Incentives for Price Manipulation in Emission Permit Markets with Stackelberg Competition

Francisco J. André and Luis M. de Castro.

Dept. of Economic Analysis. Universidad Complutense de Madrid. Campus de Somosaguas, 28223 Madrid, SPAIN.

March 2014

Preliminary and incomplete version.

Please, do not quote or distribute without authors approval.

ABSTRACT

It has been shown in prior research that cost effectiveness in the competitive emissions permit market could be affected by tacit collusion or price manipulation when the corresponding polluting product market is oligopolistic. We analyze these cross market links using a model a la Stackelberg to show that under reasonable assumptions, there are no incentives to collude for lobbying prices up. Tacit collusion to manipulate prices down exists if the permit price is low enough. We also conclude that distributing free permits among firms by means of grandfathering increase the chances for price collusions to manipulate the price up.

JEL code: D43, L13, Q58

Key words: Emissions permit market, Tacit collusion, Market power.
1 Introduction

In this paper we check the existence of oligopolistic firms’ incentives to collude in order to inflate the price of emission permits and obtain a higher profit when there is a leader-follower relationship in the output market.

The use of cap-and-trade (CAT) systems has become increasingly popular as a policy approach to incentivize firms to curb polluting emissions. Important examples include the US SO₂ trading system under the framework of the Acid Rain Program of the 1990 Clean Air Act, as an early application or, more recently, the European Union Emission Trading System (EU ETS). The main reason why CAT programs are so attractive and popular among economists is that they allow reducing polluting emissions in a cost-effective way by means of a price system. As long as marginal abatement costs differ across polluting firms, incentives for trade exist and the market can play a positive role in achieving a pre-specified environmental target at a minimum cost.

As it is well documented in the literature, under the assumption of perfect competition, cost-effectiveness is guaranteed regardless of the initial allocation rule chosen for the permits (see Montgomery, 1972, in a static setting and Rubin, 1996, in a dynamic framework). Unfortunately, the perfect-market assumption rarely holds in practice and it turns out that the cost-effectiveness of a CAT system is challenged if there is market power in either the permits market or the associated product market or in both. The literature analyzing the relationship between imperfect competition and emission permits can be divided in three different branches, whether market power is introduced in the permits market, the good market or both simultaneously.

Regarding the existence of market power in the permits market, the pioneering work is Hahn (1984). Based on a static model à la Stackelberg, he stated that the efficiency loss depends on the initial allocation of permits, and, more specifically, the permit price is an increasing function of the dominant firm´s allocation. As a seller, the dominant firm will manipulate the price upwards and vice versa to optimize its cost, unless the initial allocation equals the efficient one, what requires a perfectly informed regulator. Hagen & Westskog (1998) extended the Hahn setting in a dynamic two-period model and found a non-optimal distribution of abatement in an imperfect competitive market with banking and borrowing.
A second line of research addresses the concurrent exercise of market power in both permit and output markets. This topic has received attention, among other authors, by Misiolek & Elder (1989), who extended Hahn’s setting to the product market and concluded that a single dominant firm can manipulate the permit market to drive up the fringe firm’s cost in the product market. Hinterman (2011) found that a dominant firm will set the permit price above its marginal abatement costs and therefore cost-effectiveness cannot be achieved by means of the permit allocation alone.

This paper fits in a third branch that considers imperfect competition in the product market but not in the permit market. The reason to choose this line is twofold. Firstly, The EU-ETS price shock in 2005 generated a great deal of interest in issues related to market power. Initially, the price of allowances was far in excess of expectations, but in April 2006 the price suddenly fell and reached zero in mid-2007. Empirical studies have not been able to explain those too high price levels when the number of permits exceeded emissions in every year of the first phase. Then, it is natural to wonder if the reason for those price oscillations might be connected to the output market rather than the permit market in the sense that permits could be used somehow obtain windfall profits either in the output market or the market of some important input such as electricity.

