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Interaction between gas and power market designs

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ABSTRACT

Both gas and electricity market designs depend on how the network use is regulated. Those regulations tend to promote contracts that simplify some of the network specificities in order to increase market thickness. However, those simplifications often come at the cost of distorting network use and investment signals. This problem and the consequences of different designs have been studied for each industry separately. This paper contributes by showing the cross-industry interactions. From this view, distortions depend not only on network simplifications in one market but on the particular combinations of market designs, i.e. choices about network simplification in both markets. Therefore, policy makers concerned with gas and electricity market designs should take into account the results of network rules interaction. We use simple auction designs to represent both markets, and we analyze how players are expected to respond to different network rules. Thus, looking from the perspective of gas-fired power plants, we study the incentives given by the designs for the use of each network. We also identify long-term investment effects of such design strategies.

1. Introduction

Power and gas industries are increasingly linked. Gas-fired power plants are widely used for electricity production, and will be used even more in the future to back up intermittent generation. Hence, gas-fired power plants have become relevant users of the gas system, which motivate a strong link between industries. Furthermore, they have become users with a new and volatile pattern in the short run, which motivates a relatively new link between industries (associated with new needs of network services). Despite this new interaction between gas and electricity markets, most of the literature has dealt with the two industries separately. The main objective of this paper is to show that a large part of the interaction between these industries will depend on the incentives resulting from the interaction of both market designs.

The literature dealing with market design aspects of the gas industry can be organized under four broad headers. The first group of works analyzes the role of long-term contracts. Long-term contracting has traditionally been the building block of gas markets and hence the central focus of study is on how the industry was coordinated (see for instance Mulherin, 1986 or Masten and Crocker, 1985). The second group analyzes short-term regulatory aspects associated with the existence of a central network operator (see for instance Lapuerta and Moselle, 2002 or Lapuerta, 2003). More recently, a third stream of literature began to discuss different institutional arrangements for gas transmission and their impact on the gas market, Ruff (2012), Makholm (2012) or Vazquez et al. (2012) and aims to link the two former streams of literature. The fourth group focuses on the modeling of strategic behavior assuming a certain market design (see Holtz et al., 2008; Boots et al., 2004 or Smeers, 2008).

In the electricity industry, we find similar lines of regulatory research. In the case of power markets, long-term contracting has traditionally played a weaker role and the analogous literature is related to the design of organized markets. See for instance Sioshansi (2008) for a review in on the literature dealing with the design of mechanisms for market arrangements. The short-term regulatory issues related to power network coordination have also been extensively analyzed (see for instance Stoft (2002) for a general description). A third stream of the literature copes with the institutional setting of power markets, Joskow and Schmalensee (1983), Glachant and Finon (2000), Rious et al. (2008). The fourth area is concerned with strategic behavior issues; particularly relevant is the literature is on strategic behavior in auctions (for general models, see Ausubel and Cramton, 2002, which in turn builds on

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Wilson, 1979). Simplified applications of that strategic behavior to power systems can be found in Hobbs (2001) and Borenstein et al. (1999), who model quantity competition; Fabra et al. (2002) who model price competition; or Green and Newbery (1992), who model supply function equilibrium.

The aim of this paper is to investigate how the designs of gas and power markets interact. We will show that the incentives resulting from market designs change when considering interaction, either by intensifying some expected results or by producing additional impacts. This paper, therefore, shows that the assessment of gas and electricity market designs should take into account the interaction between their rules. We first show that the design of gas and electricity design largely depends on how network use is regulated. The liberalization of both industries open the access to network infrastructures by multiple users and the interaction among players depends on how they can physically interconnect. For both industries, market designs should address not only the coordination between the demand and supply of commodity products, but also the coordination of network operations. In particular, gas and power market designs need to define how network constraints are coordinated with commodity trading. However, there is no first-best solution or one-size-fits-all design. Market designs involve choices that consider the costs and benefits of several possibilities. This reasoning can be traced to the literature on transaction costs economics (see Riordan and Williamson (1985)).

