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Mothballing in power markets: An experimental study

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ABSTRACT

The deregulation of many electricity markets over the last two decades raises a number of issues, among which: securing adequate investments in capacity, and the possibility of cyclical behavior in capacity, are important for security of supply. A number of policies and market mechanisms aiming for capacity adequacy and market stability exist; in this paper we focus on one of these, mothballing of generation capacity. In electricity markets, mothballing is the possibility for a power generation company to temporarily withdraw generation capacity for a time, often for a year or more. Our hypothesis is that mothballing will help to stabilize markets, but at the same time increase prices. We test this hypothesis using laboratory experiments, with a simplified model of a generic electricity market. We report an experiment with twelve markets, where subjects make investment decisions; half of them had full capacity utilization (T1) and the other half had the option to mothball capacity (T2). The predictions of the effects of mothballing were confirmed in the experimental markets: prices and generation capacity exhibit clear cycles in T1, and damped cycles in the second set of experiments, T2. Furthermore, mothballing leads to higher prices on average.

1. Introduction

The deregulation of the electricity industry began in the 1980s in Chile and the UK, and spread rapidly to many other countries with the expectation of lower prices, greater efficiency, and new investment (Larsen and Bunn, 1999). These expectations have been fulfilled in some cases while in others there have been problems (see Sioshansi and Pfaffenberger (2006) for a review of the deregulation experiences). One of the main concerns in connection with deregulation is whether deregulated markets are able to deliver enough new investments at the right time to avoid shortages. In the initial phase of deregulation, the long-term security of supply took a back seat to more short-term concerns about competition, particularly in developed countries, e.g., Germany (Brunekreeft and Bauknecht, 2006) and England (Newbery, 2006). However, the issue of sufficient investment has recently taken center stage again as there is mounting concern about replacing the significant amount of capacity that is due to be retired over the next decade (IEA, 2007). Moreover, the investment dynamics has led to cyclical behavior in installed capacity, threatening the security of supply (Arango and Larsen, 2011). A number of policies and mechanisms have been tried, or are currently used, to ensure security of supply in deregulated markets. Among them are use of capacity mechanisms, forward markets, mothballing, etc. In this paper we use an experiment to observe whether mothballing reduces the cyclical pattern of investments and increases energy prices by allowing firms to restrict supply. We define mothballing as the possibility of a power plant being temporarily withdrawn from generation.

We have seen several cases over the last decade where there has been a shortage of capacity which, in a few instances has led to blackouts, and in many others to serious concerns about future ability to cover demand (Sioshansi and Pfaffenberger, 2006). Furthermore, a number of authors and policymakers have expressed concerns that the electricity sector might show a behavior, similar to many other capital intensive industries, where cycles in capacity are a major concern and which in the electricity sector might create major problems in terms of the long-term security of supply (Bunn and Larsen, 1992, 1994; de Vries and Hakvoort, 2004; Ford, 1999, 2001; IEA, 1999, 2002, 2003; Kadoya et al., 2005; Larsen and Bunn, 1999; Lomi and Larsen, 1999). After more than two decades of deregulation these concerns have been shown to be valid, as there are now strong indications of cyclical behavior in a number of deregulated markets (Arango and Larsen, 2011; Botterud and Doorman, 2008; de Vries and Hakvoort, 2004; Ford, 1999; IEA, 1999, 2003; Larsen and Bunn, 1999; Olsina et al., 2006). Cycles create two main problems: the first is obviously shortage or potential shortage in some periods, and the second is excess capacity in the other parts of the cycle. In the first case consumers get hit as the prices will rise due to the shortage, and in the second case the companies get hurt due to the low price, which

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might make them more reluctant to invest in the future causing the next downturn to become even deeper (leading to expanding cycles).

Various policies, including capacity mechanisms, have been put in place to reduce the occurrence of cycles and secure a continuity of supply, in many markets. While the theoretical design for capacity mechanisms has been developed (Finon and Pignon, 2008), there is, so far, no agreement as to whether there should be a coordination mechanism for investments, or it should be left entirely to market forces. Most countries have used some coordination of markets with more or less success instead of having a completely unregulated market (Roques, 2008; Roques et al., 2005). In this paper, we focus on one of these mechanisms — mothballing. We investigate the effect of mothballing on the long-term stability of an electricity system. As we have no direct data to show the effect, one recognized way of studying phenomena like this is to use experiments. Experiments have a long history in the area of electricity, having been used to test, for instance, alternative market designs (Rassenti et al., 2003) or the effect of forward contracts in electricity markets (Brandts et al., 2008).

We use an experimental setup to test the effect of mothballing, i.e. when generators have the possibility of mothballing capacity compared with a situation where they cannot do so. The assumption of full capacity utilization in previous experiments concerning electricity markets is relaxed (e.g., Arango, 2006; Arango and Moxnes, 2012). First, we execute six experimental markets under the assumption of full capacity utilization (T1 hereafter), where subjects only make investment decisions. Six further experimental markets are conducted in which this assumption is relaxed (T2 hereafter), as subjects make both investment as well as capacity utilization decisions. These two experimental conditions allowed us to assess the effect of mothballing decisions under market behavior.