Secondly, as noted by Montero (2009) and Muller et al. (2002), while market power among firms is very common in output markets, the existence of market power in emission permits is more likely to appear when countries rather than firms are the relevant players\(^1\). When firms are the involved agents, typically there is a very large number of them, which makes it very difficult that market power arises. This is clearly the case in the EU ETS, with around 11,000 installations involved and the latest steps of the European Commission seem to be in the direction of increasing the degree of competition (for example, by centralizing the allocation of permits or moving from grandfathering to auctioning).

In this third line, some articles have shown that perfect competition in the permits market might not be enough to render a cost-effective outcome if the product market is not perfectly competitive. Sartzetakis (1997) assumes a homogeneous Cournot duopoly and compares the efficiency of a competitive emissions market to a command-

---

\(^1\) As an example, regarding Annex 1 countries in the Kyoto Protocol, Russia received a fifth of the permits and a third went to USA. Countries with market power can easily manipulate prices up (down) through tariffs on permit exports (domestic subsidies to cleaner technologies) and also implement policies regarding the linkage between domestic and foreigner markets.
and-control regulation in which the emissions of each firm are legally fixed. Emissions trading modify the allocation of emissions among firms and consequently their production choices. Sartzetakis (2004) shows that welfare can decrease when emission trading is allowed between asymmetric firms endowed with different abatement and production technologies. The permit price that clears the market is a weighted average of the value of emissions of firms under command and control and, therefore, the cost of the more inefficient firm is reduced while the cost of the more efficient one is increased when permits trade is introduced.

Meunier (2011) analyzes the efficiency of emission permit trading between two imperfectly competitive product markets and conclude that even if the firms are price takers in the permit market, the integration of permit markets can decrease welfare because of imperfect competition in product markets. Theoretically, if markets are perfectly competitive, a unique global permit market that covers all polluting activities would be efficient to allocate an aggregate emissions level. If markets are not perfect but some firm enjoys market power, several permit markets may be more efficient than an integrated one.

Ehrhart et al. (2008) show that collusion in the product market may occur even if the firms are price takers in the permit market. Under some conditions, a permit price increase leads to higher profits due to a decrease in product quantities which increases the output price. In the industrial organization literature this strategy is generally known as “raising rivals´ costs”. In the particular case of an emission permit market, Erhart et al (2008) conclude that firms might have incentives to collude in order to push the price of permits upwards. Although this movement has the direct effect of raising one´s cost, since it also raises the rival’s, both firms could benefit by restricting the quantity and increasing the price. They argue that in EU ETS, even if there is no explicit market power in the permit market there are loopholes in the trading law that allow collusive behavior among firms to manipulate the price of permits.

This paper addresses the question if firms’ interests could be aligned to push up the price of permits (and, therefore, if there are incentives to collude) under Stackelberg competition. So, we check if the colluding incentives reported by Erhart et al. (2008) still arise in a setting that is asymmetric in nature (Stackelberg) whereas Erhart et al. restrict to purely symmetric settings.

We first set a general model in which we show that the effect of a higher permit price on the profit of both the leader and the follower is ambiguous. So, the possibility
that firms benefit from a price increase still exists, but the asymmetric role of the firms entail that such a possibility happens under different conditions for the leader and the follower.

Then we explore a particular case with a separable cost function to come up with more accurate insights. As a first central finding, we conclude that both firms face a profit function that is convex in the permit price. So, when the price is low enough, both firms will benefit from a further price decrease and, when it is high enough, both will benefit from a price increase while, for intermediate prices or high prices, only the follower benefits from a price increase and it is the other way around for the leader. Therefore, there is no room for tacit collusion. This is in contrast to Ehrhart et al. (2008), who set a symmetric model and therefore, both firms’ interests are always aligned. The implication of this finding is that the existence of leadership in output markets reduces the room for collusive agreements in the permit market. Actually, in our specific example with a separable function, we conclude that the collusive region shrinks to the extent to disappear.

