Utilities Policy 50 (2018) 194–206

Contents lists available at ScienceDirect

Utilities Policy

journal homepage: www.elsevier.com/locate/jup

# Forward risk premia in long-term transmission rights: The case of electricity price area differentials (EPAD) in the Nordic electricity market

Petr Spodniak[a,b,*], Mikael Collan[c]

[a] Economic and Social Research Institute (ESRI), Whitaker Square, Sir John Rogerson's Quay, Dublin 2, Ireland
[b] Trinity College Dublin (TCD), Department of Economics, Dublin 2, Ireland
[c] LUT School of Business and Management, Lappeenranta University of Technology, Skinnarilankatu 34, 53851, Lappeenranta, Finland

ARTICLE INFO

*Keywords:*
Forward risk premia
Time-to-maturity
Hedging

ABSTRACT

Hedging behaviour among players in derivatives markets have long been explained by forward risk premia. We provide new empirical evidence from the Nordic electricity market and explore the forward risk premia dynamics on power derivative contracts called electricity price area differentials (EPAD). This contract is critical for the market, but its efficiency has been questioned. The study investigates the significance, direction, and magnitude of forward risk premia in individual bidding areas and contract maturities during the period 2001–2013. We test the hypothesis of a negative relationship between forward risk premia and time-to-maturity, for which we find only partial support.

## 1. Introduction

This study investigates the issue of systematic differences between the trading prices of electricity as reflected in forward contracts ($F_{t,T}$) and the spot prices observed on the date of delivery ($F_{T,T}$). We call this systematic difference forward risk premia, in line with (Benth and Meyer-Brandis, 2009; Benth et al., 2008; Marckhoff and Wimschulte, 2009; Longstaff and Wang, 2004). Forward risk premia can be understood as mark-ups, or compensation in derivative contracts charged either by suppliers or consumers for bearing the demand and price risk for the underlying commodity (electricity). The emergence, magnitude, and behaviour of forward risk premia in power derivative contracts are the focus of this paper.

The research topic of forward risk premia is of importance to power producers and consumers, policymakers, as well as academic researchers. We will discuss the relevance for each in turn. First, the absolute and dynamic differences between today's forward price and the expected spot price of electricity have direct impacts on the market participants' (hedgers and speculators) cash flows. That is, by paying a very high or very low risk premia, market participants are exposed to additional uncertainty and financial risks. These financial risks generate market frictions and contribute to increased transaction costs, which adversely affect the competitiveness of factor markets.

Second, policymakers ought to sustain a competitive electricity market, so an awareness of the problems of risk premia in electricity financial contracts is needed. Presence of negative or positive risk premia, in forward contracts does not immediately point to anti-competitive behaviour. Instead, it highlights the exerted pressures from the supply or demand side of the market, and measures the costs for bearing such pressures. Surprisingly, there has only been limited research into the market inefficiencies of the financial electricity market (Redl and Bunn, 2013). Compared to the theoretical and empirical research on inefficiencies in the physical wholesale power markets (Borenstein et al., 2002; Joskow, 2006; Growitsch and Nepal, 2009), where mark-ups in spot prices are thoroughly examined, the same is not true for power derivatives contracts. Power derivatives markets, like spot markets, are equally susceptible to market inefficiencies. Earlier literature (Hicks, 1939; Lutz, 1940; Keynes, 1930) postulates that the difference between the current forward price and the expected future spot price is negative (negative risk premia), implying there are systematic hedging pressure effects at play.

Nevertheless, recent studies (Bessembinder and Lemmon, 2002; Benth et al., 2008) describe both positive and negative risk premia that are mainly determined by the behavioural interaction between buyers and sellers, as well as, their risk considerations during different trading periods. Specifically, Benth et al. (2008) formulate a theory of the relationship between forward risk premia and time-to-maturity by predicting decreasing values of risk premia (which eventually become negative) when the time-to-maturity increases. Their theory sheds light on the role of market players' attitudes towards bearing risks during different time periods. Clearly, in order to design efficient market rules and regulations for electricity markets, the risk premia mark-ups in derivatives contracts must be theoretically and empirically understood.

* Corresponding author. Economic and Social Research Institute (ESRI), Whitaker Square, Sir John Rogerson's Quay, Dublin 2, Ireland.
*E-mail addresses:* petr.spodniak@esri.ie (P. Spodniak), mikael.collan@lut.fi (M. Collan).

https://doi.org/10.1016/j.jup.2018.01.004
Received 16 November 2015; Received in revised form 12 January 2018; Accepted 12 January 2018
Available online 19 January 2018
0957-1787/ 

**Abbreviations**

| | |
|---|---|
| EPAD | Electricity Price Area Differentials |
| CfD | Contract for Difference |
| FTR | Financial Transmission Rights |
| LTR | Long-Term Transmission Rights |
| NC | Network Code |
| GARCH | Generalized autoregressive conditional heteroscedasticity |
| VECM | Vector error correction model |
| VAR | Vector autoregression |

Third, the connection between electricity spot and forward prices is unclear (Benth and Meyer-Brandis, 2009) and the current explanation of forward risk premia in electricity derivatives rests on the assumption of irregular and random behaviour of market participants. Some studies stress the behavioural motives of actors to hedge and diversify risks that explain the forward risk premium and its sign (Benth et al., 2008; Cartea and Villaplana, 2008). Others (Bessembinder and Lemmon, 2002) explain the forward risk premia as a net hedging cost due to the risk aversion between producers and retailers. Specifically, Bessembinder and Lemmon (2002) state that the forward risk premium in electricity prices depends negatively on the spot-price variance and positively on the standardised skewness of the spot price.[1] This implies that during peak daytime periods, cold winters or transmission bottlenecks, spot prices are often positively skewed, which increases the demand for long forward contracts and hence their prices rise above the expected future spot price (Redl et al., 2009). Similarly, during off-peak periods when electricity demand is low (such as summer periods in Scandinavia), demand risks are low and spot prices are closer to the normal distribution, which pushes the forward contracts below their expected spot-price counterparts. Researchers have found support for these relationships (Lucia and Torró, 2011; Furió and Meneu, 2010; Pirrong and Jermakyan, 2008; Redl and Bunn, 2013). Some have focused on the market fundamentals that explain the forward risk premia in forward contracts by such determinants as $CO_2$ prices (Furió and Meneu, 2010) or levels of hydro reservoirs (Lucia and Torró, 2011; Marckhoff and Wimschulte, 2009; Spodniak et al., 2014; Fleten et al., 2015).

