{q^{it}}\left(e^{it}\left(\alpha^{it}\right)q^{it}\right)$. Thus, the leader increases its output more than the price taker at time *t*, because it takes into consideration the additional value that permits have in increasing its rival's costs.

The welfare effect of the anticipation of the regulatory change is again ambiguous. Similarly to the case that permits market is competitive, aggregate output at time *t* increases. However, the increase is larger in the case that the permits market is dominated by one of the firms and also is not symmetric since the leader has a higher incentive to increase output. Thus, market shares at time *t* are also affected. Furthermore, in contrast to the competitive case, the equilibrium at time *t+1* is also affected. The leader, receives a larger endowment of permits relative to the case that the regulatory change is not anticipated and thus, it increases further the price of permits. The increase in social welfare due to output increase at time *t* is higher than under competition, and it is even higher if the leader is more efficient relative to the price taker. As in the previous section there is the negative effect of increased emissions. The welfare effect at time *t+1* is positive if the leader is more efficient, since anticipation of the regulatory change increases the leader's share in the product market.

The above discussion can be extended to different formulations of strategic interaction in the permits market. In all cases that one firm dominates the permits market, results will be similar to the above discussed case. In cases that firms use the permits market to stabilize collusive agreements, anticipation of the regulatory change will only affect the profits distribution among firms but not the equilibrium at time *t+1*.

V. Conclusions

In the present paper we have shown that the anticipation of a change in environmental regulation from a command and control to a permits trading system with grandfathering has a dual effect. First, it has a distributional effect which reduces, or completely eliminates, any distributional bias towards incumbent firms that is inherent to the grandfathering system. Second, it has a welfare effect due to the increase in aggregate output and emissions during the base period. The nature of the welfare effect depends on the technological structure of the industry. We have also shown that strategic action in anticipation of policy changes is stronger when the permits market is not competitive since manipulation of firms' emission levels in the base period will not only be motivated by rent seeking but also by an effort to capture (or increase) market power in the permits market. Whether the permits market is competitive or not, it is interesting to point out the possibility of a positive welfare effect due to the strategic manipulation of emissions.

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