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Agenda

Advancing economics in business

Hedging your bets: why pay over the odds for forward electricity?

Markets for forward contracts and other derivatives are necessary to enable firms to manage their risk exposures. But are these markets efficient? Álvaro Cartea, Oxera Associate and Visiting Professor at Universidad Carlos III de Madrid, and Oxera show how measuring the costs of forward purchasing of electricity, and assessing the drivers of these costs, can provide valuable insights for policy-makers, market participants, and prospective entrants

Although electricity is considered by many to be a commodity, the behaviour of electricity prices is strikingly different from that of other commodities, mainly due to the technical challenges and costs of storing meaningful quantities of it. The corollary to this is that electricity demand and supply must be balanced for every moment of every day to prevent disruptions to supply. The consequences that follow from these physical features are that future electricity prices are driven by expectations of the level of future capacity relative to demand, and that the costs of managing the power price risk can be considerable.

The availability of instruments necessary for market participants to manage their exposures to price and volume risk is essential to the operation of competitive electricity wholesale markets. Indeed, efficient and 'liquid' spot and forward markets help to ensure that new investments—whether undertaken by existing or prospective market participants—can be made in a timely manner and that prices reflect underlying supply and demand conditions. Ultimately, liquid wholesale markets help to promote effective competition.

In practice, the costs of risk management as measured by the costs of forward contracts vary significantly between electricity wholesale markets in different jurisdictions. What could explain these cost differentials, and are they unavoidable? Does market design affect the costs of electricity forward contracts, and therefore market liquidity? In order to gain insights into the efficiency of electricity wholesale markets, this article presents evidence from a model of the 'forward premium' across three different markets: PJM (Pennsylvania, New Jersey and Maryland), Nord Pool (Scandinavia), and Great Britain.

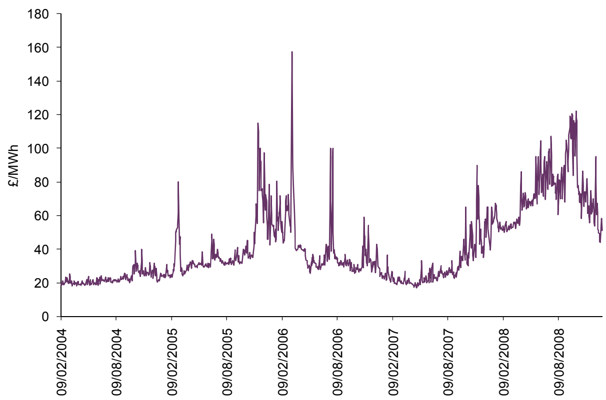
Market dynamics and the forward premium

Several remarkable features of wholesale electricity prices underlie the high risks borne by power market participants:

- the occurrence of extreme price 'spikes';
- strong mean reversion to a seasonal trend;
- short-lived price 'drops' that also revert to the seasonal trend (although these may be somewhat less dramatic than spikes, they are nonetheless important from a risk management perspective).

Figure 1 illustrates these features in GB spot prices over the period 2004–08, and it is clear from this that prices can exhibit significant volatility. For example, in

Figure 1 GB day-ahead electricity prices



Note: Prices prior to April 1st 2005 are for England and Wales due to the introduction of the British Electricity Transmission and Trading Arrangements (BETTA).
Source: Datastream.

March 2006, prices jumped from around £50/MWh to over £150/MWh within a couple of days, only to return to more normal seasonal levels a few days later. The above-mentioned features are common to other liberalised power markets such as PJM and Nord Pool.

In the absence of significant opportunities to store power (or to incentivise consumers to reduce their loads during times when supply–demand balances are tight), market participants are generally required to pursue market-based hedging and risk management alternatives such as entering into forward contracts.

A forward contract (or a 'forward') is an agreement whereby a generator agrees to deliver a quantity of power at a pre-specified future date, at which point it receives a fixed amount of money from the customer. Forwards can be privately negotiated between parties, or they may be traded 'over the counter' of a broker or dealer. Forwards are different from futures contracts (or 'futures'), which are standardised contracts that are typically traded on regulated exchanges and where the exchange (or a third-party provider of clearing services) also acts as a counterparty to all the contracts traded on the exchange. (Hereafter, the term 'forward contract' refers to both forwards and futures unless otherwise specified.) The significance of how forward contracts are traded is discussed below.