The next step of this paper is the representation of the general characteristics of each market design through an equivalent auction design in accordance with our paper's hypotheses. It is a simplified model (especially in the sense that it disregards strategic behavior) that highlights how different market designs generate different incentives and how they would impact both industries. The equivalent auction representing the power market that we use is close the ones in O'Neill et al. (2003) and Hogan and Ring (2003), where they proposed clearing mechanisms for the market. Regarding the gas market, in order to be able to compare the two sets of results, we use the auctions proposed in Vazquez and Hallack (2013).

We then show, using equilibrium conditions for the auctions, the main characteristics of the short-term incentives resulting from several market designs. We show that the effects of simplifying the allocation of network services are not confined to one industry. From this view, we analyze the dynamic implications of the previous results. Short-term mechanisms are effective long-term signals. When such signals are distorted, there are relevant long-term effects both on the commodity and the network sides of the market.

After the introduction, Section 2 shows the elements of market design for both the gas and power industries, and especially the trade-offs faced by different design solutions. Section 3 introduces our tool to compare market designs, that is, the short-term auction representation. Section 4 analyzes the cross-industry effects of the various definitions of networks use. Section 5 studies the dynamic consequences of these short-term effects and Section 6 collects our conclusions. The Appendix defines the single-auction representation of both gas and power markets.

2. The logic behind the definition of ”commercial” networks

In order to implement market arrangements in gas and power industries, a commodity must be defined beforehand. This is based on gas and power characteristics (e.g., pressure in pipelines or frequency of power flows), and of the time horizon and location of injection or delivery. Transmission infrastructures play a critical role in the definition. From this view, one needs to consider that gas and power networks operations are characterized by tight technical constraints, and hence the contracting architecture required to implement commodity delivery at different points of the network, within different time scopes, will be complex. This is the source of significant transaction costs (see Williamson, 1975, 1985 and Glachant, 2002 for the analysis of asset specificity in several network industries).

In order to reduce specificity, it is possible to simplify the actual network to broaden the trading space. That is, the simplification of networks (and the associated enlarged trading space) decreases specificity by increasing the amount of players trading the same product. In other words, network simplification brings liquidity to the market in the sense that the number of agents trading the same product is increased (based on a broad definition of temporal and spatial specificities).

Consequently, many gas and power markets are built on the idea of ”commercial networks”. Ensuring the security of the system operation typically involves a tight coordination between commodity and network services. Hence, many systems have created a set of arrangements where some transmission services are allocated according to certain rules defined by an external agent instead of by market players interactions. This allows increasing homogeneity of trading places and thus decreasing specificity with regard to complex technical characteristics. The commercial network is defined as this reduced set of network services, which is taken into account by market players when trading the commodity. The remaining differences between the commercial network and the physical network are called ancillary services, following the power markets literature (Stoft, 2002). In this context, the external agent in charge of the network operation and thus of ancillary services, will be called the Transmission System Operator (TSO).[1]

Although commercial networks are widely used to implement market arrangements in energy industries, not all of these industries use them. The paradigmatic case of not using (exogenously) simplified networks is the US gas market design, which builds on long-term pipeline contracting (see Makholm, 2012 for a detailed description). In that case, the coordination of gas networks with commodity trading is decided by market players instead of reliance on allocation through external rules. As both networks and network users are market players, the room for exogenous designs introduced by policy makers and/or regulators is reduced. From this paper's point of view, such systems are less relevant as we are focused on the interaction between designs, that is, between sets of exogenous rules. Hence, this paper considers only gas market arrangements built on the definition of a commercial network.

2.1. Design of commercial networks

The network operator can choose to reduce the specificity of each feasible trade. If the network operator simplifies the individual spatial characteristics of each trade, the spatial difficulties to trade in the network zone are reduced, and the number of market players trading the same product is increased. The same idea is pursued when the TSO simplifies the time characteristics of gas or power by defining longer periods in which injections and withdrawals are considered simultaneous. This simplification strategy implies that several services will be part of the ancillary services, and hence will be socialized. We will next describe this simplification of the network analyzing the implicit spatial and time flexibility that different regulations may associate with the commodity definition.

[1] TSO is defined in this paper as a player that operates the network as whole, at least in a certain zone. The contrary is having several operators in the same zone, as in the US gas markets.