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Ramsey prices in the Italian electricity market

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HIGHLIGHTS

- We model and estimate the demand of heterogeneous buyers in the electricity market.
- Transmission line congestion creates welfare distortions in the market.
- We derive optimal Ramsey prices in the Italian day-ahead electricity market.
- We compare optimal prices with historical ones showing how to improve welfare.

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ABSTRACT

In this paper, we derive optimal zonal prices in the Italian day-ahead electricity market using estimation of a complete system of hourly demand in 2010–2011. In Italy, the hourly equilibrium price for all buyers is computed as a uniform average of supply zonal prices, resulting from market splitting due to line congestion. We model ex-ante individual bids expressed by heterogeneous consumers, which are distinguished by geographical zones. Using empirical estimations, we compute demand elasticity values and new zonal prices, according to a Ramsey optimal scheme. This is a new approach in the wholesale electricity market literature, as previous studies have discussed the relative merit of zonal prices, considering only the issue of line congestion. Our results show that the optimal pricing scheme can improve welfare in the day-ahead Italian electricity market, with respect to both the existing uniform price scheme and the proposal to charge the existing supply zonal prices to the demand side.

1. Introduction

In the organized electricity markets, the equilibrium price is determined by the intersection of supply and demand functions, resulting from the aggregation of individual bids submitted to the Market operator. In a perfect theoretical market, this solution is efficient, insofar as all agents are price takers and there are not market inefficiencies. In reality, the existence of transmission line congestion, more generally of network security management and of not-in-my-back-yard (NIMBY) syndrome[1] raise the issue of departure from the perfect competitive model. In other word, prices may not necessarily be equal to marginal costs and therefore, there is need to search for a second best solution. In the literature, a widely recommended solution is to set Ramsey (1927) prices, in order to minimize deadweight losses deriving from departing from the efficient solution.

The main aim of this paper is to define an optimal design to determine zonal prices in the wholesale electricity market using explicit information on the individual bids demand side. Surprisingly, the literature of theoretical and empirical analysis of deregulated electricity markets has not taken into account this important side of the market; rather, it has focused analysis on the zonal price differences arising on the supply side of the market. As it is well known, line congestion in a meshed network may give rise to price differentials between any two adjacent zones. In turn, these differences reflect an efficient resource allocation, insofar as they originate from differences in marginal supply costs and technologies.

However, this approach neglects two issues. First, the zonal price scheme does not consider that there is a characteristic of public good in the network management because the network security is an indivisible good. Second, it is rather obvious to consider that consumers' behavior may change in various zones due to price differentials, and this change may have consequences on overall consumer welfare. These two considerations challenge the conclusion that zonal prices based on zonal marginal costs are necessarily an efficient solution for the system as a whole. This would be the case if the electricity market were characterized by

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[1] It refers to the behavior of local groups of citizens who are opposed to equipment and infrastructures localization near their homes. This can create suboptimal localization of necessary infrastructures.

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perfect competitive conditions. In reality, zonal prices include private costs, which would be efficient with respect to the network usage. However, they neglect social costs associated with specific network configurations that impinge on the rest of the economic activity.

As a thought experiment, consider an individual who unexpectedly goes to the local hospital. The increased electricity load due to the peculiarity of his illness (e.g., energy intensive artificial lung pumping) gives rise to line congestion and a higher zonal price. From a normative viewpoint, it is necessary to answer the following question: why should all other consumers in the zone pay more? We do not know whether they had the opportunity to decide in advance the optimal transmission level in their zone or anyway to form an expectation to face this problem. This unforeseen event is not under their control. Presumably, there is an increase in the cost of the service for all the consumers in the zone. These considerations give rise to another relevant problem. Should the cost associated to an unforeseen event such as an illness be socialized only to neighboring consumers? Alternatively, should such costs be borne by the entire society? There is the need to assess and quantify the social benefits of the hospital service in that zone with respect to the social cost of the network security in a broader zone. It is evident that this theoretical example raises normative questions involving some value judgments that go beyond the mere issue of efficient allocation of network scarcity. We deem that these normative issues are important and should be explicitly considered when analyzing the electricity market.