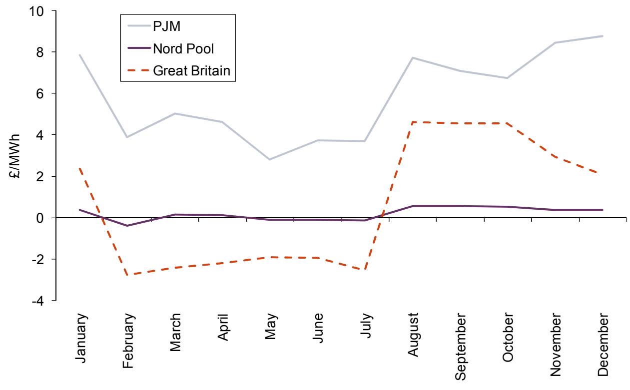
Forward contracts can be seen as a form of insurance against changes in spot prices because payment for the power does not depend on the level of spot prices when delivery takes place. A typical monthly electricity forward contract that is traded in January, for example, could require one of the parties to deliver 1MWh every day throughout February, and would receive an agreed (fixed) price on delivery of power regardless of spot prices that materialise in the period leading up to delivery taking place.

In a competitive market with a large number of producers, retailers, consumers and other 'non-commercial' participants, forward contracts would be expected to trade at prices that are relatively close to the expected spot price.[1] This is because non-commercial participants (eg, market makers or speculators) may be in a position to bear these price risks in exchange for some level of expected return signalled by the forward premium (notwithstanding concerns over information asymmetries or other transactions costs which may provide a strong disincentive for non-commercial players to engage with the wholesale electricity markets).

Quantifying the forward premium

Figure 2 shows the average monthly forward premia (in £/MWh) in Great Britain, Nord Pool, and PJM for the period 2001–06. A positive forward premium indicates

Figure 2 Average monthly forward premia



Note: Average monthly forward premia shown for Great Britain (April 2001–January 2006), Nord Pool (September 2003–December 2006), and PJM (April 2002–August 2006). The GB forward premium is calculated from reported prices of forward contracts of various maturities. The Nord Pool and PJM forward premium is based on exchange-traded futures contracts.
Source: Cartea, Á. and Villaplana, P. (2008), 'Spot Modeling and the Valuation of Electricity Forward Contracts: The Role of Demand and Capacity', *Journal of Banking and Finance*, **32**:12, pp. 2502–19; Oxera analysis.

that hedging future price risk is relatively expensive for electricity buyers (ie, retailers and other consumers), whereas a negative premium indicates that the costs of hedging are relatively high for sellers (ie, generators).

Forward premia (ie, the difference between the forward contract price and the expected spot price) have been calculated according to reported spot prices and forward contracts of varying maturity, together with a flexible statistical model of prices to account for the market price of demand and capacity risks.[2] The rationale for the use of demand and capacity as the drivers of the spot price model is that they jointly provide a reasonably complete description of the state of the market, especially its price volatility. Demand is typically inelastic and dependent on factors such as weather and macroeconomic activity. Capacity is also a volatile parameter, partly as a result of unanticipated plant maintenance or unexpected transmission constraints.

Figure 2 shows that for the GB market the average monthly forward premium is typically at its highest between August and January of each year—averaging between £2.1/MWh and £4.6/MWh—and that it also follows a seasonal pattern largely as a result of the seasonality of the volatility of demand. This pattern could be explained by the fact that in this period demand is both relatively high and volatile, making the risks to buyers commensurately greater. This motivates market participants to hedge their risks by purchasing forward contracts, despite these contracts being available only at a considerable premium over and above what would otherwise be the expected spot price.

The situation is reversed between February and July, when GB forward contracts trade at a discount, as revealed by an average monthly forward premium of between –£2.8/MWh and –£1.9/MWh. Demand volatility in this period is typically relatively low, thereby putting downward pressure on the forward premium. Importantly, this demand-side effect outweighs the effects of capacity risk, thereby resulting in a negative forward premium. An explanation for this could be as follows.

- First, during months of low volatility of demand the probability of observing upward price spikes is relatively low, so buyers have fewer incentives to cover their positions by purchasing power ahead of their physical requirements. However, since sellers still prefer to sell forward contracts to reduce variability in their profits, some downward pressure on prices would result.