The rest of this paper is organized as follows: the next section discusses mothballing, and other policies and mechanisms to improve long-term security of supply. The third section describes the experimental design, including the model underlying the experimental conditions, procedure, and testable hypotheses. The section following that presents an overview of the experimental results and the tests of hypotheses. The final section discusses the main findings and implications derived from the experiment, where we show via laboratory experiments that mothballing leads to more stability in long-term market prices, but it leads to higher average prices as well. Policy implications and further research are also discussed.

2. Mothballing

One of the main concerns regarding deregulated markets is whether they are able to create the right price signals for investment. Previously, investment was decided at the national level by a monopoly or a government agency, based on optimization models with a comprehensive set of variables; nowadays, deregulated markets rely on firms' decisions based on market signals. A number of policies and mechanisms have been tried, or are currently used, to ensure that enough capacity is in place at the right moment in deregulated markets. These include, among others:

- Capacity payment—the original England and Wales design where (in theory) the regulator could make it more attractive to invest by increasing the Value of Loss of Load (VLL) in the "capacity element" of the price paid to generators, and thereby make it more attractive to invest (Surrey, 1996).
- Capacity auctions have been, and are still used in deregulated as well as regulated markets. By using auctions the regulator has more control over the amount of new capacity being built and thus there should be less chance of cycles developing. However, this might be seen as major intervention in the market (Finon and Pignon, 2008).
- Forward markets for medium- and long-term horizons are a complement to spot markets in wholesale electricity markets. These markets are meant to hedge price risks, lower prices and increase market efficiency (Brandts et al., 2008). Moreover, forward markets can work as a coordination device for investments (Cramton and Stoft, 2008). In electricity markets, forward reliability markets are operating in, e.g., the UK and Colombia (Cramton and Stoft, 2008).
- Mothballing is when a power plant can temporarily be withdrawn from generation. This would be for a longer period of time relative to normal maintenance downtime. The plant will not be connected to the grid, temporarily, so the connection fee is avoided. However, the plant can be brought back in at a later stage if the economics of the industry improve (Bidwell, 2005; Green, 2006).

Other capacity mechanisms are also available, for instance, Finon and Pignon (2008) evaluate centralized auctioning for forward capacity contracts/reliability option contracts, capacity obligation with exchangeable rights, and procurement for long-term strategic reserves contracting; de Vries and Heijnen (2008) compare, through simulations, energy-only markets, operating reserves pricing, capacity obligations, and energy-only markets with market power; and Wen et al. (2004) discuss a capacity obligations model, an explicit capacity-added payment model, and other administrative payments for capacity.

While mothballing has long been an option for electricity markets, it is an option that has been viewed with some suspicion, in particular by regulators. It has been seen in many cases as a way in which generators could limit supply and thereby drive up prices. To some extent it has been seen as similar to collusion, i.e., an almost criminal offense (Roques et al., 2005). Mothballing decisions are made by the generators; however, through interventions the regulators can decide to limit these decisions; thus, it can be a market intervention similar to other mechanisms that aim to solve the problem of long-term security of supply. While mothballing does limit supply at times when there is excessive supply, it allows capacity that otherwise might have been retired to come back one or two years later, when demand might have picked up, and thereby prevent a potential shortfall or at least make the shortfall less dramatic. In this way mothballing might help to limit the amplitude of the cycle of over and under capacity, and in the longer term help to stabilize markets.

Evidence of mothballing has been observed in the UK electricity market, where around 10% of the installed capacity has been mothballed at different times (Green, 2006); in Queensland (Tamaschke et al., 2005); and it is also well known in other capital investment industries such as the oil tanker industry (Randers and Göluke, 2007). Moreover, the option of mothballing is now included in valuing power plants with real option analysis (e.g., Schmit et al., 2009; Takashima et al., 2008). Mothballing could lead to a more stable long-term behavior, as has been shown with simulation of power markets (Häni et al., 2006), but it will likely influence (increase) prices (Joskow and Kahn, 2002; Puller, 2007; Tamaschke et al., 2005). In fact, generators have influenced their incomes by mothballing capacity in the UK (Office of Electricity Regulation OFFER, 1998, p. 152). Thus, from the modeling perspective, the analysis of dispatch decisions is performed to maximize efficiency, which is the focus mainly in the early stages of deregulated electricity markets, while decisions such as mothballing are analyzed for long-term security of supply.

3. Experimental design

3.1. Experimental design and setup

We use a computerized experiment of a symmetrical Cournot five-player market with linear demand, under standard conditions (Huck, 2004).[2] The experimental setup has five players or subjects in order to ensure non-collusive behavior, with outcomes expected

[2] Standard conditions (Huck, 2004, p. 106): 1) interaction takes place in fixed groups; 2) interaction is repeated over a fixed number of periods; 3) products are perfect substitutes; 4) costs are symmetric; 5) there is no communication between participants; 6) participants have complete information about their own payoff functions; 7) participants receive feedback about the aggregated behavior of the other participants; and 8) the experimental instructions use an economic framework.