



Pricing of electricity futures based on locational price differences: The case of Finland

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ABSTRACT

We find that the pricing of Finnish electricity market futures has been inefficient during the latest 10 years, when the trading volumes of Electricity Price Area Differentials (EPADs) have more than doubled. Even though the calculated futures premium on EPADs is related to some risk measures and the variables capturing the demand and supply conditions in the spot electricity markets, there has been a significant positive excess futures premium in the Finnish market, and financial market participants should have been able to utilize this also in economic terms. This finding is new and relevant for the participants of the Nordic electricity markets also in the future, because both the speculative and hedging-based trading is increasing in the Nordic markets.

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1. Introduction

Electricity markets around the world have undergone a wave of deregulation and liberalization since the 1990s. The Nordic electricity market is a typical example of this development. In the Finnish and other Nordic markets, vertically integrated monopolies that used to manage production, transmission and sales of electricity have been restructured. Nowadays production and sales operate under free competition, while nation-wide transmission and communal-level distribution networks remain regulated natural monopolies. A natural extension to the restructured wholesale markets has been the development of derivatives markets, since electricity is a homogenous commodity in a given geographical area with sufficient transmission network, capacity and similar power system. Well-functioning derivatives market is of high importance for market participants, since electricity is practically non-storable, and hence, subject to extreme price volatility.

Similar to retail and wholesale markets, pricing of derivatives written on different reference prices in the electricity markets has gained notable academic interest. The focus of research has unsurprisingly been on the

derivatives in the largest and most mature markets, such as the ones in particular states in the US, the Nordic countries, and Germany/Austria (see e.g. Bessembinder and Lemmon, 2002; Redl et al., 2009; Gjolberg and Brattested, 2011; Fleten and Hagen, 2015). Due to physical transmission congestion, local prices may differ substantially from the reference prices causing market participants to incur locational basis risks.

The Nordic market has been divided into 15 bidding areas based on transmission capacities between the areas, and Finland composes one area. Electricity Price Area Differentials (EPADs) are used to hedge price differences between a bidding area and the Nordic system price. Furthermore, Marckhoff and Wimschulte (2009) note that explicit exchange-listed derivatives on the area prices do not exist, since the market was designed on purpose so that overall liquidity would not split among several products. In bidding areas where the area prices differ significantly from the system price, hedging is based on dealing with two separate contracts, which together yield an implied futures contract on the area price, that is, by using 1) a futures contract based on the system price; and 2) futures contract, commercially known as an EPAD, based on the area price difference.

Contrary to the futures on electricity reference prices, such as the Nordic system price, the previous literature on EPADs is very limited. To our knowledge, only few studies (Marckhoff and Wimschulte, 2009; Kristiansen, 2004a, 2004b; Spodniak et al., 2017; Spodniak and

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Collan, 2018) on EPADs pricing have been published in academic journals previously. In addition, EPADs have been studied by Spodniak et al. (2014) and Spodniak (2015) in conference papers. The main contribution of our research is to provide new empirical results on EPADs pricing. All the previous studies have focused on the relationship between the EPADs and respective area price difference or the ex-post futures premium, and we follow this approach, too. However, unlike Marckhoff and Wimschulte (2009) Spodniak et al. (2014) or Spodniak (2015), we attempt to link the ex-post futures premium of EPADs also to abnormal supply and demand conditions that might be of high importance specifically in the Finnish electricity market.

Electricity prices (and associated costs) are of particular importance to the competitiveness of Finnish economy due to Finland's cold climate and energy-intensive industry's large share of GDP that cause Finland to have one of the largest energy intensities, that is, the ratio of gross inland energy consumption to GDP in the EU. The electricity market spot price in Finland has differed substantially from the Nordic system price. For example, in 2015 the Finnish monthly area spot price exceeded the Nordic system spot price on average by 54.6%, exposing the Finnish market participants to a significant basis risk. Moreover, between 2006 and 2015 the system price and the area spot prices of Norway, Sweden and Denmark were on average 10.47%, 5.97%, 10.72% and 2.86% lower than the spot price in Finland, respectively. Furthermore, the Finnish area price difference has widened during the last years.

A natural question for the Finnish market participants is whether the area price differences are reflected in the EPAD prices. Self-evidently, this question is of interest for market participants hedging the future electricity consumption and generation. Speculators alike are interested to discover whether there are profitable trading strategies to be exploited. Prices of derivatives have also wider ramifications. In a market economy they provide price signals, which are essential for an efficient allocation of resources. EPADs prices could for example provide signals for investments in transmission capacity, or production planning of energy-intensive industry or electricity generators. Furthermore, a regulatory point of view matters here, too. The European Union is harmonizing the European electricity market, and EPADs are under review. Regulators are inclined to discover, whether EPADs can efficiently be used to hedge against the area price difference, or should an alternative market structure be established, where the transmission system operators (TSOs) would for example issue financial transmission rights (FTRs) (Spodniak et al., 2014).