- Second, producers face variable power prices due to unexpected changes in the system's total generation capacity. Positive capacity shocks reduce power prices and negative shocks increase them. During times of low and less volatile demand, upward price spikes as a result of a fall in capacity are less likely. Hence, although sellers would like to take advantage of possible price spikes arising from negative capacity shocks by selling through the spot market (rather than contracting forward), their fear of price falls (due to unexpected positive movements in the total generation capacity) provides a much stronger incentive to sell forward contracts. This willingness to hedge risks, induced by random deviations in capacity, drives forward contract prices down. In some circumstances, this downward pressure is strong enough to push discounts to such an extent that expected spot prices are higher than forward contract prices.

Figure 2 also shows the monthly average forward premium in the Nord Pool and PJM markets. In the PJM market it is also the months with highest demand and highest volatility of demand that exhibit the largest average monthly forward premium of around £8.8/MWh. As in Great Britain, in Nord Pool there are months where forward contracts are sold at a discount on what the forecasts of spot prices would predict. The ranges of average monthly forward premia for Nord Pool and PJM are –£0.4/MWh to £0.6/MWh and £2.8/MWh to £8.8/MWh, respectively.

Policy implications

A key point to note from Figure 2 is the disparity in the magnitudes of the average forward premia in these markets. For example, the GB market has its highest average monthly forward premium of around £4.6/MWh, whereas the equivalent premium in Nord Pool is around £0.6/MWh (both occur in August). From the perspective of policy-makers and regulators considering alternatives to the current market design, the key question is whether this difference is caused by market fundamentals that objectively justify the costs of forward contracting, or whether it is caused by poor liquidity stemming from deficiencies in market design.

There are several possible drivers of the observed differences in the forward premium. Their impacts and potential policy implications are set out below.

- **Weather and climate**. Perhaps the most obvious influence on differences between electricity wholesale markets that would also be expected to affect the forward premium is the weather. As discussed above, this is due to the substantial impact that weather has on demand and price volatility. In addition, given that it is the seasonality and volatility of demand that affects the forward premium, more settled and predictable weather patterns would be expected to be correlated with lower observed premia.

- **Generation mix**. A key supply-side driver of the observed forward premia in different markets is their mix of power generation technologies. Some plant types may be more reliable and so help to make the level of available system capacity less uncertain (the same applies to the vintage of plant connected to the system). In addition, some generation technologies may possess capabilities that help them to respond quickly to unanticipated changes in demand (eg, hydropower). To the extent that different generation technologies are unaffected by volatile input prices and are less 'lumpy' relative to the total level of demand, these factors would help mitigate power price volatility. The difference in generation mixes between Nord Pool and the GB market suggests that this driver could be material. For example, hydropower accounts for around 50% of installed capacity in Nord Pool, with thermal generation representing around a further 30% of capacity.[3] In contrast, the GB market is dominated by thermal and nuclear generation capacity, each representing around 80% and 15% of installed capacity, respectively.[4]

- **Market concentration**. A high degree of market concentration and market power would be expected to increase the forward premium on account of the greater ability and incentive of generators to withhold capacity, especially in periods with tight demand–supply balances. Aside from the direct negative impact on consumers in concentrated markets in the form of higher prices and lower output, highly concentrated markets may also have an adverse effect on price volatility and liquidity, thereby further disadvantaging consumers. The negative effects of less liquid trading of forward contracts on new market entry and investment are particularly damaging since they would be expected to be focused on long-dated contracts, resulting in fewer and/or distorted long-term price signals. It is interesting to note that in the period 2003 to 2005 reported concentration measures (using the Herfindahl–Hirschman Index, HHI) for the Nordic and GB markets were 892 and 1,068, respectively.[5] This may suggest that market concentration could have at least some role in determining the differential between the forward premia observed in these markets.

