Energy Economics 51 (2015) 288–299

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneco

Bidding behavior in the Chilean electricity market

Javier Bustos-Salvagno [1]

Facultad de Emprendimiento y Negocios, Universidad Mayor, Manuel Montt 367, Santiago, Chile

ARTICLE INFO

Article history:
Received 3 February 2014
Received in revised form 29 June 2015
Accepted 3 July 2015
Available online 26 July 2015

JEL classification:
C72
D44
L13
L94
Q41

Keywords:
Auctions
Electricity
Forward contracts
Chile
Spot price
Contracting capacity
Entry

ABSTRACT

Contracts in power markets are usually obscure. From recently public auctions of long-term supply contracts we can obtain information on how contract prices are determined. To understand generators' bidding behavior, this paper examines the Chilean experience from 2006 to 2011. Using a divisible good auction model we provide a theoretical framework that explains bidding behavior in terms of expected spot prices and contracting positions. Empirical estimations indicate heterogeneity in the cost of over-contracting depending on incumbency, bringing evidence of significant barriers to entry.

1. Introduction

One of the main concerns in developing countries is how to acquire new power generation resources to ensure that enough capacity is built in a timely manner and at the least possible cost. In the last ten years, several countries have decided to introduce auctions for long-term supply contracts (LTCs), to encourage capacity investment and optimal risk allocation.[2]

LTC auctions provide an opportunity to have information on a obscure part of the electricity markets: how contract prices are determined. In this case, it is not clear how generators determine their bids. To what extent are bids influenced by a generator's own technology or by spot prices? How important is generators' own capacity? More generally, there are questions about how competitive the contract market can be when there is high concentration in generation capacity and there are barriers to entry. Also, if the contract market was previously under price regulation, can the introduction of LTC auctions encourage generators' strategic behavior? For all these reasons we think that understanding bidding behavior is important.

In order to provide an answer to the determinants of bidding behavior in electricity contract markets, the first step consists in providing a theoretical approach to bidding behavior for LTC, using the Chilean experience. Chilean LTCs are forward contracts signed between electricity generators and distributors (or large customers) in which generators agree to supply power at a fixed price for a long-term period (i.e. from 5 to 15 years).[3]

Methodologically, we first analyze the data from Chilean auctions from 2006 to 2011, to infer the main determinants of bidding behavior. We find that generators submitted non-decreasing bid functions, for what it is clear that a multi-unit auction approach is needed. We use a model of a divisible good auction in the sense of the Wilson (1979) share auction, adapting a framework developed by Hortaçsu (2002) and Hortaçsu and Puller (2008). Second, in order to explain the increasing slope in several bid functions, we choose to use a model of a risk-

E-mail address: ricardojavierbustos@gmail.com.
[1] Tel.: +56 09 62132293.

[2] The typical obstacles procuring efficient new power generation are finance limitations, spot market volatility and regulatory uncertainty. By providing access to long-term contracts it can be possible to solve part of these problems. For a compilation of the international experience on auctions for electricity contracts, see Maurer and Barroso (2011).

[3] Contracts with distributors were historically under price-regulation by the energy authority. The new regulatory scheme is to auction LTC and let average winning bids become final prices for distributors' customers, which remain fixed in real terms along the contract's duration.

http://dx.doi.org/10.1016/j.eneco.2015.07.003
0140-9883/

averse generator who bids for the right to supply power to a distribution company in a future period. Our model uses contracting capacity and expected spot prices as the main determinants of the bid function. More important than the physical capacity at the moment of the auction is the contracting capacity, which is the minimum uncommitted capacity a generator has available in order to participate in an LTC auction. It is his own expected generation, considering adverse scenarios (i.e. drought), net of already committed capacity on other contracts. If a risk-averse firm bids to supply more than his contracting capacity, it has to face the risk of over-contracting and buying from other generators at the spot market in order to honor his contract. Thus, due to future spot price uncertainty, we explicitly include in the generator's profit function the cost of over-contracting. As a result, firms submit supply functions where the slope becomes steeper for quantities above their contracting capacity. Supply functions have a change in slope because, as quantity supplied increases, generators have to assume riskier forward positions to be closed in future spot markets. Once a model is available, we proceed to estimate it empirically. We find evidence of heterogeneity across bidders that can be explained by the cost of over-contracting. This cost is larger for small generators and entrants. As it would be expected, assuming riskier positions for these types of firms is more costly than for larger and diversified generators. This result is overlooked by previous research that uses a single-unit auction approach.

