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Increasing market interconnection: An analysis of the Italian electricity spot market ☆

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ABSTRACT

We estimate the benefits (in terms of savings to end-users) resulting from an improved interconnectivity in the Italian electricity spot market. The market is currently divided into two geographic zones – North and South – with limited inter-zonal transmission capacity that often induces congestion, and hence potential inefficiency. By simulating a fully interconnected market, we predict that the total spot market expenditure would reduce substantially. Moreover, since savings do not increase linearly with the size of new transmission capacity, even a slight increment to transmission capacity is found to substantially reduce end-users' expenditures. Finally, our analysis shows that the (partly State owned) dominant firm in the market is not maximizing short-term profits.

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1. Introduction

In the Lisbon agenda, in March 2002, the European Union recognized market integration – both within, and across its member countries – as a prerequisite for sustained economic growth. In this paper we quantify the expenditure reduction that results from one such interconnection: the case of the Italian electricity spot market. Specifically, our study has two aims. The first one is to characterize the objective function of a pivotal electricity generator in a *semi-regulated* environment with a mixed ownership structure: the Italian treasury and private investors. The second one is to estimate the expenditure reduction in the spot market after congestion removal — in the form of lower electricity prices primarily due to a more efficient utilization of existing generation capacity.

The Italian electricity market is a good example for understanding the benefits of improved market interconnection. At present, there is a hot debate in Italy regarding infrastructural enhancements, primary among which is the discussion on the electricity transmission network. While the proponents of such venture argue that an improved network would reduce prices substantially, its opponents claim that it would lead to environmental damages without bringing about any significant benefits to end-users. To our knowledge, there is no scientific attempt on either side to quantify either costs or benefits. Therefore, our study can be viewed as partially bridging this gap by estimating the benefits of interconnection in the spot market.

Moreover, the structure of the Italian electricity spot market is particularly suitable for addressing the question at hand. Currently, the market is divided into several zones, with the amount of electricity that can flow across zones being limited due to insufficient transmission capacity. Generators, with varying degrees of efficiency and capacity, are located all over the country. While a no-arbitrage condition ensures that the market clearing price is the same across all zones when the transmission capacity is not fully saturated, zonal prices differ when the transmission constraint is binding. One way to eliminate this price difference is to invest in inter-zonal transmission capacity, so that generators can reallocate production among more efficient units, thereby reducing overall costs. Therefore, the question

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addressed in our paper can be restated as follows: what is the change in the expenditure incurred by the Italian economy on the electricity spot market, after sufficient inter-zonal transmission capacity is installed such that the price difference between zones is reduced or completely eliminated? Lower electricity prices are an indication of a more efficient market. While in the short-run demand is inelastic, and thus total welfare is invariant to price changes, in the long run this does not occur, since the elasticity of demand is higher.

Expenditure reductions from interconnection are computed based on a behavioral assumption on the dominant player in the market, *Enel*. A natural assumption of market leader being a short-run profit maximizer need not be an appropriate one in the Italian case for a variety of reasons. First, *Enel* is a partly State-owned firm. Second, electricity is a necessary good, and hence the fear of regulatory intervention is strong if there is an evidence of exploitation of market power. Finally, there is a potential chance of entry if short-run profits were too high.[1] In other words, dynamic considerations could lead a firm away from myopic profit maximization paradigm in the short run. Therefore we assume that *Enel*'s objective function has two portions. The first one is the short-run profit maximization and the second one is the minimization of consumers' expenditure. While the former represents the short-run interest of *Enel*'s private investors, the latter is a proxy both for *Enel*'s long run profit considerations (prevention of regulatory retaliation and entry), as well as the public ownership incentives (end-users' welfare).

We identify the relative weights of these two contrasting objectives empirically. We find that *Enel* places a weight of roughly 2/3 on its profits and 1/3 on consumers' expenditure. Under the assumption that the weights in the objective function of *Enel* do not change due to interconnection, we find that easing bottlenecks would result in a saving of just over 10 million euros to the end-users of electricity in the month of May 2004, the sample period considered here. These savings account for almost 6% of spot market expenditure in the congested hours of the corresponding time period. As we do not have complete data on the costs of providing additional transmission capacity, we characterize the cost savings alone. One interesting issue is the question of optimal price differential. It is conceivable that the total welfare gain (net of costs of increasing transfer capacity) might be maximized at a point where prices are not always uniform across zones. Though a policy maker is likely to install *sufficient* transmission capacity so that the problem of inadequate interconnection does not reoccur in the near future, we also consider the expenditure savings for end-users accruing with "less than full" interconnection (i.e. completing resolving congestion only in a limited amount of hours).[2]

The industrial organization literature is rich in studies that investigate various nuances of (de)regulation in electricity markets. In a theoretical study, Borenstein et al. (2000) show that a small investment in transmission capacity can substantially improve welfare. In their analysis of Norwegian electricity markets, Johnsen et al. (2004) find that when the transmission capacity across zones binds, generators can more readily exercise market power. In this regard, the main objective of our paper is to estimate the savings associated with congestion elimination.

