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Hedging strategies in energy markets: The case of electricity retailers

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ABSTRACT

As market intermediaries, electricity retailers buy electricity from the wholesale market or self-generate for re(sale) on the retail market. Electricity retailers are uncertain about how much electricity their residential customers will use at any time of the day until they actually turn switches on. While demand uncertainty is a common feature of all commodity markets, retailers generally rely on storage to manage demand uncertainty. On electricity markets, retailers are exposed to joint quantity and price risk on an hourly basis given the physical singularity of electricity as a commodity. In the literature on electricity markets, few articles deal on intra-day hedging portfolios to manage joint price and quantity risk whereas electricity markets are hourly markets. The contributions of the article are twofold. First, we define through a VaR and CVaR model optimal portfolios for specific hours (3 am, 6 am,. . . ,12 pm) based on electricity market data from 2001 to 2011 for the French market. We prove that the optimal hedging strategy differs depending on the cluster hour. Secondly, we demonstrate the significantly superior efficiency of intra-day hedging portfolios over daily (therefore weekly and yearly) portfolios. Over a decade (2001–2011), our results clearly show that the losses of an optimal daily portfolio are at least nine times higher than the losses of optimal intra-day portfolios.

1. Introduction and literature review

In competitive wholesale and retail electricity markets, electricity retailers buy electricity from producers through long-term contracts, on the day-ahead/spot market, or self-generate, for (re)sale on the retail market. On the residential segment, retailers have to serve fluctuating load at usually fixed predetermined prices (Boroumand and Zachmann, 2012; Bushnell et al., 2008). As market intermediaries, retailers have the contractual obligation to harmonize their upstream (sourcing) and downstream (sales) portfolios of electricity (Boroumand, 2015). Demand uncertainty is a common feature of all commodity markets and is traditionally managed through inventories. For all commodity retailers, inventories enable intertemporal arbitrages and facilitate matching between sourcing and selling portfolios in accordance with supply/demand variability. However, in electricity markets, retailers are uncertain about how much electricity their customers will consume at any hour of the day until they actually turn switches on. In standard electricity retail contracts, retailers operate under an obligation to serve and cannot curtail delivery (except in the case of the so-called 'interruptible contracts'). On the supply side, the economic non-storability of (large) electricity volumes contributes to make electricity markets very specific. Consequently, electricity needs to be generated and consumed simultaneously. This non-storability contributes to the exceptionally high volatility of electricity wholesale prices in most spot markets around the world (Geman, 2008). The crucial dimension of price formation in electricity markets is the instantaneous nature of the product (Bunn, 2004) leading to structural price jumps (Goutte et al., 2013, 2014). Regardless of how retailers hedge their expected load, they will inevitably be short or long given demand stochasticity. Any corresponding adjustment on the spot market will be made at volatile hourly prices whereas retail prices are generally fixed for a significantly longer period given consumers' risk aversion (generally 1 year minimum with tacit conduction). This asymmetry of price patterns combined to demand variability can generate very high losses for retailers which are not efficiently hedged (Boroumand, 2009). Indeed, retailers cannot pass through increases of

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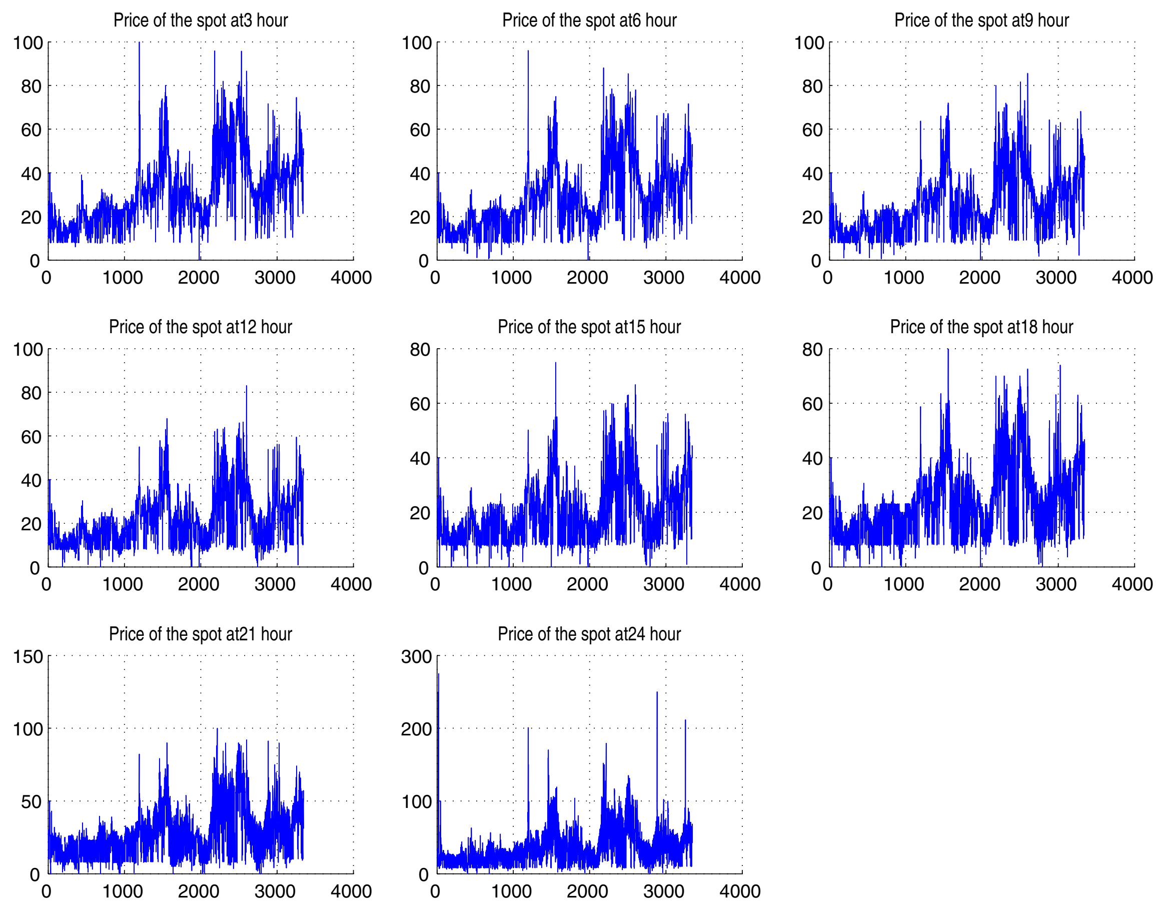

