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Liquidity and risk premia in electricity futures

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ABSTRACT

Research on electricity futures markets has to date not explored the role that market liquidity may play in determining risk premia. Further, no detailed empirical examination of both liquidity and risk premia in the New Zealand electricity futures market are discernible. Using data from October 2009 to December 2015, we address these gaps in the literature. We find that liquidity has been gradually increasing and that a policy intervention to impose a maximum bid-offer spread was associated with liquidity-enhancing structural breaks, but this was evident only in the nearest-to-maturity futures contracts. Further, we develop models to explain risk premia that include a range of risk factors, which we categorise as either statistical, physical market, production cost or liquidity variables. From this analysis, we document significant time-varying premia that are driven by potentially inefficient behaviour. Finally, we find that liquidity risk does affect risk premia, but generally only in the case of longer-dated futures.

1. Introduction

Futures contracts allow participants to manage their overall risk profile and exposure to the underlying spot market. The ability to do so has inherent value. Such value will be reflected in the risk premia present in these futures contracts. Previous research has found significant premia in electricity futures markets, which are relatively large in comparison to those found in other commodities (Shawky et al., 2003). Further, a considerable literature across a broad range of international electricity futures markets has not reached consensus with regards to the sign of these premia (for instance, Longstaff and Wang, 2004; Kolos and Ronn, 2008; Botterud et al., 2010).

A strand of the electricity futures market risk premia literature examines the determinants of risk premia, with a range of models and explanatory variables utilised. These include equilibrium hedging models (e.g. Bessembinder and Lemmon, 2002), physical market factors (e.g. Douglas and Popova, 2008) and production-cost-related variables (Bunn and Chen, 2013). However, an omission in the literature is the exploration of market liquidity as a determinant of risk premia. This is surprising, since it is well established in the finance literature that liquidity risk affects asset prices (Acharya and Pedersen, 2005; Amihud and Mendelson, 1986b; Amihud and Mendelson, 1986b). We address this gap in the literature.

Moreover, the literature examining liquidity in a more general sense (i.e. not necessarily within the context of risk premia) in electricity futures markets is thin (notable exceptions are Frestad, 2012; Hagemann and Weber, 2013). Again, this is surprising since regulators have shown concern about illiquidity and how this may affect the effectiveness of hedging markets (and by extension risk premia) (see Section 2 and EA, 2014).

In this paper, we look at the liquidity of electricity futures generally, and whether liquidity risk is apparent in risk premia in the context of the New Zealand (NZ) electricity market (NZEM). NZEM is an early example of a deregulated market structure, and is considered by some to be an example of 'textbook' reform (Joskow, 2006). In the NZEM, the volatility of spot prices is exacerbated by the predominance of hydroelectric generation, which has limited storage and exhibits a high degree of volatility in the inflows into storage lakes. In order for market participants, whether they are generators, retailers, or large consumers,

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to successfully operate in this sector, effective hedge instruments need to be available to mitigate risk. One such tool available in the NZEM is futures contracts.

No empirical research on risk premia and liquidity of electricity futures markets is discernible.[1] Within the NZ context, there have been concerns that large positive risk premia exist in the futures market and that these may potentially be indicative of inefficiencies in the market (EA, 2014). Further, concerns about illiquidity of the futures market have led to two 'policy-induced' or 'encouraged' interventions to increase the efficiency and liquidity of the futures markets. These were the introduction in 2010 of 'mandatory' market making by the four largest generators and, in 2011, the implementation of a maximum bid-offer spread of 5% in the futures market (see Section 2). No prior empirical research has explored whether these interventions were successful in increasing liquidity.

To summarise, this paper makes two broad contributions. First, we augment the literature on the determinants of risk premia by incorporating measures of (il)liquidity in our comprehensive models of the determinants of risk premia. Second, we provide the first detailed empirical examination of both liquidity and risk premia in the NZ electricity futures market. We do so by addressing the following two research questions:

- *Q1: How has the liquidity of the NZ electricity futures market evolved over time, and have policy-induced interventions to increase liquidity succeeded?*
- *Q2: What drives risk premia in the NZ electricity futures markets and is (il)liquidity a factor in these premia?*

These questions are addressed by using data for the period 2nd October 2009 to 31st December 2015. We employ from the literature three measures of liquidity or illiquidity on which we run structural break tests (Bai and Perron, 1998). Further, our comprehensive models to explain risk premia include a range of risk factors, which we categorise as either statistical, physical market, production cost, investor behaviour, or liquidity variables. We use the *ex post* approach to modelling risk premia which has dominated the literature, however, alternative approaches such as the *ex ante* and portfolio asset pricing approaches that decompose premia into spot and term components have become more prominent in recent years (see respectively Maryniak et al. 2018; Szymanowska et al. 2014 and Footnote 3, Section 4.3).

