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Expectations and forward risk premium in the Spanish deregulated power market

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ABSTRACT

Deregulation in energy markets has entailed important changes in the way agents conduct business. Price risk arises as a result of fluctuations in the future price of electricity and agents assume long or short positions in the forward and spot markets to hedge their exposure to price risk. The presence of forward risk premium in prices is evidence of the fact that agents act in the market according to risk considerations. This work aims to analyse the information content of the difference between the forward and spot prices (the so-called forward premium) regarding the agents' decisions. We find that the sign and magnitude of the *ex post* forward premium depend on the unexpected variation in demand and on the unexpected variation in the hydroelectric capacity, and that both the *ex post* and the *ex ante* forward premia are negatively related to the variance of spot price, as Bessembinder and Lemmon (2002) predict. We provide additional insights about relevant aspects of spot price pricing in the Spanish electricity market such as the positive relation between spot prices and CO_2 emission allowance prices or the impact on spot prices of the set of market matching rules introduced in March 2006.

1. Introduction

The process of deregulation in energy markets has entailed important changes in the way agents conduct business. It has changed the reality of the electricity sector, moving from a monopoly into competition, in which utilities and independent power producers are no longer suppliers with guaranteed returns, but enterprisers that have to compete. This competition has forced utilities to improve their overall efficiency taking into account additional factors when operating in a complex market characterized by volume and price uncertainty and significant volatility that result in new types of risk.

Thus, deregulation has led to the need for hedging exposure to price risk. To do so, agents adopt (long or short) positions in the forward and spot power markets. Therefore, one of the consequences of deregulation of the power sector is that forward markets for electricity have gained increased interest for suppliers and consumers of electricity. Understanding the links between forward and spot prices allows for better planning of operations and investments. It also contributes to clarifying the degree to which prices respond to technical factors and/or strategic behaviour as well as the extent to which market participants are exposed to price risk and the way they manage to hedge their positions. Such insights are very important from a political viewpoint, and should be taken into account when designing new regulations leading to a fully liberalised market.

The presence of risk premium in electricity prices is evidence of the fact that agents act in the market according to risk considerations. Nevertheless, other aspects such as regulatory risk or the differences in the generation park of a particular country or area will likely help to explain deviations between forward and expected spot prices. This work aims to analyse the information content of that difference (the so-called forward premium) regarding the agents' decisions.

The study of the relationship between forward and spot prices has been the main topic of many theoretical and empirical papers. The cost-of-carry relationship links spot and forward prices as a non-arbitrage condition. However, the implementation of arbitrage strategies includes taking the underlying asset and holding it until the contract expiration date. In the case of electricity, this matter becomes particularly difficult to address due to the fact that electricity cannot be directly stored.[1] This means that the non-arbitrage approach to pricing derivative securities cannot be directly applied (Eydeland and Geman, 1998; Bessembinder and Lemmon, 2002; Lucia and Schwartz, 2002; Longstaff and Wang, 2004; Pirrong and Jermakyan, 2008).

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[1] Though power is not storable, potential energy can be stored in the form of fuel stockpiles or water behind dams.

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Another general approach to price forward contracts, used in the literature as an alternative to the arbitrage value theory, is based on equilibrium considerations. Bessembinder and Lemmon, 2002 (henceforth, B–L) adopt this approach and model the economic determinants of market clearing forward power prices. Their model assumes that prices are determined by industry participants rather than outside speculators, and that power companies are concerned with both the mean and the variance of their profits. One directly testable result is that the forward risk premium (defined as the difference between the forward and spot price) depends negatively on the spot price variance and positively on the standardised skewness[2] of the spot price. In the second part of their paper, they generally present empirical evidence on the theoretical results commented above. The data in their study consists of a set of spot and monthly electricity forward prices from the Pennsylvania, New Jersey, and Maryland (PJM) electricity market and from the California Power Exchange (CALPX). Ullrich (2007) proposes an extension to the B–L model to explicitly account for constrained capacity. According to his results, the behaviour of the forward premium depends on whether the level of the expected spot price is greater or lesser than the fixed retail electricity price. Cartea and Villaplana (2008) propose a model whereby wholesale electricity prices are explained by two state variables: demand and capacity. They apply their model to the PJM, England and Wales and Nord Pool markets and observe that the forward premium dynamics are seasonal, according to the volatility of demand. Pirrong and Jermakyan (2008) suggest a model in which the spot price of power is a function of two state variables: demand and fuel price. Subsequently, it is implemented empirically using data from PJM. Their results are consistent with those of B–L stating that power forward prices are upward biased and the upward bias is more extreme for forwards expiring during high demand periods. Finally, Benth et al. (2007) provide a framework to explain the relation between the forward premium and the risk preferences of market players—as well as the interaction between buyers and sellers.

