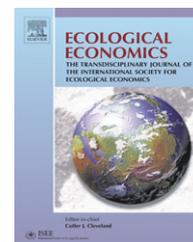


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ANALYSIS

Marginal CO₂ cost pass-through under imperfect competition in power markets

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ABSTRACT

In line with economic theory, carbon ETS determines a rise in marginal cost equal to the carbon opportunity cost regardless of whether carbon allowances are allocated free of charge or not. This paper aims at evaluating to what extent firms in imperfectly competitive markets will pass-through into electricity prices the increase in cost. By using the load duration curve approach and the dominant firm with competitive fringe model, we show that the result is ambiguous. The increase in price can be either lower or higher than the marginal CO₂ cost, depending on several structural factors: the degree of market concentration, the available capacity (whether there is excess capacity or not), the power plant mix in the market and the power demand level (peak vs. off-peak hours). The empirical analysis of the Italian context (an emblematic case of imperfectly competitive market), which can be split into four sub-markets with different structural features, provides a contribution supporting the model predictions. Market power, therefore, would determine a significant deviation from the “full pass-through” rule but we cannot know the sign of this deviation, a priori, i.e. without before taking carefully into account the structural features of the power market.

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1. Introduction

The EU Emissions Trading Scheme (EU ETS) is the first international trading scheme for CO₂ emissions in the world.¹ It covers several industry sectors of which power generation is the largest one. Therefore, on the one hand, the performance of the trading scheme largely depends on the

efficacy in inducing power industry to reduce CO₂ emissions in a significant way in the short and long run. On the other hand, it might have a considerable impact on consumers' surplus and firms' profits and competitiveness. Either the performance of the EU ETS or its impact on social welfare depends on how and to what extent the CO₂ price is passed through into power prices.

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¹ The EU ETS started in 2005. In the period 2005–2007, each European country allocates allowances to eligible firms. At least 95% of the total amount of allowances are allocated free of charge and firms can use or trade them. At the end of each calendar year each eligible firm must deliver a number of allowances corresponding to his total emissions in that year. Note that, since allowances are allocated for the full trading period (2005–2007), there is an implicit banking. At the beginning of 2008 the second trading phase starts and the first period allowances become worthless.

This study focuses on this latter issue, attempting to find empirical evidence of how a CO₂ price could impact on power pricing when electricity markets are imperfectly competitive.²

The empirical literature does not provide enough evidence to make clear this topic. In fact, there are no specific studies aimed at measuring the impact of market power. Most analyses try to check whether CO₂ costs are fully passed through into electricity prices and generically attribute the deviation from this “rule” to various factors among which the exercise of market power in the output markets.

In this paper, instead, we attempt to assess the impact of market power by combining the theoretical analysis with the empirical study of an emblematic case of imperfect competition in power market.

The article proceeds as follows. Section 2 focuses on the theoretical issues. We present a model useful to derive the price equilibria and the marginal pass-through rates under imperfect competition. Section 3 sets out the empirical analysis of the Italian market which is an emblematic case of imperfect competition. Finally, Section 4 summarizes the main results of the article.

2. Theoretical analysis

2.1. The model³: basic assumptions

Consistently with most contributions on this topic, power demand is assumed to be perfectly inelastic,⁴ predictable with certainty and given by a typical load duration curve $D(H)$, where H is the number of hours of demand equal or higher than D , with $0 \leq H \leq H_L$. $D_L = D(H_L)$ is the base-load demand (the minimum level) and $D_M = D(0)$ is the peak-load demand (the maximum level).

We assume that the power system consists of only two groups of plants, a and b. Each group includes a very large number n of homogeneous generating units⁵ such that $K_j = \sum_{i=1,2,\dots,n} k_j^i = nk_j$, $j = a, b$, where K_j is the total capacity of group j and $k_j^i = k_j > 0$ is the capacity of the i -th unit belonging to group j . Thus K_a and K_b are the installed capacities of groups a and b, respectively, with

$K_T = K_a + K_b$ and $K_T = D_M$, i.e. the units of a and b are sufficient to meet the peak demand.