In an extension, we consider the possibility that some permits are distributed for free (by means of grandfathering) and we conclude that this possibility opens again the way for collusive agreements.

The remainder of the paper is organized as follows. Section 2 states the basic model. In Section 3 a particular abatement cost function is considered. Concluding remarks are given in the last section.

2 The Model

We set up a simple duopoly Stackelberg model of a polluting industry sector with tradable permits. Firm 1 is a leader and firm 2 is a follower in the output market while both firms are price takers in the related emissions permit market. For the sake of comparability, the same as Ehrhart et al. (2008), in this section we assume that the firms do not enjoy any initial allocation of permits, and so they have to buy all the permits they need in a market at a given price \( p \) (the possibility of a free endowment of permits is considered as an extension in Section 3). The game has two stages: in the first stage, firms decide sequentially their output levels, \( x_1 \) and \( x_2 \), a la Stackelberg facing the
inverse demand function $P(X)$, where $X := x_1 + x_2$ and, in a second stage, they decide simultaneously their cost-minimizing emission levels, $e_1$ and $e_2$.

The cost function of firm $i \in (1,2)$, $C_i(x_i, e_i)$, depends on output ($x_i$) and net emissions ($e_i$) and is continuous and twice differentiable in both arguments with the following properties:

$$\frac{\partial C_i}{\partial e_i} < 0, \quad \frac{\partial^2 C_i}{\partial e_i^2} > 0, \quad \frac{\partial^2 C_i}{\partial x_i \partial e_i} < 0. \quad (1)$$

This function integrates production and abatement costs and reflects the fact that producing clean (with low emissions) is more costly than producing dirty. Every unit of emissions must be covered by a permit that can be obtained in the market at a given price $p$. Considering the cost of permits purchasing, total cost of firm $i$ is given by

$$TC_i(x_i, e_i) := C_i(x_i, e_i) + p e_i. \quad (2)$$

The model is solved by backward induction. In the second stage of the game both firms decide their emission levels to minimize their total cost, $TC_i(x_i, e_i)$, subject to $e_i \geq 0$, while taking as given their output levels and the price of permits. If the solution is interior, we get the standard first-order condition (FOC) from which we obtain the (inverse) demand for permits of each firm:

$$\frac{\partial C_i}{\partial e_i} + p = 0. \quad (3)$$

Total differentiation of the FOC shows that optimal emissions are increasing in output and decreasing in the permit price:

$$\frac{\partial^2 C_i}{\partial e_i^2} de_i + \frac{\partial^2 C_i}{\partial e_i \partial x_i} dx_i = 0 \Rightarrow \frac{\partial e_i}{\partial x_i} = -\frac{\partial^2 C_i}{\partial x_i \partial e_i} > 0, \quad (4)$$

$$\frac{\partial^2 C_i}{\partial e_i^2} de_i + dp = 0 \Rightarrow \frac{\partial e_i}{\partial p} = -\frac{1}{\frac{\partial^2 C_i}{\partial e_i^2}} < 0. \quad (5)$$

Using the envelope theorem, we conclude that the minimized total cost function defined as

$$2 \text{ The second order condition is always fulfilled due to the convexity of } C \text{ in emissions.}$$


\[ TC^*_i(x_i) := TC(x_i, e^*_i(x_i, p)) = C(x_i, e^*_i(x_i, p)) + p e^*_i(x_i, p) \]  

has the following properties:

\[ \frac{\partial TC^*_i}{\partial p} = e^*_i \geq 0, \]  

\[ \frac{\partial TC^*_i}{\partial x_i} = \frac{\partial C_i}{\partial x_i} + \left( \frac{\partial C_i}{\partial e_i} + p \right) \frac{\partial e_i}{\partial x_i} = \frac{\partial C_i}{\partial x_i}, \]  

