DAY-AHEAD POWER PRICES INFLUENCED BY INTERMITTENCY: EFFECT ON THE FORWARD RISK PREMIUM.

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Overview

The increase of **i**ntermittent resource capacity in power generation has two main effects on the power prices. In one way the low variable costs of renewable energy generation and supporting incentives such as fixed feed-in tariffs and premiums resulted in lower wholesale market clearing prices (Gelabert et. al [2011]; Sáenz de Miera et. al [2008]; Forrest and MacGill [2013]. However next to this price suppressing effect the high volatility of wind power generation or other intermittent power sources resulted in more volatile day-ahead prices (Jacobsen and Zvingilaite [2010]). Forward contracts are being used to hedge for price risk. The lower day-ahead power prices and increased volatility makes it relevant to analyze the effect of these on the behavior of risk premiums embedded in electricity forward prices. Bessembinder and Lemmon (2002) demonstrate that the forward premium is positively related to the skewness of the spot price and negatively to the variance. The risk of price spikes and volatility in the prices can have important effects on the size and the sign of the forward premium. In this paper, we question to what extent a change in the day-ahead prices with respect to an increase of intermittent resources has an effect on the risk premia in forward power prices. To do so, we examine the day-ahead and the one-year and one-month to maturity forward power prices for the German market (EEX) from 2002 until 2014 with a Markov regime-switching model, the expectation and equilibrium models.

Methods

Let $s(t)$ be the natural logarithm of the imbalance price for delivery of 1 MW during hour H on day t. The spot price is assumed to be the sum of a deterministic component $d(t)$ and a stochastic component $x(t)$. $d(t)$ is a highly predictable component accounting for the seasonality effects and $x(t)$ is the random component reflecting unpredictable movements of the prices (Hamilton, 1994). The construction of the model is based on Mount et. al. (2006) and Huisman (2008).

$$s(t) = d(t) + x(t) \qquad (1)$$

The deterministic component consists of a mean price level μ_1 and allows for a different price for the hour during weekend delivery reflected by β. The parameter β is expected to be negative as weekend days normally exhibit lower prices than working days. $w(t)$ is the weekend dummy variable, which incorporates seasonality in the estimation process and is 1 if t is a weekend day and 0 if it is any other day.

$$dt = \mu_1 + \beta w_t \qquad (2)$$

The stochastic component in the normal regime consists of a mean reversion component with speed of mean reversion α and a normally distributed error term $\epsilon_{1,t.}$ with standard deviation σ_1.

$$xt = (1 - \alpha)x_{t-1} + \sigma_1 \epsilon_{1,t.} \qquad (3)$$

The stochastic component in the abnormal regime consists of a mean price μ_2, which is the increase in the price level in the abnormal regime. $\epsilon_{2,t}$ is a normally distributed error term with standard deviation σ_2.

$$xt = \mu_2 + \sigma_2 \epsilon_{2,t.} \qquad (4)$$

The transition probability is determined by a random variable that follows a Markov chain with different possible states. The transition probability for switching from one regime to the other regime as logistic functions ensures that predicted probabilities are between 0 and 1. The element Pi,t denotes the conditional probability that the process is in regime i at time t given that the process was in regime i at time $t-1$: $Pi,t = Pr\ St{=}i|St{-}1 = i$. The transition probability 1-Pi,t equals the probability from being in regime i at time $t-1$ and moving to the other regime in the next day. The transition probabilities are assumed to be constant over time:

$$Pi,t = \lambda i. \quad (5)$$

With the Markov regime switching model we try to distinguish whether the volatility and mean price level for the German day-ahead prices has changed over the different years.

To observe the risk premium in the electricity forward prices we will follow Fama and French (1987), which model the behavior of commodity futures prices. F (t,T) is the futures price per MWh at time t for the delivery of 1 MW of electricity in each hour of the delivery period T. s(t) is the day-ahead price per MWh quoted on day t for delivery of 1MW of electricity in each hour of the day t+1. The future expected spot price E_t [S(T)] is the day-ahead price on a future date T, subject to information sets available to market participants at time t.

$$F(t,T) - S(t) = E_t[S(T) - S(t)] + F(t,T) - E_t[S(T)]. \quad (6)$$

Eq. (6) shows that the forward basis $F(t,T) - S(t)$ at time t can be decomposed in the expected change in the spot price between t and T, $E_t[S(T) - S(t)]$, and the realized risk premium, $F(t,T) - E_t[S(T$). The following equation considers the regression of the premium on the basis:

$$F(t,T) - S(T) = \alpha 1 + \beta_2[F(t,T) - S(t)] + \sigma 1 \in_t \quad (7)$$

The risk premium is according to the equilibrium model positively related to the skewness of the wholesale price and negatively related to the variance of the wholesale price.

$$F(t,T) - S(T) = \alpha_3 + \beta_3 [Skew\ S(T)] + \beta_4 [Var\ S(T)]\ v_t \quad (8)$$

Conclusion

The increase of intermittent resource capacity in power generation has two main effects on the power prices. In one way the low variable costs of renewable energy generation and supporting incentives such as fixed feed-in tariffs and premiums resulted in lower wholesale market clearing prices. However next to this price suppressing effect the high volatility of wind power generation or other intermittent power sources resulted in more volatile day-ahead prices. Forward contracts are being used to hedge for price risk. The lower day-ahead power prices and increased volatility makes it relevant to analyze the effect of these on the behavior of risk premiums embedded in electricity forward prices. In this paper, we question to what extent a change in the day-ahead prices with respect to an increase of intermittent resources has an effect on the risk premia in forward power prices. To do so, we examine the day-ahead and the one-year to maturity forward power prices for the German market (EEX) from 2000 until 2014 with a Markov regime-switching model, the expectations model of Fama and French (1987) and the equilibrium model of Bessembinder and Lemmon (2002). We show that over the years the day-ahead price behavior has changed from more volatile positive price movement to more volatile negative price movements. The risk premium has reacted to this through becoming less volatile after 2008 in the short run and negative in the long run. German futures prices do contain information about expected changes in spot prices, but only shows evidence of risk premia in a time-varying manner. The percentage of risk premium embedded in the futures prices is not constant. With a higher level of electricity produced by wind and solar generation, which are 'imperfectly storable fuels' compared to 'perfectly storable' thermal fuels, such as gas and coal the futures prices should indeed contain more information about expected changes in spot prices than risk premia. However this is evident for the short term (M1), but not for the long-term contract (Y1). The risk premia-increasing effects of spot price volatility and skewness are clearly visible in the short term.

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