The rest of the paper is structured as follows. Section 2 provides more background on the NZEM and the related futures market. Section 3 reviews the relevant literature on liquidity and on risk premia in electricity futures markets. Section 4 outlines the data and models we employ. Section 5 presents our results, and Section 6 provides some conclusions.

2. The New Zealand electricity market

Total generation and consumption of electricity in New Zealand in 2015 were 42.9 and 39.8 TWh, respectively (MBIE, 2015). Industry is the largest sector by consumption, accounting for 36% of consumption in 2015, followed by 32% for residential consumption, 24% for commercial consumption and 7% for agricultural consumption.

Total consumption stopped growing after 2006, peaked in 2010 at just over 40 TWh, and has been relatively constant since. While other sectors have continued to grow, the industrial sector has shrunk, primarily due to rationalisation in the wood pulp and processing sector, but the country's largest load at the Tiwai Point aluminium smelter has also fallen in response to weak aluminium prices.

The supply-side is dominated by four vertically integrated companies that, between them, also have the majority of retail customers. These four companies together generated 87% of all electricity in 2015 and, despite their large retail businesses, they also act as market-makers in the electricity futures market and are key players in the OTC hedge market.

The number of new players in the retail side of the NZEM is increasing rapidly and by the end of 2015 just over 6% of all customers were supplied by these new retailers (EA, 2015). The rate at which new retailers are appearing is also increasing and this is, in turn, creating more interest in the hedge market and the futures market, in particular, as new entrants look to manage risk.

The NZEM utilises locational marginal pricing, or nodal pricing, with spot prices set half hourly. This mechanism simply refers to the fact that there is no single market price and that spot prices vary across the country, reflecting the marginal cost of supplying electricity at that particular location. Another characteristic of the NZEM is the use of a mandatory pool, meaning that apart from a small portion of supply generated and consumed entirely within a consumer's site, all electricity must be traded through the spot market. This differs from, for example, Great Britain, where the majority of wholesale electricity is contracted prior to real-time and only a small portion is traded through a balancing market at real-time.

Due to the natural resources NZ is endowed with, in particular voluminous rivers and lakes, generation in the NZEM comes primarily in the form of hydro – currently around 57% of the total energy generated (MBIE, 2015). In this sense, the NZEM is similar to the Nord Pool market, which has received considerable academic attention (see, for example, Botterud et al., 2010; Fleten et al., 2015; Weron and Zator, 2014). As a result, the approach we employ in this paper in the context of the NZEM draws from the literature on Nord Pool.

Though much of the generation comes from hydrological sources, there is still a significant portion which comes from alternative sources. Geothermal, gas and coal comprise approximately 18, 13 and 4%, respectively (MBIE, 2015). The decisions to utilise these peaking plants will not only be influenced by the wholesale spot price of electricity, but also fossil fuel prices such as oil, gas and coal. Another relevant cost of production in New Zealand is the price of carbon. The New Zealand Emissions Trading Scheme (NZ ETS) has applied to electricity generators since July 2010 (see Diaz-Rainey and Tulloch, 2018).

Over-the-counter (OTC) electricity swaps were traded in New Zealand even prior to the establishment of the spot market, and total swaps traded in 2015 still totalled 20% of the physical market. Trading in NZ electricity futures contracts commenced July 2009 on the Australian Securities Exchange (ASX) with 1 MW (MW) quarterly baseload contracts available from Q4 2009 to Q4 2012. All electricity futures are cash settled. The contract size was reduced to 0.1 MW in November of 2015 to line up with the size of other contracts traded in the NZEM and to encourage greater participation by smaller players. Contracts are referenced to one of two nodes, or locations, on the power grid: Benmore in the South Island and Otahuhu in the North Island. Initially, both quarterly and "strip" contracts were traded, while peak quarterly contract and baseload monthly contracts were not introduced until December 2013. This paper focuses on the quarterly baseload contracts, which remain the most highly traded of all the NZ electricity futures contracts and which totalled 43% of the physical market in 2015.

A consultation by the Electricity Authority (EA), the regulatory body of the electricity market in New Zealand, suggested that the hedge market should provide effective means of managing spot price risk, whilst giving a transparent view of future prices (EA, 2014). The EA added that the "more liquid the hedge market is, the better these ends will meet" (EA, 2014;p.11). Unfortunately, responses from market participants to the EA consultation indicated that the futures market may not be supporting risk management and price transparency as much

[1] There is a nascent literature on New Zealand's electricity spot and futures markets (de Bragança and Daglish, 2016; Young et al. 2014). These contributions have been largely modelling based and concerned with market power as distinct from our endeavour of exploring liquidity and determinants of observed risk premia. By way of contrast, a number of studies explore risk premia in the Australian context (see for instance Maryniak et al. 2018).