\[ \frac{\partial^2 TC^*_i}{\partial x_i^2} = \frac{\partial^2 C_i}{\partial x_i^2} + \frac{\partial^2 C_i}{\partial x_i \partial e_i} \frac{\partial e_i}{\partial x_i} = \frac{\partial^2 C_i}{\partial x_i^2} \left( \frac{\partial^2 C_i}{\partial x_i \partial e_i} \right)^2, \]  

\[ \frac{\partial^2 TC^*_i}{\partial x_i \partial p} = \frac{\partial^2 C_i}{\partial x_i \partial e_i} \frac{\partial e_i}{\partial p} = \frac{\partial^2 C_i}{\partial e_i^2} > 0. \]  

Now we move to the first stage, where the firms choose their output levels. We start analyzing the follower’s behavior, who faces the following maximization problem:

\[ \text{Max} \Pi_2(x_1, x_2, e^*_2, p) = P(x_1 + x_2) x_2 - TC^*_2(x_2, p). \]  

The FOC of this problem is

\[ P(x_1 + x_2) + \frac{\partial P}{\partial X} x_2 - \frac{\partial TC^*_2}{\partial x_2} = 0 \]  

which, solving for \( x_2 \), gives the reaction function of the follower, \( x_2^*(x_1, p) \).

Differentiating the FOC and operating we conclude that the optimal follower's output is decreasing in the leader's output and the price of permits:

\[ \frac{dx^*_2}{dx_1} = \frac{-\frac{dP}{dX}}{2 \frac{dP}{dX} - \frac{\partial^2 TC^*_2}{\partial x_2^2}} < 0, \]  

\[ \frac{dx^*_2}{dp} = \frac{\frac{\partial^2 TC^*_2}{\partial x_2 \partial p}}{2 \frac{dP}{dX} - \frac{\partial^2 TC^*_2}{\partial x_2^2}} < 0. \]

The leader takes the follower's reaction function into account when maximizing its own profit. The FOC of the corresponding problem is
\[ P(x_1 + x_2) + \frac{\partial P}{\partial x_1} x_1 \left( 1 + \frac{\partial x_1^*}{\partial x_1} \right) \frac{\partial TC_1}{\partial x_1} = 0 \]  

(15)

and, by differentiating the FOC, we conclude that the leader's output supply is also decreasing in the price of permits:

\[ \frac{dx_1^*}{dp} = -\frac{\partial^2 TC_1}{\partial x_1 \partial p} \frac{\partial TC^*}{\partial x_1} < 0. \]  

(16)

Now we are ready to address the main issue of this paper, namely the effect of an increase in the price of permits on the firms’ profit. The question is: could both firms benefit simultaneously from a price increase as predicted by Erhart et al (2008) in a symmetric setting? The motivation behind this question is that, if the answer happens to be positive, both firms might have incentives to collude or, by any means, to lobby in order to manipulate the price of permits up.\(^3\) By direct differentiation of the profit functions we conclude that the marginal effect of the price of permits on the profits of both firms is given by the following expressions:

\[ \frac{\partial \Pi_1}{\partial p} = \frac{\partial P}{\partial x} \frac{\partial x_1^*}{\partial p} x_1 - e_1^*, \]  

(17)

\[ \frac{\partial \Pi_2}{\partial p} = \frac{\partial P}{\partial x} \left( 1 + \frac{\partial x_2^*}{\partial x_2} \right) \frac{\partial x_2^*}{\partial p} x_2 - e_2^*. \]  

(18)

There are two important points to be stressed here. First, the sign of both expressions is ambiguous. The reason is that an increase in the price of permits has two different effects. On the one hand, it drives cost up, what tends to reduce firms' profit but, on the other hand, it also causes output to decrease and, therefore, the product price to increase, which can be beneficial for both firms. So, in principle it is possible that the second effect dominates the first and, therefore, profits increase with the price of permits. If this happens simultaneously for both firms, there exist incentives to collude in order to manipulate the price up, as noted by Ehrhart \textit{et al}. (2008).

