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On the risk premium in Nordic electricity futures prices

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ABSTRACT

This paper examines empirically the relationship between electricity spot and futures prices, by analysing a decade of data for a set of short term-to-maturity futures contracts traded in the Nordic Power Exchange. It is found that, on average, there are significant positive risk premiums in short-term electricity futures prices. The significance and size of the premiums, however, varies seasonally over the year; whereas it is greatest during winter, it is zero in summer. It is also found that time-varying risk premiums are significantly related to unexpectedly low reservoir levels. Furthermore, before the unprecedented supply-shock that hit the market around the end of year 2002, the risk premiums were related to the variance and the skewness of future spot prices.

1. Introduction

Since electricity futures contracts started to be traded worldwide during the last decade, the relationship between futures prices and spot electricity prices has attracted the attention of finance academics and market participants alike. This paper belongs to the line of research that analyses the important relationship between electricity spot and futures prices based mainly on risk considerations. In particular, it focuses on what is termed the futures or forward risk premium, which is defined as the futures or forward price minus the expected delivery-date spot price. This paper provides an empirical analysis of the sign and behaviour over time of the futures or forward premium, by studying a set of short term-to-maturity futures contracts traded in the Nordic Power Exchange, Nord Pool ASA. The Nord Pool is a non-mandatory multinational wholesale electricity market that covers several Nordic European countries. The analysis of this market is particularly relevant for the understanding of electricity markets because this market has a long history of both "spot" (day-ahead) and futures contracting that can be traced back to the early nineties.

Botterud, Bhattacharyya, and Ilic (2002) provided some previous preliminary empirical evidence for the premiums at the Nord Pool market. They studied a sample of futures and forward data that covered six years of weekly observations, for the 1996–2001 period, for contracts with 1, 4, 26 and 52 weeks to delivery, and delivery periods that ranged from one week to one season in length. However, they only analysed the average premiums for the whole sample period. They found evidence of positive average premiums. They also reported that the magnitude and standard deviation of the premiums increase with the length of the holding period. They also tried to informally link the long-term premiums to deviations from usual reservoir levels, by simple visual inspection of a graph. They, however, left several related issues unexplored, which are addressed for the first time in this paper.

We thus make several contributions to the analysis of the futures premiums at the Nord Pool. Firstly, we explore the importance of the *time of maturity* (i.e. when electricity is deliverable). In particular, we characterize the seasonal behaviour of the premiums. We find that the premiums are the greatest in winter, whereas they are zero during summer. Secondly, we formally explore the links between the risk premium and the basis (futures price minus spot price) through a VAR econometric model with

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a high explicative power. In particular, our empirical results clarify that it is in fact the unusually low reservoir level which has an additional explicative power on the time-varying behaviour of the risk premiums. Thirdly, we examine some testable implications of the equilibrium model by Bessembinder and Lemmon (2002). To the best of our knowledge, this model is the most serious attempt published to date to cast the determination of electricity forward prices into a one-period equilibrium model specifically developed for electricity markets.[1] We find that the variation of the risk premium is related to the variance and skewness of future spot prices as predicted by the model – for the period before the shock that hit the Nord Pool market around the end of 2002. This result is consistent with agents that determined futures prices based on risk considerations. Finally, diverse evidence provided throughout the paper supports the view of tighter market conditions in the Nordic market after 2002. Prices and volatility increased, and the Bessembinder and Lemmon implications are rejected after the 2002–2003 turmoil.

From a broader point of view, this paper builds on the body of research devoted to the direct empirical analysis of the electricity forward risk premium based on equilibrium considerations. Several previous papers concentrate on the day-ahead forward premiums: Geman and Vasicek (2001) consider the Western Hub of the Pennsylvania–New Jersey–Maryland (PJM) market; Longstaff and Wang (2004) analyse the forward premiums in the 24 day-ahead hourly prices traded daily at the PJM electricity market, and Karakatsani and Bunn (2005) consider an intra-daily data set from the British electricity market after the reforms introduced in March 2001 (NETA). Other papers, on the contrary, analyse the premiums for contracts with longer time-to-maturity periods: Bessembinder and Lemmon (2002), for instance, examine one-month-ahead power forward contracts (for delivery each on-peak hour during the delivery month) from the PJM and the California Power Exchange (CALPX) markets.

