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Contract market power and its impact on the efficiency of the electricity sector

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H I G H L I G H T S

- The paper analyzes the pro-competitive impact of contracts for difference.
- The reference price of contracts is the average spot price.
- Installed capacity increases with total quantity of energy contracted.
- Social welfare is maximized when energy contracted equals the efficient capacity.
- An aggregation of all consumers would choose to auction the efficient quantity.

A R T I C L E I N F O

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A B S T R A C T

This paper analyzes the pro-competitive effects of financial long-term contracts in oligopolistic electricity markets. This is done in a model that incorporates the main features of the industry: non-storable production, time-varying price-elastic demand, and sequential investment and production decisions. The paper considers contracts for difference that have as reference price the average spot price. Assuming that the spot market coordinator sets competitive prices, the paper shows that installed capacity increases with the quantity of energy contracted, reaching the welfare-maximizing capacity when energy contracted equals this same level. Next, the paper studies the case where the quantity of energy contracted is endogenous and contracts are traded before capacity decisions are taken. Regarding purchasers of contracts, two polar cases are considered: either they are price-taker speculators or they are an aggregation of consumers that auctions a long (buy) contract for a given energy quantity. In the former case the strike price equals the reference price, i.e., arbitrage is perfect, and the quantity of energy contracted falls short of the efficient level. In turn, in the latter case, the strike price equals the average efficient spot price. Moreover, an aggregation of all consumers would choose to auction the social optimum quantity.

1. Introduction

This paper discusses the impact of introducing a contract market in the efficiency of the electricity sector using a model that considers the main features of the industry: a non-storable product, a time-varying and price-elastic demand, and the sequential nature of investment and production decisions.[1,2] These characteristics of electricity markets, particularly the first two, impose the need to balance demand and supply in real-time. Indeed, even if almost all consumption were purchased in forward markets, a mechanism to handle supply and demand short-run deviations from contracts would still be required. This paper assumes that this mechanism is a spot market, which is the choice of most countries that have liberalized their electricity sectors.

Given the concentrated nature of electricity markets, the spot market is susceptible to non-competitive pricing by generators when demand is at or near its peak. In fact, given that, in the short run, capacity is fixed and no inventories are available, producers have incentives to withhold capacity.[3] In those markets where the regulation mandates holding day-ahead auctions to receive supply offers, generators tend to bid above marginal cost.[4] These behaviors

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[1] Since the paper focuses on power generation, transmission and distribution activities are omitted.

[2] A fourth feature, which is in part a consequence of the other three, is that the installed capacity typically includes units with different technologies.

[3] Kwoka and Sabodash (2011) found that strategic withholding of production occurred in the New York system during the summer of 2001 and resulted in unusually high prices.

[4] Von der Fehr and Harbord (1993), assuming that the coordinator of the spot market holds day ahead supply auctions, found that in high-demand realizations (all suppliers needed to cover demand) prices exceed the cost of even the most inefficient supplier.

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are fostered by the lack of demand participation in the spot market. Although the idiosyncratic characteristics of the electricity sector combine to produce significant fluctuations in spot prices, retail prices remain constant in the short and even in the medium term in most electricity markets.

The literature broadly concurs that the policy response to market power in the electricity sector should combine the introduction of contract markets and demand participation in the spot market.[5] The intuition is that producers have less incentive to raise the spot price if part of their production is sold prior to the spot market clearing.[6] The empirical evidence supports the view that forward contracting has a pro-competitive impact on those markets (Fabra and Toro, 2005; Bushnell et al., 2008; Petrella and Sapio, 2011). In addition, a greater demand participation in the spot market would result in higher price elasticity, the critical factor in determining market power.

Although demand participation in the spot market still confronts some practical difficulties, recent technological developments known as smart grid – which allow for bi-directional flows of information in the grid – could aid consumers to manage their electricity needs more efficiently. For instance, smart switches could turn on/off high-consuming appliances depending on real-time prices. There is thus a real possibility of increasing demand participation in the spot wholesale market.[7]

We assume demand participation in the spot market and concentrate our analysis on the impact that contracts have on the industry's efficiency. This effect depends on the degree of market power exercised by generators on the contract market. We thus focus the attention on the effect that market power on contract trading has on the industry. To do so, we assume competitive pricing in the spot market because it simplifies the analysis without detracting from the main objective. Moreover, this condition holds in a number of real markets. Indeed, legislation in a number of countries, especially in Latin America, entrusts the spot market coordinator to set competitive prices.[8]

Our analysis is formalized first in a two-stage game with exogenous contracts. In the first stage, each generator decides on its capacity by taking its rivals' capacity as given and considering standing contracts. In the second stage, the spot market coordinator sets the competitive spot price for each time segment. Thus, the model considers the variability of demand and the non-storability of the product (instantaneous clearing of the spot market), and the sequential nature of investment and production decisions (the two-stage game nature of the model).