\(^3\) Erhart \textit{et al}. (2008) argue that, in the EU ETS, there are several loopholes in the trading law that foster collusion. These loopholes consist in the existence of some mechanisms that create the possibility for a price manipulation even in the absence of market power. The most important of these mechanisms are first, the possibility to influence the initial allocation of permits (to make it more stringent), second, the 'opt-in' rule that enables industries not committed to participate in the permits trading system to do so voluntarily, third, the possibility to implement project-based mechanisms and pay more for these credits than they would at the market and, fourth, by paying additional emissions duties.
Second, the conditions under which a higher price is profit-enhancing are different for the leader and the follower. This opens the door for the possibility of a disagreement between the firms in the sense that one is interested in a price increase and the other one in a price decrease. This is in contrast to Ehrhart et al. (2008), where both firms are symmetric and, therefore, either both firms are better-off or both are worse-off after a price increase. This asymmetry seems to reduce the scope for a price manipulation agreement. To get some additional insight on this issue, in the next section we assume a particular abatement cost function.

3. A Separable Function

3.1. Basic case

Assume that the costs of production and abatement are separable in the following way. The production cost of firm $i$ is given by $cx_i$, so there is a constant marginal production cost equal to $c$. Gross emissions of each firm are in fixed proportion to output with a fixed coefficient of pollution intensity, $r > 0$ (thus, gross emissions of firm $i$ are given by $rx_i$). By doing abatement activities, firms can reduce their flow of pollution. Denote as $q_i \geq 0$ the amount of emissions abated by firm $i$. Then, net emissions are given by $e_i = rx_i - q_i$. Following Sarzetakis (1997) we assume the following quadratic abatement cost function:

$$AC_i(q_i) = q_i (d + tq_i)$$  \hspace{1cm} (19)

where $d$ and $t$ are positive parameters. Adding up the costs of production, abatement and permits purchasing, and using the definition of $q_i$, we can write total cost as a function of output and emissions:

$$TC_i(x_i, e_i) = cx_i + (rx_i - e_i)(d + t(rx_i - e_i)) + pe_i.$$  \hspace{1cm} (20)

Moreover, assume that the (inverse) demand function has the linear form $P(X) = a - bX$. Proceeding as in the general model, we solve first the second stage, where both firms decide their levels of emissions. Endowed with our specific analytical expressions, now we can explicitly account for interior and corner solutions. Solving firm $i$’s problem using the Kuhn-Tucker technique we get the optimal emissions of firm $i$ and plugging that value in (18) we get the minimized cost function:
\[ e^*_i = \begin{cases} \frac{d-p}{2t} + rx_i & \text{if } p \leq d + 2rtx_i \\ 0 & \text{otherwise} \end{cases} \quad (21) \]

\[ TC^*_i (x_i, p) = \begin{cases} x_i (c + pr) - \frac{(d-p)^2}{4t} & \text{if } p \leq d + 2rtx_i \\ x_i (c + rd) + tr^2 x_i^2 & \text{otherwise} \end{cases} \quad (22) \]

It is immediate to see that, if the solution is interior \((e_i > 0)\), marginal product cost is constant in output and increasing in the permit price whereas, in a corner solution, total cost is strictly convex in output and independent of the permit price.

On the other hand, as it is typical in the Stackelberg model, we get that in equilibrium, the leader's output and emissions are always higher than the follower's (see below) and, therefore, \(e_1\) cannot be zero if \(e_2\) is not zero. The case where the emissions of both firms are zero is uninteresting from an environmental point of view, and so we rule it out by assumption. Therefore, we are left with two relevant cases: the first, that we label as "interior solution case", involves \(e_1 > 0, e_2 > 0\), whereas the second (labelled as "corner solution case") involves \(e_1 > 0, e_2 = 0\). Since each scenario results in a different (minimized) costs function for firm 2, we have to solve each of them separately. As shown in the Appendix, the equilibrium quantities for the interior solution case are given by