Other papers focus directly on the empirical analysis of the risk forward premium. For example, Shawky et al. (2003) conclude there is a non-zero premium in the California–Oregon border. Lucia and Torró (2008) contrast the implications of the B–L model, specifically, the implication that links the risk forward premium and the volatility of the spot price using weekly electricity contracts from Nord Pool. These authors also show the importance of water reserves to explain the dynamics of the premium through an econometric vector autorregression (VAR) model. In some studies the day-ahead electricity contract price has been chosen as the forward price for analysing the risk forward premium. This is the case of Geman and Vasicek (2001) who conclude the existence of asymmetrically positive premiums in the PJM market for the summer months. Without changing markets, Longstaff and Wang (2004) conduct an empirical analysis of the forward risk premium using hourly prices. They discover there are significant electricity forward premiums and that these premiums vary systematically throughout the day and are directly related to economic risk factors, such as the volatility of unexpected changes in demand, spot prices and total revenues. They also test some of the empirical implications derived from the B–L model, concluding that they are supported by the data. Karakatsani and Bunn (2005) determine systematic patterns in day-ahead forward premiums after classifying half-hourly trading periods into two homogeneous peak and off-peak clusters.

[2] The standardised skewness is calculated as the skewness divided by the standard deviation cubed.

In addition to the financial literature, the industrial organization literature has also addressed this problem by studying the impact of forward contracting on spot prices. The evidence for the sign of the forward premium is, however, unclear. According to Allaz (1992) and von der Fehr and Harbord (1992), forward contracts reduce the sensitivity of generators' profits to spot price fluctuations having a softening effect on market power. As a result, spot prices drop. This is empirically verified for the Australian electricity market in Wolak (2000). Nevertheless, neither the response of forward prices to lower spot prices nor the expected sign for the forward premium are explained. Allaz and Vila (1993) show that forward markets can improve the efficiency of output decisions in a Cournot duopoly. In the limit, when the number of forward contracts gets large, the outcome tends to the competitive outcome. Batstone (2001) considers the implications of strategic behaviour on the part of risk-neutral electricity generators who contract with risk-averse consumers maximizing mean-variance utility. He shows that, in equilibrium, generators have an incentive to increase the variance in the spot market price to obtain larger forward premium and sell more forward contracts.

This study intends to conduct an empirical analysis of the presence of risk in both *ex ante* and *ex post* forward premiums in the Spanish electricity market. We also aim to shed light on the way the sign of forward premiums informs about the behaviour of market agents, which is always of concern to regulators when designing the rules for a competitive market.

This paper contributes to the literature on the empirical analysis of risk in forward electricity premiums by adopting not only the *ex post* approach but also the *ex ante* and thus enabling an enriched analysis. To build the series of *ex ante* forward premium, we first need to estimate the future spot price. Consequently, another contribution of this paper is the proposal of an estimation model for electricity spot price at a monthly level. We present the fundamentals that explain the Spanish electricity forward risk premium, evidencing that market players trade forward contracts according to risk considerations. Our results also suggest that market agents have built into their cost structure the CO_2 emission allowances prices. Moreover, we find support for the implications derived from the B–L model. Finally, we would like to note that this study analyses the forward risk premium in the Spanish electricity market for the first time.

The main results are as follows. First, the *ex post* one-month-ahead forward premium depends on the unexpected variations in demand under tight market conditions, and on the unexpected variations in the level of hydroelectric energy capacity. Second, by estimating the proposed spot price model, we obtain two additional interesting results related to pricing in the Spanish electricity market. On the one hand, electricity prices are linked to CO_2 emission allowances prices. On the other hand, prices have been systematically lower during the period in which the transitory matching-rules-related reform introduced by Royal Decree-Law 3/2006 was in force. Third, as the B–L model predicts: (i) both the *ex post* and the *ex ante* one-month-ahead premium are negatively related to the variance of the spot price. From the above results, it can be stated that the forward premium is variable according to supply and demand market conditions and to agents' hedging needs.

The remainder of this paper is organized as follows. Section 2 is devoted to a brief description of the structure of the Spanish electricity market and the composition of the generation park. In Section 3, the data used is detailed. Section 4 provides some insights into the theoretical background of the risk forward premium. Section 5 is concerned with the variables that may explain the magnitude and sign of the *ex post* premium and tests whether the B–L model implications are supported by data.