Fig. 1. Spot electricity price for each cluster hour from 27 Nov 2001 to 8 March 2011.

wholesale prices to their customers either because of potential losses of market shares on a longer run or because electricity prices are frozen (like in most US states). Given the strong positive correlation and multiplicative interaction between load level and spot price (Stoft, 2002), any under- or over-contracted position will be settled at the most unfavorable times. Most likely, when retailers are short (consumption exceeds demand forecasts), spot prices are high and above retail prices. Reversely, when retailers are long, spot prices will most likely be lower than their average sourcing cost. To sum up, the hourly variability of demand, its inelasticity, and the rigidity of supply (non-storability and plant outages) expose retailers' net profits to hourly volumetric and price risks, both correlated with weather conditions (Stoft, 2002). Price and quantity risks can bess very severe given that supply and demand conditions usually shift adversely (Stoft, 2002). Suppliers' profits depend on electricity demand, spot price, and retail price. Since retail prices are usually fixed for residential customers (Henney, 2006), profit is strongly impacted by hourly spot price variations. Consequently, retailers are unable to hedge their electricity sales by only trading in forward and spot markets on a monthly, weekly, or daily basis. They need to engage in risk management strategies on an hourly basis to mitigate the exposure of their profits or their opportunity cost (if they self-generate) exposed to joint price and volumetric risk. As a consequence of electricity liberalization, a wide variety of hedging instruments have emerged to enable economic agents to manage their risks (Geman, 2008; Hull, 2005; Hunt, 2002; Hunt and Shuttleworth, 1997). Since quantity risk is non-tradable (i.e. cannot be transferred by a retailer to another economic agent), hedging consists in price-based financial instruments (Brown and Toft, 2002). In electricity markets, efficient hedging should be against variations in total costs (quantity times price), which is complex with hourly demand variability. A retailer profit facing a multiplicative risk of price and quantity is nonlinear in price. Therefore, hedging with linear payoff instruments (forward and futures contracts) is not efficient (Boroumand and Zachmann, 2012). Conventional hedging strategies deal with one source of uncertainty. Methodologies to hedge price risk have been studied by the literature. However, hedging joint price and quantity risk for electricity retailers remains an outstanding issue. The literature on risk management within electricity markets adopts usually the perspective of electricity producers (Conejo et al, 2008; Paravan et al., 2004; Pineda and Conejo, 2012; Roques et al, 2006). Chao et al. (2008) deals with the vertical allocation of risk bearing within the electricity value chain. On retailers' perspective, Boroumand and Zachmann (2012) compare the risk profiles of different financial and physical hedging portfolios according to the Value at Risk (95%). By defining optimal annual hedging portfolios, they show the risk management benefits of relying on financial options and physical assets with different marginal costs (base, semi-base, and peak plants). Chemla et al (2011) show the superior efficiency of vertical integration over forward hedging when retailers are highly risk averse. Xu et al. (2006) present a midterm power portfolio optimization and the corresponding methodology to manage risks. Oum et al (2006) and Oum and Oren (2010) obtain the optimal hedging strategy with electricity derivatives by maximizing the expected utility of the hedged profit (Oum et al, 2006) and the expected profit subject to a VaR constraint (Oum and Oren, 2010). The authors explore optimal procurement time of the hedging portfolio. VehvilŠinen and Keppo (2003) study the optimal hedging of price risk using a mix of electricity derivatives. Carrion et al (2007) develop a risk-constrained stochastic programming framework to decide which forward contracts the retailer should sign and at which price it must sell electricity in order to maximize its expected profit for a given risk exposure. Carrion et al (2009) propose a bilevel programming approach to solve the medium-term decision-making problem of an electricity retailer.