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Marginal cost and congestion in the Italian electricity market: An indirect estimation approach

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HIGHLIGHTS

- We construct an indirect measure of the supply marginal cost function.
- We compute the residual demand function taking into account transmission line congestion.
- We find a general evidence of a stable U-shaped marginal cost function for Italian generators.
- We find flat marginal cost function for the former national monopolist.
- We use excessive deviations from estimated marginal cost function as a new market surveillance mechanism.

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ABSTRACT

In this paper we construct an indirect measure of the supply marginal cost function for the main generators from the observed bid data in the Italian electricity market in the period 2004–2007. We compute the residual demand function for each generator, taking explicitly into account the issue of transmission line congestion. This procedure allows recovering correct zonal Lerner index and the implied measure of the marginal cost function. We find evidence of a stable U-shaped marginal cost function for three main Italian generators, but a flat function for ENEL, the former national monopolist. The policy relevance of our approach lies in the possibility to offer some empirical knowledge of the marginal cost function of each generator to the regulator to design appropriate policy measures geared to the promotion of competitive market conditions. We propose a new market surveillance mechanism, which is based on the principle of sanctioning excessive deviations from the estimated measure of the marginal cost function presented in this work.

1. Introduction

The crucial relationship between market power and congestion is becoming a structural problem in electricity markets, and for this reason, regulators have emphasized the need to better understand electricity market restructuring and the liberalization process[1].

In the literature, there are many empirical studies that have analyzed market equilibrium data or individual bid data to construct a measure of market power to indirectly infer a measure of the marginal cost (MC). This has been done assuming the absence of line congestion, i.e., assuming that the electric system behaves as a single bus-bar system. Moreover, the theoretical debate on market power and oligopolistic market structure has contributed to obscuring the line congestion issue. In fact, the empirical analysis of the electricity market has thus far not completely followed the theoretical approach of Supply Function Equilibrium (SFE) in analyzing the interaction between market power and line congestion. Holmberg (2008), analyzing the SFE, has set forth a comprehensive theoretical framework. This approach is particularly fruitful when

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[1] It has to be recognized that the promise of a competitive environment set forth by the liberalization of the late 1990s has been partially realized as a consequence of the relatively high level of concentration in the electric industry (Domanico, 2007), as anticipated by Thomas (2003). In an early stage of the liberalization process, he disputed the possibility that the presence of the "Seven Brothers", i.e., the main electricity companies in Europe at that time, would be favorable to a competitive industry. On the contrary, the market concentration, a privileged position in the home market, the lack of technological innovation and the disguised control of the transmission network remain the unresolved problems today, which undoubtedly nurture the exercise of market power.

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analyzing electricity markets because it allows for avoiding the confusion between the exercise of market power and opportunistic behavior aimed at exploiting the existence of transmission line congestion and gaining profit from congestion rent. Holmberg and Newbery (2010) argue that SFE can be used not only for predicting market outcomes but also to estimate empirically offer curves from individual bid data, as pioneered by Wolak (2003) for the California market. Willems et al. (2009) compare market outcomes from the traditional Cournot model and the SFE model estimating a market aggregate supply function for the period January-February 2006, distinguishing peak and off-peak periods in terms of different forward contract coverage, but assuming an absence of line congestion. With regard to the Italian market, Bosco et al. (2012) estimated MC using only spot market data characterized by the absence of congestion, following the original approach of Wolak (2003), who raised the problem of determining correctly the residual demand in presence of congestion. Gianfreda and Grossi (2012), using daily data, found that congestion influences zonal prices. Only recently, Bigerna et al. (2014) have applied a general method to disentangle congestion rent from market power in the empirical analysis of individual bids in the electric markets. The aim of this paper is to recover an indirect measure of the supply MC for the main generators from the observed bid data. We start our analysis assuming that generators maximize profit in the electricity market[2]. In the context of profit-maximizing behavior, we have computed the residual demand (RD) function for each generator in the market and we have used the Lerner index (LI) to obtain a measure of MC, taking into account the problem of congestion. The relevance of our approach lies in the possibility of offering some empirical knowledge of the MC function of each generator to the regulator, who acts to design appropriate policy measures geared toward the promotion of competitive market conditions. Notice that this is particularly relevant in the case of Italy, where the legislation empowers the Energy Authority not only to regulate tariffs and natural monopoly segments in the electric sector but also to actively promote competition in the generation sector[3]. The remainder of our paper is structured as follows. Section 2 provides the theoretical model of the firm behavior in the market. Section 3 describes the dataset for the Italian market and discusses the simulation results, providing an indirect estimation of the MC function for the main generators in the Italian market. Section 4 concludes by discussing our policy proposal with operational and institutional suggestions to spur competition in the electric market.

