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Has renewable energy induced competitive behavior in the Spanish electricity market?

Aitor Ciarreta[a], Maria Paz Espinosa[a], Cristina Pizarro-Irizar[a,b,*]

[a] University of the Basque Country (UPV/EHU), Faculty of Economics, Department of Foundations of Economic Analysis II, Avenida Lehendakari Aguirre 83, 48015 Bilbao, Spain

[b] Basque Centre for Climate Change (BC3), UPV/EHU Science Park, Barrio Sarriena s/n, 48940 Leioa, Spain

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ABSTRACT

Recent energy policy has favored a massive introduction of Renewable Energy Sources on electricity markets, which has greatly impacted their performance. First, the electricity price has decreased as a consequence of the so-called merit-order effect. Another relevant effect is associated to the intermittent nature of Renewable Energy, which has increased the cost of ancillary services. A third and important aspect, less addressed in the literature, is the induced change in the strategic behavior of the conventional electricity producers. In principle, the entry of new generators in a concentrated market would make it more competitive and change the strategic behavior of the incumbents. We test this hypothesis for the Spanish wholesale market. While we find no significant change in behavior for Nuclear, Hydropower and Coal, a change is observed in Combined Cycle bidding strategies after the entry of renewable generators. Our analysis shows that the massive entry of Renewable Energy Sources made other generators' behavior more competitive in the short run, but the effect was not persistent.

1. Introduction

The entry of Renewable Energy Sources (RES, hereafter) in electricity markets has attracted a great deal of attention in recent years. The current energy policy landscape has favored RES and high shares of renewable participation have been achieved, which had important economic implications. Many empirical studies conclude that there has been a reduction of electricity prices, due to the merit-order effect[1] (Sáenzde Miera et al., 2008; Sensfuss et al., 2008; Jónsson et al., 2010; Gelabert et al., 2011; Ciarreta et al., 2014, among others). However, there has been little empirical research so far into the reaction of conventional producers to the introduction of green capacity resulting in a more competitive environment. This paper addresses this issue. Did non-renewable generators change their bidding strategies as a result of the increasing renewable participation in the electricity market? Depending on the answer, the findings of previous merit-order effect analysis could be reevaluated. On the one hand, price reductions entailed by RES could have been underestimated in previous research, if traditional sources should now bid at lower prices in order to avoid being displaced from the market by renewable units.[2] From a theoretical perspective, this would be the expected result when a market becomes more competitive. On the contrary, the effect of RES could have been overestimated, if conventional sources had been bidding currently at higher prices or imposing more restrictions in order to limit the energy matched in the spot market. This would be the case if the entry of RES had forced a partial exit of other technologies, as market prices in the pool were below their marginal costs. In this case, they could refuse to participate in the spot market and transfer their production to adjustment markets[3] at higher prices.

This paper analyzes behavioral changes after the entry of renewable generators in the Spanish electricity market, which resulted from the combined system of Feed-in Tariffs and Premiums that was in force until 2013. Our first result is that the effect on behavior was only

* Corresponding author at: University of the Basque Country (UPV/EHU), Faculty of Economics, Department of Applied Economics III, Avenida Lehendakari Aguirre 83, 48015 Bilbao, Spain.

E-mail addresses: aitor.ciarreta@ehu.eus (A. Ciarreta), mariapaz.espinosa@ehu.eus (M.P. Espinosa), cristina.pizarro@bc3research.org (C. Pizarro-Irizar).

[1] The merit-order effect is defined as the impact of Renewable Energy on the electricity price in the power market. Since RES usually bid at lower prices (even zero), their participation results in a reduction of wholesale spot prices.

[2] In a competitive market, generators would never place bids below their marginal costs. However, if there were market power in the electricity market, CC generators could lower their markup in order to avoid being displaced from the market by renewable units.

[3] Adjustment markets include the resolution of technical restrictions, the allocation of ancillary services and the management of deviations.

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noticeable for Combined Cycle (CC, hereafter) bidding. While there was little change in other technologies, we do observe that CC bidding strategies have evolved to adapt to the introduction of RES.

After the massive entry of RES in the electricity market, CC was the technology that suffered the most drastic reduction, both in production and in operating hours. According to data provided by the Spanish system operator (Red Eléctrica de España, REE hereafter), the utilization ratio[4] of CC plants dropped from its maximum value of 52% in 2008 to its minimum value, 12%, in 2013 (REE, 2002–, 2013). Moreover, CC plants experienced a shift in their operating hours, from 5119 production hours in 2005 (Navarro, 2011) to 1000 in 2013, most of them assigned to comply with technical restrictions (CNMC, 2014).

To detect any behavioral changes in producers' bidding, we use the methodology to construct synthetic supply curves in Ciarreta and Espinosa (2010a), Ciarreta and Espinosa (2010b), combined with the procedure to solve the electricity market equilibrium in Ciarreta et al. (2014), and compute the counterfactual electricity spot market outcomes under different scenarios. We select a *reference year* before the massive entry of RES and construct synthetic supply curves by assuming that the bidding behavior in other periods (*target years*) is the same as in the reference year. Therefore, the difference between counterfactual and actual outcomes can be attributed to the change in bidding behavior. While Ciarreta and Espinosa (2010a) explored the effect of the size of the firms on market power, we here test whether there has been a behavioral change for the same technology in two different time intervals.[5]

We select 2008 as the reference year because RES production was beginning its ascent, but its level was still 59% of that reached in 2013, and at the same time most of the CC capacity was already installed. Additionally, new regulation enacted in mid-2007[6] set a new framework for the RES incentive regime in Spain and induced what has been considered a bubble of RES in the electricity market.[7] The target years include a *before-RES period* from 2002 to 2006, when renewable participation was moderate (in 2002, 31% of the level reached in 2013 and 42% in 2006); and an *after-RES period* from 2009 to 2013, when renewable production reached its maximum in Spain. The year 2007 is regarded as a transition period and therefore is not included.[8] We build our synthetic bids considering gas and carbon price pass-through, we do not modify the demand in any scenario and we consider the change in behavior only for the CC generating units present in both the reference and the target years, leaving the other units unchanged.