We model technologies by means of two distinctive elements: variable costs (essentially, fuel costs) and CO₂ emission rates (emissions per unit of electricity generated). The CO₂ emission rate (emissions per unit of electricity generated) of the i -th unit belonging to group j is $e_j^i = e_j \geq 0 \forall i, j$ and the corresponding variable cost of production (essentially, fuel costs) is $v_j^i = v_j \geq 0 \forall i, j$ for production levels less than capacity, while production above capacity is impossible (i.e. infinitely costly). Furthermore, we assume $v_a < v_b$ and $e_a < e_b$, i.e. the technology with lower variable cost (the most efficient plants) is also the cleaner technology and vice versa (there is not “trade-off in the plant mix”).⁶ A typical relevant example is given by CCGT – combined cycle gas turbine – technologies (a) vs. gas-fired steam cycle plants (b).

Emission abatement is supposed to be impossible or, equivalently, abatement cost infinitely costly. This hypothesis is consistent with the time horizon of the analysis (short term analysis of the ETS impact).

The wholesale power market is a typical day ahead market organized in the form of first price auctions. The day ahead the generators simultaneously submit bid prices for each of their units on hourly basis. The market-clearing price is the highest bid price accepted and, if called upon to supply, generators are paid according to the market-clearing spot price (the system marginal price).⁷

With regard to the carbon market, the allowance price, p^{TP} , is given exogenously and carbon emission allowances are allocated free of charge.⁸

Finally, we assume that firm’s offer prices are constrained to be below some threshold level, \hat{p} . This threshold can be interpreted in two ways. It may be a (regulated) maximum price, \bar{p} , as officially introduced by the regulator. It may be simply perceived by the generators, i.e. firms believe that the regulator will introduce (or change) price regulation if the price rises above the threshold. In both cases we assume that the price cap is insensitive to the CO₂ price.⁹

² Many authors deal with the link between market structure and environmental issues. For a survey, see also Requate (2005).

³ For a more detailed description of the assumptions and structure of this model, see Bonacina and Gulli (2007).

⁴ In this paper this hypothesis mainly reflects the fact that hourly demand forecasts announced by the market operator are fixed quantities. Indeed, the aggregate demand should exhibit some elasticity, to the extent that eligible customers are allowed to announce demand bids. Nevertheless, actually observation highlights that the price elasticity of demand is very low (Crampes and Creti, 2005). Furthermore, a reasonable way (even if not optimal) to justify this assumption is to consider the short term. However, it is important to underline that focusing on the short term implies not considering mid and long-term strategies of utilities in managing their fuel and hydro reserves, and therefore may not represent correctly their bidding strategies. This may explain to a certain extent the difference between empirical and simulated results. Finally, most contributions using auction models assume inelastic demand (e.g. von der Fehr and Harbord, 1993; von der Fehr et al., 2006; Crampes and Creti, 2005).

⁵ Assuming that each group includes the same number n of units implies that k_j depends on K_j ; This is an arbitrary assumption which does not undermine, however, the significance of the analysis.

⁶ Indeed, this is the technology mix useful to simulate the empirical case analyzed in this paper (the Italian market). However, other technology configurations are possible. For the relevant case in which the technology with the lower variable cost is the worse polluter (“trade-off in the plant mix”), see Bonacina and Gulli (2007).

⁷ We suppose that all players are assumed to be risk neutral and to act in order to maximize their expected payoff (profit). Production costs, emission rates as well as the installed capacity of the plants are common knowledge. Furthermore, we neglect the existence of technical constraints such as start-up costs.

⁸ Both these hypotheses are consistent with the EU ETS. In particular, we suppose the allowance market is very large (consistently with the extent of the European ETS) and that firms are price takers. Indeed, the electricity sector accounts for basically 50% of the EU ETS. Therefore, in principle it has a certain power to influence prices in the carbon market. However, in our analysis, what is important is the single firm’s ability to do this. This ability is relatively low if we consider the entire European carbon market.

⁹ In fact, firms might decide to bring bid prices down not only to avoid regulation in the wholesale electricity market but also to avoid change in allowance allocation (e.g. under allocation) or change (increase) in taxation. These are two of the options taken into consideration for the second phase of the EU ETS in some countries in order to reduce the so-called windfall profits.

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