2. Model

The literature analyzing electricity markets indicates that good progress has been made toward introducing competition, despite several oligopolistic and or non-competitive market outcomes that remain in Europe. This gives rise to the opportunity for generators to exercise market power and raise the price above the MC (Borenstein et al., 2002; McRae and Wolak, 2009; Sweeting, 2007; Wolak, 2003). Such a state of affairs also occurs in the Italian market (Bigerna et al., 2014; Boffa et al., 2010; Bosco et al., 2012, 2007), in which the type of market structure that prevails through time is unclear. In fact, there is evidence of pivotal and monopolistic behavior in certain periods (Perekhodtsev and Baselice, 2010), while a duopoly occurs at other times (Bigerna et al., 2014). In addition, some evidence of Cournot competition exists, (Boffa et al., 2010) but, at certain times, a Stackelberg model seems to emerge (Floro, 2009). In other words, there is no definite view about the most appropriate description of the Italian market structure. Thus, we deem it appropriate to set forth a minimal set of assumptions on market behavior, that is, we assume that, in the Italian market, generators maximize profit by submitting bids according to a well-defined supply function (Wolak, 2003), explicitly taking into account the existence of transmission network congestion[4].

2.1. Theoretical model

We assume that market segmentation due to congestion can changes the relevant position of the RD faced by each supplier. We consider this when modeling strategic ex-ante behavior in the day-ahead market, assuming that suppliers make ex-ante efficient expectations of line congestion occurrence based on available information. In other words, we do not consider whether suppliers can strategically induce congestion to increase market power (Quick and Carey, 2002)[5]. This approach allows us to compute an indirect measure of the firm-level MC in the Italian market using the LI, which can be interpreted as a measure of unilateral market power (Lerner, 1934). To this end, we assume that each generator formulates its bidding strategy to maximize the expected profit. They choose the best pricing strategy considering the RD, computed as the difference between the market demand and the bids submitted by all other competitors.

In a general form, we can represent, for each operator i and for each zone z, the hourly (h) bidding behavior, assuming that there exists a profit function as follows:

$$\Pi_{hiz} = RD_{hiz}(p_{hz}) \times (p_{hz} - MC_{hiz}) - (p_{hz} - pc_{hi}) \times QC_{hiz} - F_{iz} \qquad (1)$$

where F_{iz} is the zonal fixed cost; MC_{hiz} is the hourly zonal MC and $RD_{hiz} = QD_{hz} - QS_{hz(-i)}$, where QD_{hz} is the hourly total zonal demand; and $QS_{hz(-i)}$ is the hourly zonal supply of all of the other competitors. The notation $(-i)$ indicates all others except generator i. Notice that it is possible to interpret the behavior underlying Eq. (1) as follows. The first term captures the short-run variable profit obtained in the spot market with a markup of the price over the MC. The second term expresses the profit generated from sales of contracted quantities and/or purchasing activities on the forward market. Notice that, operationally, it is not possible to recover information on pc_{hi}, and therefore, we have simply subtracted QC_{hiz} from RD_{hiz} for each hour and each operator (similar to Bosco et al. (2012)) to compute a measure of the uncontracted quantity, i.e., the quantity net of contract for differences. We used this latter quantity to compute the correct arc elasticity. Specifically, we used the procedure described in Bigerna et al. (2014), which entails recording the total contracted electricity supply in the market for each operator and then appropriately

[2] A large stream of literature has shown that generators adopt profit maximizing strategies for bidding in the wholesale electricity markets. See among others Boffa et al. (2010), Bosco et al. (2013, 2012), Hortaçsu and Puller (2008), Wolak (2003).

[3] Notice that this concept of MC is different from the pure technical notion of engineering plant data. This latter derives strictly from technical operational specifications of the equipment. Therefore, it is at the same time more accurate from a technical viewpoint, but it is also less realistic in economic terms.

[4] From an empirical viewpoint, the interaction between congestion and market power can occur in different periods, not necessarily only during peak hours, as demonstrated by the recent Italian market outcomes in which the importance of renewables injection has changed the traditional peak and off-peak distribution, Bigerna and Bollino (2014).

[5] The interaction between congestion and market power is likely to depend on the covariance of the two phenomena. Technical line congestion can reinforce the oligopolistic exercise of market power (this would be the case of positive covariance). However, it is possible that market power could weaken the occurrence of congestion if the monopolistic generator completely dominates several market zones and therefore decides the supply quantity to maximize profit, extracting the whole consumer rent. Thus, the monopolistic generator has no interest in causing congestion (this would be a case of negative covariance).