The paper is structured as follows. First, Section 2 presents a descriptive analysis of the interaction between RES and conventional producers that suggests that CC plants could have reacted to the presence of RES, whereas other technologies remained almost unaffected. Afterwards, Section 3 provides the details of the procedure to build the synthetic supply curves. We present and discuss the results of our simulations under the different scenarios in Section 4. Finally, concluding remarks follow in Section 5.

2. The interaction between Renewable Energy and conventional producers

The participation of RES in the Spanish electricity market has been increasing in the last decade. According to data published by the Spanish market operator (Operador del Mercado Ibérico de Electricidad, OMIE hereafter), only 11% of total production in the spot market came from RES in 2005. By 2008 this share had reached 33% and it was over 60% by 2013 (OMIE, 2015a). The combination of the merit-order effect (induced by the massive introduction of RES), with changes in demand, carbon prices, fuel costs and conventional overcapacity led to a significant drop in annual average electricity prices, i.e. from 64 EUR/MWh in 2008 to 44 EUR/MWh in 2013 (OMIE, 2015c). Thus, conventional producers[9] could have reacted to this price decrease in two ways.[10] In terms of prices, they could be bidding lower, to avoid being withdrawn from the market. On the contrary, if they try to exert a certain degree of market power, their price bids would be higher. In terms of quantities, they could be restricting the energy sold in the spot market at low prices, in order to participate in adjustment markets,[11] where prices are generally higher.

This section analyzes the evolution of several variables that could affect the interaction between Renewable Energy and conventional producers. In particular, the installed capacity, supply curves and production shares of the main technologies taking part in the Spanish electricity mix: Nuclear (NU), Hydropower (HY), Coal (CT), Combined Cycle (CC) and Special Regime (SR).[12] In principle, any of the conventional producers could be experiencing a behavioral change after the development of RES. However, we find empirical evidence suggesting that CC plants are the most likely candidate for changes in bidding strategies.

First of all, comparing the evolution of the installed capacity by technology during the period 2002–2013, we observe in Fig. 1 that both SR and CC plants were the technologies receiving all the new investment. While the installed capacity of NU (Fig. 1a), HY (Fig. 1b) and CT plants (Fig. 1c) remained almost constant over the period (increasing only 1%, 7% and −4%, respectively), there were important capacity increases for CC units (719%, Fig. 1d) and SR technologies (225%, Fig. 1e) from 2002 until 2013. Furthermore, after 2007 SR and CC can be considered as substitutes in terms of investment, as new investment was transferred from CC technologies to green energy.

Concerning bidding behavior, Fig. 2 shows annual aggregate supply curves and supply curves by technology for the before-RES period from 2002 to 2006 (solid black line) and the after-RES period for 2009–2013 (dashed black line), excluding 2007 and 2008 as the transition years. We observe that the slope of the aggregate supply curves (Fig. 2a) after 2008 is lower than in the previous period (27% lower in a linear fit). This effect could be due to the rise in RES capacity, but it could also indicate a change in the bidding strategy of some agents. In fact, if we represent the aggregate supply without RES (Fig. 2b), we observe that both curves are much closer but still the dashed line is flatter, which suggests changes in the bidding strategies of other actors.[13]

We also observe that, as expected, changes in the slope of NU

[4] The utilization ratio is the ratio between actual and maximum available production or production that the power plant could reach operating at nominal capacity during the hours in which the plant is available.

[5] This procedure is reminiscent of the difference-in-differences method or the synthetic control approach by Abadie and Gardeazabal (2003).

[6] Royal Decree 661/2007 (BOE, 2007).

[7] For a detailed analysis on the effect of Royal Decree 661/2007 (BOE, 2007) on renewable production see Ciarreta and Pizarro-Irizar (2014).

[8] For a detailed analysis on the evolution of RES participation in the Spanish electricity market see Ciarreta et al. (2014).

[9] We include Nuclear, Hydropower, Coal and Combined Cycle plants as conventional producers.

[10] wolak and patrick (1996) claim that there are two strategic weapons available for electricity generators: first, the maximum amount of capacity made available at the pool and, second, the price bids.

[11] According to the rules of the Spanish electricity market (OMIE, 2007), producers must offer all their capacity in the spot market in order to be allowed to participate in adjustment markets. However, they could bid most of their capacity at high prices to make sure that it is not matched in the pool and sell it more profitably in the subsequent adjustment markets.

[12] SR includes RES (Wind, Solar Photovoltaic, Solar Thermal, Small Hydro power and Biomass/Wastes) and Cogeneration and was cancelled in 2014. We do not consider Oil, since its participation is lower than 2%.

[13] The change could also be due to the difference in commodity prices. However, if we compare prices before and after our reference year 2008 (we use the Commodity Price Index published by IndexMundi based on data from the International Monetary Fund and the Brent price by IndexMundi based on data from the World Bank), we observe that both commodities and Brent prices are higher on average in the period 2009–2013 than in the period 2002–2006 (an increment of 97% for commodities and 123% for Brent). Therefore, we cannot attribute the drop in the supply curve to a drop in commodity prices.