\[ x^*_1 = \frac{a-c-rp}{2b}, \quad (23) \]

\[ x^*_2 = \frac{a-c-rp}{4b} \quad (24) \]

and, in the corner solution case they are given by

\[ x^*_1 = \frac{(a-c)(b+2r^2t) + brd - 2rp(b+r^2t)}{2b(b+2r^2t)}, \quad (25) \]

\[ x^*_2 = \frac{(a-c+rp-2rd)(b+2r^2t) + rb(p-d)}{4(b+r^2t)(b+2r^2t)} \quad (26) \]

Proposition 1 shows the main result of this part.
**PROPOSITION 1**

There exists one threshold value for the permit price, $\bar{p}_i$, such that if $p < \bar{p}_i$, a price decrease would increase the profit of each agent. If $p > \bar{p}_i$, a price increase will decrease the leader’s profit and increase the follower’s profit.

The consequence of Proposition 1 is that, in our example, there is a range where both firms are interested in decreasing the price but, unlike the symmetric case developed by Ehrhart *et al.* (2008), it is never the case that both firms simultaneously profit from a price increase, and therefore they never have incentives to lobby in order to press the price up.

The intuition behind the proof is the following. Under interior solution, the profit of function of firm $i$ is strictly convex in $p$ with a minimum at $\bar{p}_i$ ($i=1, 2$), with $\bar{p}_2 < \bar{p}_1$. So, when $p < \bar{p}_2$ both firms are in the decreasing part of the profit function and their profit would by higher with a lower price. If $\bar{p}_2 < p < \bar{p}_1$, the follower is in the increasing part (and so he would benefit from a price increase) whereas the leader is still in the decreasing part (and, therefore, he would still prefer the price to decrease). Finally, if $p > \bar{p}_1$ the leader reaches the minimum of the profit function, but it is the case that $\bar{p}_1$ is precisely the value of the threshold value for the price that makes the follower choose a corner solution (i.e., $e_2 = 0$ for any $p \geq \bar{p}_1$) and so, in this third region the shape of the profit functions change. Since firm 2 does not pollute in this range, its cost is not directly affected by the price of permits, while the leader’s is. As a consequence, in this range the leader’s output, and consequently its profit are decreasing (in the price) while the follower’s output and profit are increasing.

In this example we have illustrated how the asymmetry between the firms (in the sense of a leader-follower relationship) reduces the chances for collusive behavior to the extreme to make them disappear. In the next subsection we show a generalization of this example where the result is not so extreme in the sense that the chances for collusive agreements decrease but they do not disappear.
3.2. Grandfathering

In the previous section, for comparability with Erhart *et al.* (2008) we have assumed that the firms do not have any initial allocation of permits and, therefore, they have to buy all the permits they need in the market. We now extend this setting to consider the possibility that some permits are initially distributed with no cost for the firms by a grandfathering scheme. So, the firms only need to buy the permits requirements that exceed their initial allocation and, moreover, they have the option to sell permits if they pollute less than their initial allocation.

Consider that both firms receive an equal allocation of free permits, $S$, and denote as $y_i$ the amount of permits that any firm buys ($y_i > 0$) or sells ($y_i < 0$) in the market, which can be calculated as the difference between net emissions and the allocation of permits,

$$y_i = e_i - S = rx_i - q_i - S , \quad (27)$$

from where we get $e_i = y_i + S$, i.e., the net emissions of a firm must be covered by permits that either come from her free allocation or are bought in the market. Therefore firm $i$’s total cost function is now given by the equation:

$$TC_i(x_i, y_i) = c x_i + (r x_i - y_i - S) \left( d_i + t_i (r x_i - y_i - S) \right) + py_i , \quad (28)$$

which can be expressed in terms of output and net emissions as

$$TC_i(x_i, e_i) = c x_i + (r x_i - e_i) \left( d_i + t_i (r x_i - e_i) \right) + p(e_i - S) . \quad (29)$$