Overall, the empirical findings of these papers suggest that the size and sign of the forward premium crucially depends on the time of delivery. Specifically, it is positive and large for those contracts with delivery during demand peak periods (at an hourly as well as at a seasonal level). Additionally, the results seem to be at least broadly consistent with equilibrium considerations (in particular, with those testable implications provided by Bessembinder & Lemmon, 2002).[2] Nevertheless, the papers above mentioned use samples that cover around two to three years of data. While this length of sample period may be sufficient to reach sound conclusions when the researcher uses daily-frequency data to uncover intra-daily patterns, it is usually considered to be insufficient to study other patterns with longer horizons, such as monthly or seasonal patterns.

We thus make a significant contribution to the literature on the electricity forward risk premium since, by using ten years of data from one of the oldest spot and futures electricity markets in the world, we circumvent, as far as possible, the statistical difficulties related to the lack of long historical time series that affected other previous studies and cast doubts on the robustness of some of their results. Additionally, as another way of completing the sample, instead of concentrating on a single maturity, we analyse the first four consecutive weekly maturities of the term structure of futures prices traded in Nord Pool.

From a more general perspective, this paper adds to a number of papers devoted to the valuation of the forward and futures contracts traded in Nord Pool, with different objectives, such as: Lucia and Schwartz (2002), Audet, Heiskanen, Keppo, and Vehviläinen (2004), and Koekebakker and Ollmar (2005).

The reminder of this paper is organized as follows. Section 2 summarizes the risk premium approach to futures pricing, and describes and motivates the general features of the empirical research carried out in this paper. It also includes an overview of the empirical findings provided by others following the same general approach in analysing other electricity markets. Section 3 describes the data set used in the study. Section 4 examines the properties of the futures risk premium – including an analysis of its time variation. Section 5 concludes with a summary of the main results and some final remarks.

2. The risk premium approach to futures pricing and empirical research issues

2.1. The risk premium

In this section we first quickly review, for future reference, some basic well-known definitions and relationships.[3] Under the risk premium approach to futures pricing, the futures price is split into the expected spot price on the maturity date and a premium, which is variously known as the risk premium, the futures or forward premium, and the futures or forward bias. To fix notation, let $S(t)$ denote the spot electricity price for electricity to be delivered at time t, let $F(t,T)$ denote the futures price observed on day t for electricity to be delivered at time T, and let $P(t,T)$ denote the risk premium. The basic futures pricing relationship under the risk premium approach can be written as follows:

$$F(t,T) = E_t[S(T)] + P(t,T), \tag{1}$$

[1] The general equilibrium model by Bessembinder and Lemmon (2002) has received special attention from previous researchers. The model assumes that prices are determined by industry participants (including producers as well as retailers), and that power companies are concerned with both the mean and the variance of their profits. Along with other interesting results, the model provides equilibrium forward power prices in a closed form, with testable implications concerning the forward premium. In particular, it is shown that the forward risk premium is negatively related to the variance of spot power prices and positively related to the skewness of spot prices. It is also shown that the equilibrium premium in forward power prices is likely to vary in sign and magnitude on a seasonal basis (due to seasonal changes in the probability distribution of spot electricity prices).

[2] In a closely related paper, Shawky, Marathe and Barret (2003) briefly investigate the premiums in the California–Oregon border (COB) one-month delivery period futures contracts traded on NYMEX, with up to 180 days to maturity, and find that the average premium increases with the length of the time-to-maturity period.

[3] In this paper, we abstract the daily liquidation (marking to market) from the analysis of futures positions. In other words, we consider futures and forward contracts as being indistinguishable. This is an extremely reasonable assumption, provided that we only analyse short-term futures prices in this paper. For the distinction between futures and forward contracts, see Cox, Ingersoll and Ross (1981).