Market imperfections – in the sense of market price distortion (away from the first best) – are well studied in the literature. The empirical literature suggests that there is little correlation between market concentration and the degree of market power exercised by electricity generators. For example, Wolfram (1999) shows that the mark ups in the England and Wales electricity spot market in the early 1990s were lower than those implied by a Cournot duopoly model. Sweeting (2007) shows that, in the second half of 1990s, firms in the English electricity market exercised significant market power "in spite of decreasing market concentration". Borenstein et al. (2002) find that the presence of market power doubled the wholesale electricity price in the California's electricity market. Hortaçsu and Puller (2008) show that large generators' bids in the Texas market support the assumption of profit maximization. Another contribution this paper makes is to show that *Enel* does not exercise the fullest extent of its market power.

The rest of the paper is organized as follows. Section 2 describes the Italian electricity spot market. In Section 3 we present our theoretical model. Section 4 discusses our dataset and presents some summary statistics. In Section 5 we present our results along with counterfactual simulations. Section 6 presents some extensions and robustness checks. Section 7 concludes.

2. The Italian electricity spot market

2.1. Market organization[3]

In 2004, Italian national electricity consumption was around 322 terawatt hours (TWh), an increase of about 0.4% from the previous year. Hydrocarbons (coal, oil and natural gas) accounted for around seventy five percent of the overall installed generation capacity. Hydroelectric power plants accounted for around twenty five percent and other bio-friendly generation plants (wind, photovoltaic, etc.) accounted for less than 0.5% of the total production. Nuclear energy has been banned in Italy since 1988.[4] This ban, combined with a lack of any substantial competition, is often blamed for Italy's high electricity prices.

Transactions in the Italian electricity market occur both through a spot market and through individual bilateral contracts signed between the generators and the end-users. The spot market is designed to cater to the needs of the residential sector and all the industrial customers that do not sign individual contracts. It also acts as a buffer for any unanticipated short-term shocks to the demand, and operates on an hourly basis.

Residential and industrial customers are subject to two different sets of market rules. The residential sector is supplied through an intermediary (single buyer), who operates via the spot market. It accounted for more than 95% of the overall spot market quantity. Residential consumers pay a tariff set by the Italian electricity regulator (AEEG), fixed throughout Italy irrespective of zone, and subject to a quarterly review.[5] Industrial spot market customers pay a weighted average of previous month's spot market clearing prices, irrespective of zone. Therefore the spot market demand can be safely regarded as independent of that day's spot market clearing prices. Hence, it is fixed for spot market considerations.

For generators, nodal pricing is in place. That is, generators participating in the spot market receive the market clearing price of the zone in which they are located. The *Market Operator* (*MO*) solicits bids from all generators each hour every day. A typical bid submitted by a generator consists of at most fourteen price–quantity combinations. A price–quantity combination is a commitment from the generator of the amount of electricity he is willing to supply at that price. The *Transmission System Operator* (*TSO*) announces the maximum amount of electricity that can be transferred across zones, which depends on several engineering criteria. The transmission network needs to undergo regular maintenance operations, thereby frequently cramping the maximum amount of electricity that

[1] Limit pricing as a reasonable strategy is discussed in Section 5.2.

[2] We do not consider the ownership of the transmission network and assume that the entire transmission network is under the control of a public authority. In 2004, private investment in transmission network was banned in Italy. See Joskow and Tirole (2005) for arguments against and Harvey et al. (1996) for arguments in favor of merchant transmission.

[3] The market structure described here is relevant for the sample period (May 2004). In some cases market rules have changed since then.

[4] Roughly 60% and 15% of electricity consumption in France and Germany, respectively, are produced by nuclear power plants. In the last months of 2008 the Italian Government devised new plans to build nuclear power plants.

[5] The electricity price paid by the residential sector is a politically sensitive issue. Therefore, though in principle it is supposed to be set as a weighted average of all the spot market clearing prices (with weights being quantities consumed), several considerations play a role during the review.

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