As we will show immediately, now the interior solution case covers all the relevant regions and so, we can now restrict to interior solutions without any important lose of generality. Proceeding as we did in the previous subsection we get the optimal traded permits and the corresponding minimized cost function:

$$y_i^* = \frac{d - p}{2t} + rx - S , \quad (30)$$

and

$$TC^*_i(x_i, p) = x_i (c + pr) - \frac{(d - p)^2}{4t} - p S . \quad (31)$$

It is immediate to see that marginal product cost is constant in output and increasing (decreasing) in permit price when the firm is a net buyer (seller) of permits. Note that the partial derivative of the total cost with respect to the permit price is precisely $e_i$. 

---

12
PROPOSITION 2
When both firms are initially endowed with a free allocation of permits, there exist two thresholds values for the permits price, \( \hat{p}_1, \hat{p}_2 \), with \( \hat{p}_2 < \hat{p}_1 \), where \( \hat{p}_1 < \bar{p}_1, \hat{p}_2 < \bar{p}_2 \), such that if \( p < \hat{p}_2 \) both firms get better off when \( p \) decreases, if \( \hat{p}_2 < p < \hat{p}_1 \), the leader gets better off when \( p \) decreases and the follower gets better off when \( p \) increases and, finally, if \( p > \hat{p}_1 \), both firms get better off when \( p \) increases.

The consequences of Proposition 2 are the following. The profit of both firms is still strictly convex in the price of permits, with a minimum at price \( \hat{p}_i, \ i = 1, 2 \). When grandfathering is introduced, the values of the permit price at which the minimum is reached shift to the left, what implies that there is wider range of the prices such that both firms are better-off when the price of permits increases. The reason is that the existence of free permits makes permit purchasing less costly for firms and, moreover, it opens the way from getting positive revenues by selling some permits.

More importantly, when grandfathering is included, we have three regions instead of two. In the new region, to the right of \( \hat{p}_1 \), both firms profit from a price increase, while the solution is still interior \((e_1, e_2 > 0)\). Technically, the reason why this new region arises is that, now, it is easier for the firms to profit in the permit market. Specifically, \( \hat{p}_1 \) is the price at which firm 2 starts being a net permit buyer and turns into a net permit buyer. The policy implication of this fact is that the free distribution of permits increases the incentives of the firms to collude in order to push the price up.

4 Conclusions

We have explored the possibilities that two firms competing a la Stackleberg in the output market and are subject to a cap and trade system could have incentives to manipulate the price of permits up. We do so in a framework similar to the one by Erhart el al (2008) with the difference that they restrict to symmetric situations whereas we explore a situation that is asymmetric in nature. The main research question is if the incentives for this type of collusive behaviour, that have been previously reported for symmetric models, still exist in a model that is asymmetric in nature, such as the Stackelberg model.
In a general model, we have shown that the sign of the effect of a permit price increase on the firms' profit is ambiguous. This opens the way for the firms to benefit from a price increase and the possibility to make collusive agreements in order to manipulate the price up. Nevertheless, the asymmetric role of each firm causes that the conditions under which a price is profit-enhancing are different for them.

Under a separable cost function we show, first, that the profit functions are convex in the permit price with a minimum, and second the the minima are different for both firms, which creates a region of disagreement where the leader prefers that the price goes down whereas the follower prefers that the price goes. This situation is ruled out in Erhart et al. (2008) by construction. Actually, in the basic case in which there are no free permits distributed between the firms, the region where there incentives to collude disappears. Then main policy implication of this finding is that leader-follower relationships in the product market can prevent the existence of incentives for collusion in the permits market.

Another policy implication is that distributing some permits for free (by means of grandfathering) opens again the way for collusive agreements. This is an argument in favor of moving from a grandfathering scheme to another ways to distribute the permits, such as auctioning.

References