In this study, we focus on a specific type of power derivative contract, called electricity price area differentials (EPAD), which enables market participants in the Nordic electricity market to hedge (or speculate) against the local area electricity prices.[2] The reason for studying this particular contract is its unique design and the exceptional role it plays in the European and global electricity markets. According to the two main EU electricity network codes (NC) designed by ENTSO-E (NC on Forward Capacity Allocation, and NC on Capacity Allocation and Congestion Management), an alternative mechanism to hedge local electricity prices, called financial transmission rights (FTR), should be implemented EU-wide. The Nordic EPAD contracts have so far received an exception from the planned FTR mechanism, under the assumption that "appropriate cross-border financial hedging is offered in liquid financial markets on both side(s) of an interconnector" (ACER, 2011, p. 10). However, the liquidity assumption of EPAD has been questioned (NordReg, 2010; Hagman and Bjørndalen, 2011; Spodniak et al., 2015). As expected, EPAD liquidity may impact the risk premia buyers (sellers) are willing to accept (charge) for bearing the price risk (demand risk).

Both EPAD and FTR are financial derivative contracts that fall into the group of long-term transmission rights (LTR) that provide market participants the possibility to reduce, or share transmission congestion risks. While FTR hedge the electricity price difference between two bidding areas, EPAD hedge the difference between the local area price and a reference system price. It falls beyond the scope of this study to address the FTR, which are currently mainly implemented in power markets with nodal pricing, such as the US. For a theoretical discussion on European FTR, see Spodniak et al. (2017). For the remainder of this paper, we focus solely on EPAD in the Nordic electricity market, starting with a brief overview.

In liberalized and deregulated electricity markets, power producers compete for the limited capacity of the transmission network to supply power to customers. Because of the diverse operational conditions of the power system, transmission networks can become congested and consumers are prevented from accessing power from the most efficient producers. To address the problem of limited transmission capacity, congestion management and tradable long-term transmission rights (LTR) are integral to the fundamentals of power market designs. EPAD is a financial contract with weekly, monthly, quarterly, and yearly maturity, traded on Nasdaq OMX Commodities, and used for hedging the price difference between a specific bidding area and a reference system price, in the Nordic electricity market. The system price is an equilibrium price of the whole Nordic electricity market, where bids and offers from players across seven countries (Norway, Sweden, Finland, Denmark, Estonia, Latvia, and Lithuania) discover electricity prices for each hour of the following day. As part of congestion management, the Nordic electricity market uses a zonal pricing model, which splits geographical regions (countries) into multiple bidding areas (currently fifteen) that are selected to reflect the transmission congestion between neighbouring regions. Hence, area prices represent the marginal cost of congestion and the system price is the reference price for the entire market.

A major challenge with quantifying risk premia with traditional forward pricing methods (e.g., buy-and-hold) is that these methods are not applicable to non-storable goods and commodities, such as electricity. Electricity systems rely on a constant balance of supply and demand (Kirchhoff's laws), as current technologies limit economic storage of large quantities of electrical energy. Hence, the forward electricity price is usually defined as the *expected price* of the commodity at delivery conditioned on an information filtration (Benth et al., 2008; Benth and Meyer-Brandis, 2009) plus the *risk preferences* of market participants as reflected in risk premia (Breeden, 1980; Cootner, 1960; Dusak, 1973). To quantify the risk premia in EPAD contracts, we revisit the ex-post approach (Marckhoff and Wimschulte, 2009; Longstaff and Wang, 2004; Shawky et al., 2003) and define the ex-ante risk premia as the differential between observed forward prices and delivery-date spot prices, as revealed ex-post. We quantify risk premia in EPAD for the time period 2001–2013 using daily financial price data from Nasdaq OMX Commodities and daily spot-price data from Nord Pool Spot. Despite the fact that EPAD is a standardized defered settlement futures contract, we use the term forward risk premia, or simply risk premia, because of its established usage in finance.

There are three main objectives of this paper. First, due to the limited research on electricity price area differentials (EPAD), this paper contributes empirical evidence on risk premia in EPAD to support academic and policy discussion on long-term transmission rights in Europe. Second, due to the indeterminate evidence on the factors affecting risk premia in power derivatives, this work investigates the significance, direction, and magnitude of risk premia according to location, delivery periods, and time-to-maturity in the Nordic electricity market. Third, the work scrutinizes the time-evolution of forward risk premia and tests on the Nordic electricity market the theory (Benth et al., 2008), which predicts decreasing values of risk premia (eventually turning negative) as the time to maturity increases.

Our main contribution lies in expanding the scale and scope of the limited theoretical and empirical research on transmission risks and forward risk premia in power derivatives markets. By quantifying

[1] The standardized skewness coefficient is calculated as the skewness divided by the standard deviation of spot power prices cubed.

[2] EPAD contracts were originally called contracts for differences (CfD) in the Nordic electricity market setting.