- **Transparency**. The availability of comprehensive and reliable information on market prices and other network characteristics affecting market fundamentals is potentially a significant driver of the forward premium. This is due to the impact that the availability (or cost) of such information can have on the ability and incentive for non-commercial players to participate in the market, which can limit opportunities for physical market participants to spread their risks (whether through forward or futures contracts). This is perhaps surprising, since in the absence of market ‘frictions’ it would be expected that any investor would be willing to have at least some (small) exposure to commodities in their asset portfolios so long as the payoffs on commodities contracts are not perfectly correlated to returns on marketable securities. However, the presence of informational asymmetries, transactions costs, and other set-up costs (eg, minimum contract sizes or the costs of learning about specific markets) for non-commercial players can be shown to increase the risk premia required to induce market participation.[6] Specifically, the magnitude of the forward premium can be shown to increase with the square root of the set-up cost, which would imply that the combined costs for these market participants entering the GB market could be as much as seven times greater than the costs of entering Nord Pool, based on the peak average monthly forward premia referred to above.[7]

- **Bilateral and/or exchange-based trading**. The interplay between different trading platforms or ‘routes to market’ for market participants is potentially another significant driver of the forward premium. To the extent that multiple routes to market provide opportunities for a wider and more diverse set of players to participate, this would be expected to positively influence market liquidity and efficiency. For example, by reducing the set-up costs and the minimum efficient scale of trading operations (eg, by limiting counterparty risks), this would be expected to make participation by smaller or non-commercial players more feasible. As described above, this would be likely help to reduce the forward premium and it could help to explain the disparity in observed forward premia between Nord Pool and the GB market. It is notable that the volume of electricity traded in the UK and Nord Pool in 2005 was, respectively, around 650TWh and (at least) 2,100TWh, which suggests that trading in Nord Pool is considerably more liquid (the total consumption in the UK and Scandinavian countries covered by Nord Pool was around 350TWh and 390TWh, respectively).[8] Although liquidity as measured by the total reported volume of trading in these markets has increased in the period to 2008, Nord Pool remains considerably more liquid than the GB market. Furthermore, the liquidity gap between these markets may be exacerbated by the lack of significant exchange-based trading in Great Britain relative to Nord Pool and a credible, transparent spot market that also serves to underpin trading in a variety of derivative contracts. Exchange-based trading was estimated to be 1% of the GB market consumption in 2004/05 (ie, around 3–4TWh), whereas in Nord Pool it was around 200% (ie, approximately 790TWh).[9]

Summary

Based on published academic research, this article has described how excess volatility and abrupt spikes in spot market prices are driven mainly by shocks to demand and supply during times of high and volatile demand. In turn, this pushes forward contract prices up as a consequence of market participants’ desire to hedge their exposures to price risk, thereby giving rise to a greater forward premium. Ordinarily this would be expected to also result in greater incentives for new market entry, although this investment incentive could be thwarted by the effects of poor liquidity driven by high market concentration, a lack of market transparency, and limited exchange-based trading of electricity futures and other derivatives. Accordingly, this would suggest that policy-makers could perhaps consider market reforms to mitigate these deficiencies (where applicable) in their existing market designs.

[1] Bessembinder, H. and Lemmon, M. (2002), 'Equilibrium Pricing and Optimal Hedging in Electricity Forward Markets', *Journal of Finance*, **57**, pp. 1347–82.
[2] Cartea, Á. and Villaplana, P. (2008), 'Spot Modeling and the Valuation of Electricity Forward Contracts: The Role of Demand and Capacity', *Journal of Banking and Finance*, **32**:12, pp. 2502–19.
[3] Norwegian Competition Authority (2007), 'Capacity for Competition', September 13th, p. 67.
[4] Department for Business Enterprise and Regulatory Reform (2008), 'Digest of UK Energy Statistics', July 31st, Table 5.7.
[5] London Economics (2007), 'Structure and Performance of Six European Wholesale Electricity Markets in 2003, 2004 and 2005: Executive Summary', report prepared for the European Commission, February 26th, p. 15; and Norwegian Competition Authority (2003), 'A Powerful Competition Policy', August 1st, p. 36.
[6] Hirshleifer, D. (1988), 'Residual Risk, Trading Costs, and Commodity Futures Risk Premia', *Review of Financial Studies*, **1**:2, pp. 173–93.
[7] Ibid., p. 182.
[8] Financial Services Authority (2006), 'Analysis of Activity in the Energy Markets 2006', p. 2; Nord Pool ASA (2006), 'Nord Pool: Financial Results 2005', press release no. 04/2006, March 10th; Nordel (2005), 'Annual Statistics 2005', p. 3; Department for Business Enterprise and Regulatory Reform (2008), op. cit., Table 5.2.
[9] Financial Services Authority (2005), 'Analysis of Activity in the Energy Markets 2005', pp. 1–2; Nord Pool ASA (2006), 'Annual Report 2005', p. 9.