Germany´s Energy Transition and European Electricity Market Integration

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(1) Overview

The German *Energiekonzept* (Energy Concept) was proposed in 2010 with the goal of making the country one of the world's most energy efficient and environmentally friendly economies (Bundesregierung, 2011). One year later, as a reaction to the multiple reactor meltdowns in Fukushima, this strategy was reinforced with a broad consensus within the German government to implement its *Atomaustiegsgestz* (Nuclear Phase-Out Act), by closing immediately eight nuclear power plants and then the remaining nine until 2022 (Bundesregierung, 2011).[1] Subsequently, the Renewable Energy Source Act 2012 (RESA, 2012) aims to increase electricity generated from renewable sources to at least 35% by 2020 and to at least 80% by the year 2050. In this context this paper examines long run and short run associations between European electricity markets. We examine the potential impact of wind generated electricity produced in Germany on other European electricity markets, by employing MGARCH (multivariate generalized autoregressive conditional heteroscedasticity) models with constant and time-varying correlations for daily data as well as a semiparametric time varying fractional cointegration analysis. The short run interrelationship of electricity spot prices of APX-ENDEX (UK and Netherlands), Belpex (Belgium), EPEX (Germany and Switzerland), OMEL (Spain and Portugal), Nord Pool (Finland, Denmark and Norway), Ipex (Italy), OTE (Czech) and Powernext (France) with wind penetration induced by the German system is studied from November 2009 to October 2012, thus covering the period before and after the closures of eight nuclear power plants. The long run associations are studied from 2006 to 2009 with mean average week daily data of the same markets.

(2) Methods

Dynamic Conditional Correlation

Tse and Tsui (2002) and Engle (2002) proposed *dynami*c conditional correlation models (DCC), by including a time dependent conditional correlation matrix (Γ_t) and thus the conditional covariance matrix is:

$$H_t = D_t \Gamma_t D_t \quad (1)$$

$$D_t = diag(h_{11t}^{\frac{1}{2}} \dots h_{KKt}^{\frac{1}{2}}), \quad (2)$$

$$\Gamma = \rho_{ij} \quad (3)$$

h_{iit} is the conditional variance of a univariate GARCH model and Γ is the symmetric positive definite constant conditional correlation matrix, with $\rho_{ii} = 1 , \forall i$.

Fractional cointegration

Fractional cointegration analysis is the natural extension of standard cointegration analysis but allows for a wider range of mean reversion behaviour than conventional cointegration analysis (Cheung and Lai, 1993). Two time series x_t and y_t, integrated of order d, are said to be fractionally cointegrated of order (d, b) if the error correction term represented by the linear combination $z_t = y_t - \beta * x_t$ is fractionally integrated of order $d - b$, where $0 < b \leq d$ (Banerjee and Urga, 2005).This paper extends the rolling cointegration procedures based on Hansen and Johansen (1999) and Rangvid and Sørensen (2000) for standard cointegration analysis to the fractional framework. In the rolling tests, the sample size is kept the same, but the sample period is allowed to change (Rangvid and Sørensen, 2000). We utilize the semiparametric two step Feasible Exact Local Whittle (EWFL) estimator by Shimotsu (2006) which extends the exact local Whittle (ELW) estimator by Shimotsu and Phillips (2005).

[1] In 2010, Germany consumed almost 530TWh of electricity, of which more than 26% (140TWh) were generated by nuclear power plants (country factsheet 2012). The shutdown of 8 nuclear power plants reduced the available nuclear capacity to ¼ (BDEW, 2011).

(3) Results

The results of the time varying fractional cointegration analysis suggest that electricity spot prices are long memory stationary processes and that there is fractional cointegration between a few markets which changes over time.

The MGARCH models indicate positive cross-market and lagged spillovers, as well as significant reduction in electricity spot prices with increasing wind penetration. Positive time-varying correlations between spot market volatilities are found for markets with substantial shared interconnector capacity. Wind penetration volatility is negatively associated with electricity spot price fluctuations.

Both analyses provide evidence of altered long and short run associations of European electricity markets before and after the incidents in Fukushima.

(4) Conclusions

In conclusion, the results of the study highlight the challenges associated with Energy Transitions and its effect on price convergence. The findings call for a consensus approach to the efficient management of complementarities of national energy mixes, thereby facilitating the transition towards a low carbon economic system.

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