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# An empirical study of the information premium on electricity markets

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ABSTRACT

Due to the non-storability of electricity and the resulting lack of arbitrage-based arguments to price electricity forward contracts, a significant time-varying risk premium is exhibited. Using EEX data during the introduction of emission certificates and the German "Atom Moratorium" we show that a significant part of the risk premium in electricity forwards is due to different information sets in spot and forward markets. In order to show the existence of the resulting information premium and to analyse its size we design an empirical method based on techniques relating to enlargement of filtrations and the structure of Hilbert spaces.
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## 1. Introduction

The electricity market is special — it features a homogeneous good with prices driven by the technical restriction of the merit order (the sequence in which power plants are used). The price process shows seasonalities, mean reversion and spikes, all of which make stochastic modelling challenging. But the most striking distinction to most other commodities (and financial assets) is the non-storability of electricity. It has to be used when produced. Hence, the relation between forward and spot prices must be driven by risk premia only and cannot be explained by standard no-arbitrage arguments, storage or a convenience yield. In fact, the relationship must exhibit the structure of an intertemporal risk premium in a pure way. This risk premium has been analysed in terms of hedging needs of the various actors of the market such as producers and retailers.

The risk premium is defined as the difference between the observed forward price and the expected spot price. In this paper we will follow an information-based approach brought forward recently in Benth and Meyer-Brandis (2009) to explain the risk premium. We will design a statistical test to analyse the information sets used by market participants, and we will show that the market risk premium can be explained in terms of these different information sets.

For electricity markets empirical research has shown a rather inconclusive and random behaviour of the risk premium. For example Longstaff and Wang (2004) prove that the risk premium exists and is significant and positive on average for high-frequency data of the *PJM* (the Pennsylvania–New-Jersey–Maryland) market. They also find that the risk premium is correlated negatively with price volatility and positively with spot skewness (as suggested by Bessembinder and Lemmon, 2002 and discussed in the next paragraph). Furthermore, Torró and Lucia (2011) examine short-term futures (with a delivery period of one week) traded on the Scandinavian NordPool. They, too, find a statistically positive premium that depends particularly on the season during which the contract matures, being highest in winter and zero in summer. For the Spanish electricity market and forwards with maturity within two months Furiò and Meneu (2010) find that the risk premium

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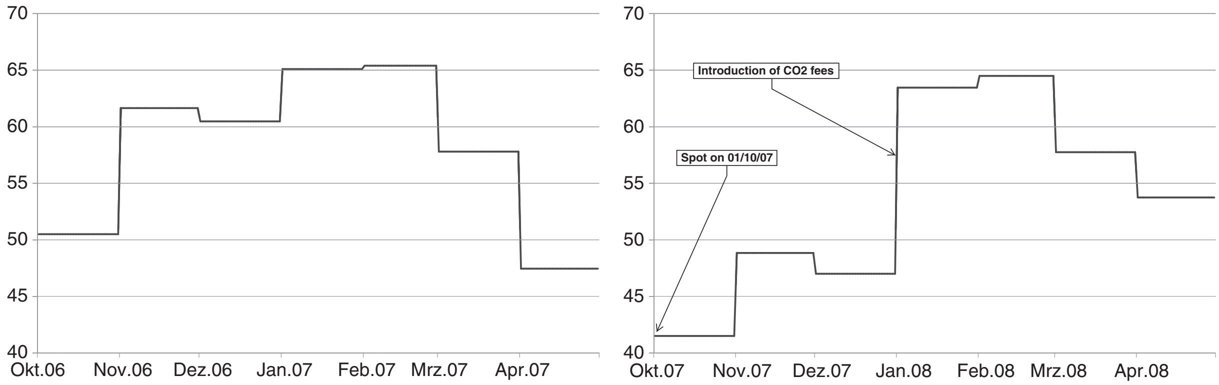


**Fig. 1.** Monthly forward prices observed on October 1st 2006 (left) and October 1st 2007 (right). Lengths of horizontal lines denote the corresponding delivery periods.

decreases with unexpected variations in demand but increases in unexpected variations of the level of hydroelectric energy capacity. Moreover, Diko et al. (2006) find a term structure for the risk premium for data from the German, French and Dutch markets that features a change of sign and negative values for large time to maturity. Their results are similar to those of Kolos and Ronn (2008) who use EEX and PJM data and include oil and gas as more mature markets for comparison. A link between gas storage and electricity forwards is established in Douglas and Popova (2008) in terms of the moments of the electricity spot price distribution confirming the analysis of Bessembinder and Lemmon (2002).