The paper further assumes that parties trade two-way contracts for difference (*CfD*s), where the reference price is set equal to the average spot price. Thus, generators pay (or are paid by) their counterparties the difference between the reference price and the strike price times the quantity contracted. Accordingly, generators that sold supply contracts have incentives to lower the reference price by installing more capacity. In addition, all firms are identical, all parties have perfect foresight, and contracts are observable and enforceable. For simplicity, discount factors are ignored.

Within this framework, the paper shows that the Nash equilibrium aggregate capacity is increasing in total quantity of energy contracted and that the welfare-maximizing level is reached when the quantity contracted equals the welfare-maximizing aggregate capacity. Consequently, social welfare is increasing in contracted energy as long as it does not exceed the welfare maximizing capacity.

The analysis then turns to the case where the quantity of energy contracted is endogenous and contracts are traded before capacity is committed. Two polar market structures are examined; first, the counterparty of generators is a competitive fringe of speculators; second, the counterparty is an aggregation of consumers that auctions a long (buy) contract for a given energy quantity. For the former case, this paper shows that the emergence of a contract market curbs but does not eliminate the exercise of market power by generators. In fact, introducing a *CfD* market increases the industry's capacity, but not by enough to reach the social welfare maximizing level. Accordingly, the emergence of a contract market lowers spot prices (in those time segments where capacity is binding), but not to their efficient levels. Moreover, arbitrage is perfect, i.e., the strike price equals the reference price.

The paper then addresses the case where an aggregation of consumers awards a long (buy) *CfD* contract in a sealed first-price auction. In this situation, the strike price equals the average efficient spot price, reflecting the fact that generators are price-setters in the contract market. Hence, those consumers who participate in the auction benefit both from a reduction in the spot prices, as do all other consumers, and from the auction of the contract. Furthermore, the paper proves that an aggregate of all consumers would auction a contract for the quantity that ensures welfare maximization.[9]

Thus, the effect of contracts on the efficiency of electricity markets hinges both on the structure of the contract market and on the sequencing of investment and contracting decisions. In fact, in this paper, regulated spot prices depend solely on capacity and time demand, neither of which can be modified by contracts traded after capacity decisions are taken. To achieve the efficient solution, contracts have to be settled before investments are committed and generators must be price-takers in the contract market.

Long-term contracts, i.e., contracts that are awarded before capacity is committed, have been implemented in a number of countries. For instance, regulations in Brazil and Chile require distribution companies to auction contracts to supply energy at least 3 years ahead of the delivery date (Moreno et al., 2010). Demand requirements are auctioned with supposedly enough lead-time to allow for the entry of new firms and for existing ones to expand their capacity. Distribution companies auction on behalf of their consumers given that there is a pass-through of contract prices to end-consumers. There is also evidence that large energy consumers auction their energy supply with enough anticipation to let bidders build new capacity if necessary.

This paper builds on the pioneering work of Allaz and Vila (1993), who modeled the interactions between a contract market and a spot market of an oligopolistic industry in a two-stage game. In the first stage, firms and competitive speculators trade contracts that close in the second stage; in stage 2, given standing contracts, firms compete à la Cournot in the spot market. Firms have constant marginal costs and do not face capacity constraints. Within this context, they find that forward markets have a pro-competitive impact on the spot market.[10]

[5] See, for instance, Borenstein (2005) and Joskow (2008).

[6] Firms end up worse when they all trade in the forward market. However each generator has incentives to trade forward because, by moving first, it gains a strategic advantage in the spot market (Allaz and Vila, 1993).

[7] Moreover, halfway solutions such as time-of-use pricing have been put into practice by quite a few countries.

[8] As shown by Castro-Rodriguez et al. (2009), among others, in an oligopolistic industry with a regulated spot market, producers can still exercise market power by investing below the social optimum level.

[9] We have derived similar results in a working paper that considers a single-period and uncertain supply.

[10] Bushnell (2007) extends the work of Allaz and Vila (1993) by introducing increasing marginal costs. Calibrating the model with parameters of existing electricity markets, he concludes that, when forward contracts are present, the