Following all this motivation, we attempt to contribute to the existing literature by analyzing first the size of the futures bias for Finnish EPADs, and how biased forecasts do the EPAD futures prices provide for the realized difference between the Finnish area and the Nordic system price. Furthermore, we want to find out which market factors can help to explain the possibly observed bias, or in other words, *is the bias a consequence of market inefficiency, a risk premium, or a combination of them.*

To answer these research questions we use monthly observations from January 2006 to January 2016 on the Finnish EPADs or the difference between the realized area spot price and futures price for the corresponding delivery period. Futures price data were obtained from a third party that have received it from the Nasdaq OMX Commodities exchange, whereas the spot prices were obtained from the Nord Pool, the physical power exchange in the Nordic market.

Our results imply that on average there has been a positive bias in the pricing of monthly Finnish EPADs. In other words, the futures price before the delivery period has exceeded the spot price difference in the respective delivery period in general. However, the bias is statistically significant only after excluding the extreme observations from the sample. Furthermore, the bias seems to exhibit seasonality being the highest during autumn and winter, and the lowest and even negative during the summer time. Both risk considerations and market efficiency seem to explain the bias and we find only little support for the findings of e.g. Bessembinder and Lemmon (2002), or Marckhoff and Wimschulte (2009), but we do find that the bias has increased after 2012. This

could be attributed to the decrease in Russian imports, which may have widened the imbalance between the electricity consumers and generators that naturally hedge the Finnish area price leading to a positive premium in the futures market. Finally, we also document a feedback mechanism (bi-directional causality) between the Finnish area price difference and the EPADs, which could hint that the futures market may be inefficient to some extent.

The rest of this study is structured as follows. In section two we give a short overview on the specific characteristics of Nordic and especially the Finnish electricity markets to lay some background regarding the market specific factors relevant for our empirical analysis. In Section 3 we present the theoretical framework and results from some previous studies to serve as the background for our empirical analysis. Section 4 describes the data and empirical methodology used for our analysis, Section 5 reports the empirical results, and finally, Section 6 gives conclusions and suggestions for further research.

2. Characteristics of the Nordic and Finnish electricity markets

The Nordic market is one of the largest and was among the first liberalized electricity markets. The history of the common Nordic market dates back to 1991, when Norway deregulated its wholesale electricity market. This formed a model for Sweden, Finland, and Denmark, that joined the common exchange titled *Nord Pool*, in 1996, 1998 and 2000, respectively. Estonia, Lithuania and Latvia joined the exchange in 2010, 2012 and 2013, and in 2014 Nord Pool was coupled with the Western European spot markets. In practice this implies that a single algorithm is used to compute spot prices across the involved exchanges and to allocate the cross-border capacities. Currently the physical exchange is owned by the Nordic and Baltic transmission system operators (TSOs, see NordPool, 2015a, 2015b). The first financial contracts on the system price were introduced in 1997, while the trading of EPADs, or CfDs (contracts for differences, as they were called at that time), were launched in 2000. In 2002 the physical and financial exchanges were demerged into separate companies, and in 2008 the financial exchange was acquired by Nasdaq OMX and merged into Nasdaq OMX Commodities (Nasdaq Omx, 2015).

Wholesale markets in the Nordic countries can be divided into short-term physical market and longer-term financial market. Market participants in the physical market include retailers and large industrial consumers, generators and trading houses. They have to be physically connected and to have a balance agreement with the TSO in the bidding area they are residing, as the physical market balances the supply and demand of electricity at every instant. In the day-ahead spot market the participants purchase and sell electricity for each hour for the next day according to their preliminary supply or consumption plans, which yields the spot prices for each hour. In the secondary market the trading is continuous, and participants can manage unanticipated imbalances or optimize their supply or purchase plans up to 1 h before the delivery hour. Finally, the ancillary market maintained by the TSOs balances the power system in real-time, maintains system security and quotes the balance prices, which are used in settling the imbalances, i.e. the difference between actual generation (consumption) and electricity sold (purchased). The TSO of Finland is called Fingrid.

Trading in the day-ahead physical market takes place either bilaterally in the OTC list or in the Nord Pool market. The physical spot market is operational 365 days a year and produces spot prices for each hour. Over 300 market participants from the Nordic and Baltic countries submit daily their bids to the Nord Pool before 12:00 CET. Bids are like individual demand and supply curves: they reveal the quantity demanded and supplied at a given price. Nord Pool aggregates the bids to the market-wide supply and demand curves for each hour and the spot price clears the market. The individual orders are fulfilled if price at which the quantity demanded (supplied) is above (below) the spot price. This procedure is repeated for each hour yielding a spot price for every hour, and results for the next day are published normally

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