It is noticeable that incomprehension prevails as to the true character of the risk premium. Bessembinder and Lemmon (2002) present a very influential one-period model in which the risk premium depends on the variance and the skewness of the spot price. Their model features retailers' demand as the only exogenous variable and they deduce their risk premium by applying market clearing and equilibrium arguments. Benth et al. (2008a) try to explain the term structure of the risk premium by taking market power and risk aversion of retailers and producers into consideration. They succeed in explaining the change of sign and the negative premium for large time to maturity as mentioned above.

However, as stated before, the most important intrinsic property of electricity is that it is non-storable. To illustrate the effect on prices consider the announcement of a power plant to be closed down for, say, maintenance reasons. Obviously, this will result in higher forward prices with delivery over the time of the shut-down. Still, this information will have no effect on current spot prices as no arbitrage possibilities arise, i.e. we cannot buy the underlying now and sell in the future.

This reasoning was the motivation for the recent paper by Benth and Meyer-Brandis (2009). In this paper the authors complement the historical filtration as generated by the spot process with additional future information. This is done by means of the theory of the initial enlargement of filtration (French “Grossissement initial de filtration”). This theory was developed mainly by French mathematicians in the 1970s and 1980s, for example in Jeulin (1979) or Jeulin and Yor (1978).

Benth and Meyer-Brandis introduce the *Information Premium* as the difference between the forward price under the finer (market) filtration and the coarser (historical) filtration and find analytical expressions for a well-known two-factor arithmetic spot price model. This model was introduced in Benth et al. (2007) and is widely used (for example in Meyer-Brandis and Tankov, 2008; Benth et al., 2008a); we will introduce it in Section 2. We remark that a related approach is followed in Cartea et al. (2009). There, the authors suggest a spot model which takes specific forward looking information (in this case capacity and demand forecasts) into account. Still, their emphasis lies on simulating the spot rather than pricing forward contracts.

Furthermore, we want to stress that in this paper we will work with a reduced-form spot model and in the typical risk-neutral setup of classical financial mathematics. This is the same framework as in Benth and Meyer-Brandis (2009) or Benth et al. (2008a) but distinct from that of Bessembinder and Lemmon (2002). The latter makes use of a structural or fundamental model (and is the more common choice of economists). These models take specific price drivers such as demand or fuel prices into consideration to calculate model prices. In our paper the focus lies on price movements and corresponding information sets and thus we need not take fundamentals into consideration.

In this paper, we will present a method to test for the existence of the information premium empirically. This turns out to be non-trivial as the premium is not measurable with respect to the historical filtration (as will be explained in Section 2.1). Thus, the usual approach, a mere measure change is not possible here. Instead, we will propose a method involving regressions and Hilbert-space representations. The method will also provide a time series for the information premium whose features will match our economic intuition in size and shape. The approach is generally applicable for testing for differences in information sets in any financial market.

In particular, we will analyse two EEX market situations, both of which, we claim, exhibit significant information premia.

Firstly, we will examine the beginning of 2008 with the introduction of emission certificates. After the first, rather non-committal phase of the European Union Emission Trading Scheme (EUETS), the stricter second phase commenced on 01/01/2008. The market anticipated a general upwards shift in prices and a large information premium can clearly be seen in the prices observed. Indeed, in Fig. 1 EEX prices observed on 1 October of the year 2006 and 2007 respectively are illustrated where their delivery period is represented as the length of the horizontal line denoting the price. On the left hand side one can nicely see the typical shape of prices in winter: lower values for October and April, a peak in January and February with slightly lower prices in December due to bank holidays.

One faces a different situation in the subsequent year. The most striking feature here is the price increase between the December and the January forwards of more than 16 Euro (corresponding to some 34%, compared to an increase of 4.50 Euro (7.5%) in 2006). Generally, there appears to be a shift upwards (of about 10 Euro) as the remaining price variations are very similar to what was observed the year before. The spot price[3] on that day was around 45 Euro as indicated in the graphic. Clearly, the price increase can be explained by the market's anticipation of the effects due to the introduction of the second phase of emission certificates. The costs of these certificates were obviously assumed to cause a major rise in electricity prices.

[3] As usually, we take the EEX day-ahead base load price as the spot price.

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