With these considerations in mind, we want to place emphasis on the demand side of the electricity market. We analyze the demand response to market signals and estimate the demand elasticity to design an optimal Ramsey price scheme in the Italian deregulated electricity market, where prices are determined in an auction market, the day-ahead Italian power exchange market (IPEX). We assess the welfare implications of the actual market design for determining prices in the electricity market. To conduct such evaluation, we perform a calculation of optimal prices according to Ramsey pricing theory with the objective to maximize social welfare. Then, we compare actual prices and zonal prices to optimal prices, to assess whether the actual price scheme can be improved upon and whether the adoption of zonal prices goes in the direction of optimality. To our knowledge, this is the first attempt in the literature to analyze optimal prices in an organized wholesale electricity market, like the IPEX; therefore, we attempt to bridge the literature of theoretical and empirical analysis of deregulated electricity markets and the literature on optimal price design. Specifically, we use the IPEX data published by the Italian Market Operator ("Gestore mercato elettrico", GME), considering individual bids in the day-ahead market to construct demand schedules in the period 2010–2011.

This paper is organized as follows. Section 2 presents a brief review of the related literature. Section 3 presents the theoretical framework of optimal pricing and the empirical methodology to estimate consumer behavior and describes the data set used. Section 4 presents the results and the discussion. Section 5 presents policy implications and concludes the paper.

2. Related literature

The methodology to determine the vector of optimal prices involves the estimation of the demand elasticity in order to compute the Ramsey proportionality factor, which is needed to differentiate the charge according to the inverse of the demand elasticity. There are consolidated applications of this method in both theoretical and empirical economic analyses in the public utility sector, starting from the seminal contribution of Laffont and Tirole (1996), discussing the Ramsey optimality of the price cap regulation.

Ramsey pricing appears to influence welfare in the sectors of public utilities. Shepherd (1992) criticizes it by stating that Ramsey prices are a different way to label monopoly behavior. In the transport sector, Jorgensen et al. (2004) discuss the need to subsidize optimally the ferry services in Norway, because they are welfare enhancing, by regulating fares so to generate sufficient revenue to support the sector deficit. Martín-Cejas (1997, 2010) discusses the environmental implications of long-term growth in the air transport in Spain and the consequent need to design a Ramsey airport pricing structure for landing fees, which takes into account the social externality of the environmental damage. Hakimov and Mueller (2014) propose Ramsey pricing for landing fees differentiated by distance for five German airports. They find that Ramsey prices are optimal for airports with cost recovery problems, but are inefficient for busy airports and provide inconclusive evidence in favor of Ramsey pricing. Sanchez-Borras et al. (2010) apply Ramsey pricing to the high-speed trains in Europe. Lin and Prince (2009) show an optimal gasoline tax in California. Other examples are in the health sector (e.g. Melnick et al., 1992; Danzon, 1997; Wedig, 1993) discussing the application of Ramsey pricing to regulate the physicians market power to induce their own demand.

There are many relatively recent applications related to the electricity markets. Qi et al. (2009) compute Ramsey prices for the Chinese residential sector and Matsukawa et al. (1993) analyze the Japanese utility sector. They both conclude that the welfare effects of rate regulation could be improved by increasing the residential electricity price and decrease the industrial one. Horowitz et al. (1996) discuss the case of unknown bypass costs. Berry (2000, 2002) discusses Ramsey pricing as a tool for the regulator to discriminate between liberalized and bundled customers and to charge optimally stranded costs. The conclusion is that unbundled customers are more elastic, because they can search for alternatives in the market, and therefore their optimal Ramsey price should be lower than that charged to bundled customers.

Nahata et al. (2007) apply Ramsey pricing of electricity to final customers in Russia, based on estimation of single equation demand elasticities for six major groups of consumers (households and industrial users), using company data provided by the local distributor. Their findings support the view that the pricing policy adopted by the utility is not in accordance with the Ramsey rule and advocate that the welfare improving regulation should lower the price for industrial users and increase the price for households.

Raineri and Giaconi (2005) propose to apply Ramsey pricing to the regulation of the electricity distribution to final customers and competitive energy sellers in Chile, concluding that the current regulation is not optimal. Kopsakangas-Savolainen (2004) computes the component of the final electricity price relative to network prices based on Ramsey pricing in Finland. Even under the assumption that the wholesale price is determined efficiently, the conclusion is that Ramsey pricing is welfare improving. Lin and Liu (2011) analyze the Chinese pricing reform for energy intensive industries enacted to promote energy efficiency and industrial restructuring. They analyze eight electricity intensive industries demand, showing that the optimal pricing policy is indeed inducing productivity growth.

Santos et al. (2012) analyze the electricity distribution systems in Brazil, combining time-of-use tariffs and Ramsey prices to be charged to both energy consumers and micro-generation units. Their conclusion is that the pricing regulation enacted by the Brazilian Electricity Regulatory Agency can be improved in terms of welfare. Klein and Sweeney (1999) analyze the natural gas distribution utilities in Tennessee using panel data to estimate Ramsey prices. They find empirical support to optimal Ramsey