The main contributions of this paper are three. First, we have the opportunity of looking at a previously obscure contract market in electricity and use actual data to infer how prices are determined. To do so, we provide a multi-unit auction model that can reproduce actual data on LTC auctions. Single-unit approach can be misleading in this kind of auctions since they do not account for the increasing slope of bid functions. Second, to our knowledge, this is the first paper that uses a multi-unit auction model with the Chilean data. The Chilean experience is interesting not only because it represents a new case study, but also because the auctions' results have been somewhat disappointing in terms of capacity expansion and entry in comparison with other South-American countries (Moreno et al., 2010).[4] By providing a theoretical approach that fits with the empirical evidence, it is possible to present policy recommendations. Finally, we analyze heterogenous behavior due to incumbency, finding significant barriers to entry due to the cost of over-contracting.[5]

On auction literature, this paper is based on the existing theoretical developments of Hortaçsu (2002) and Hortaçsu and Puller (2008). The Chilean experience has been studied under the single-unit approach by assuming each bidder submits one price per contract. This is the case of Caravia and Saavedra (2007), who use uncertain supply and risk-averse generators to show that the auction winner depends on the cost of generation of each bidder. However, as Roubik and Rudnick (2009) show, for risk-averse generators who sign forward contracts following an optimal portfolio decision, spot price uncertainty is the only relevant variable in generators' decisions. In a different venue, Arellano and Serra (2010) show how an auction of LTC could reduce market power with a two-firm, two-technology, linear-cost, static model. Their result is an extension of Allaz and Vila (1993) seminal work on how forward contracts can foster competition in oligopolistic spot markets.

Empirically, Varas and Rudnick (2014) and Fabra et al. (2014) use data on bilateral contracts without price regulation and LTC auctions to estimate the average mark-up. Both find more intense competition in LTC auctions than in the bilateral contract market. Additionally, they find no evidence of anti-competitively behavior in LTC auctions. Even though we are not studying in this paper how competitive Chilean auctions have been, we believe that the provision of a model that fits the actual Chilean data is a first step to test how intense is competition.[6]

Section 2 includes a description of the power market in Chile, its regulation and competition in generation. The main features of the Chilean LTC auctions are described and results are presented. Section 3 includes the theoretical approach to understand actual bids. In Section 4, empirical estimations are presented. Section 5 includes conclusions and policy recommendations.

2. Description of the Chilean power system

Power regulation in Chile has been an object of study since the 1980s, when a profound market-oriented reform was implemented earlier than even in more developed countries.[7] This paper will focus on the main Chilean power system, the SIC (*Sistema interconectado Central*) that covers the southern and central areas of the country. The northern part of the country is the SING (*Sistema Interconectado del Norte Grande*). SIC is the bigger system with a total installed capacity of 15, 043 MW, serving 90% of the population of the country. 55% of demand comes from regulated customers while the rest comes from unregulated or "free customers".[8] The electricity generation system has a large installed hydro-generation capacity (43%), but as demand increases fossil fuels have become more important.

The generation market exhibits high market concentration. In the Appendix, Table A1 shows installed capacity and Table A2 market shares of the major generation groups in SIC: Endesa, Colbun, AES-Gener and Guacolda.[9] When Auctions for LTC were introduced in 2005, 90% of the installed capacity and 95% of market share was in the hands of these four firms, while in 2011 those percentages were 80% and 83%. Incumbents' share of the market is dropping due to entrants in renewable energies. However, no entrant, by itself, has more than 3% of SIC's physical capacity. On the contract market, there was not a significant entry in LTC auctions until 2014. Entrants seemed to prefer to have contracts with non-regulated customers or even to supply to incumbents. Hence, there was some barrier to entry or risk an entrant has to face that was discouraging them to participate for a larger share of the contract market. However this could be changing in the near future. In part because of renewable generators are now allowed to bid for LTC with blocks of 8 h and their investment costs are getting closer to conventional thermal units. Also, the interconnection between SIC and SING programmed by 2018 is attracting bigger players that could have room to enter.

2.1. Regulation of the power market

The Chilean regulation splits the industry into three sectors: generation, transmission and distribution. Transmission and distribution are seen as natural monopolies and remain under price regulation. Since

[4] There was not a significant entry in LTC auctions until 2014, but this could be changing in the near future. Renewable energy is getting competitive in terms of levelized cost to conventional generation. Also, the interconnection between SIC and SING programmed for 2018 is attracting new entrants. The effect on competition of these new players is yet to come.

[5] An example of how useful this results can be, has been the outcome of the last electricity auction performed during November 2014. In this auction, renewable bidders where allowed to bid for blocks of 8 h. This rule allowed solar and wind generators to bid more aggressively since they can bid when their cost of over-contracting is minimum. While the historical average was around four generators, this time there were seventeen bidders. We think regulatory changes have to continue in this direction, in order to foster competition by reducing entry barriers, like the over-contracting cost we have identified.

[6] In fact, Varas and Rudnick (2014) implement their empirical strategy by following an earlier version of this paper (Bustos-Salvagno, 2012).

[7] As Pollitt (2004) mentions, "Chile's electricity reform has been hailed as a highly successful example of electricity reform in a developing country and a model for other privatization in Latin America and around the world."

[8] Large consumers are known as "free customers" because they are free to contract directly with generators for power supply, while regulated customers are supplied by local distribution companies and haven't any direct contact with generators. A consumer is considered large if she demands a capacity of 2 MW or more. Consumers between 0.5 MW and 2 MW can choose to be free customers or regulated customers.

[9] Guacolda is the fourth firm in size, but 50% of it belongs to AES-Gener. In March 2014 the latest acquire the full property of Guacolda.