[*PAPER/POSTER TITLE*]

The Nordic/Baltic Spot Electric Power System Price: Univariate Nonlinear Impulse-Response Analysis

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Overview

This paper revisits the conditional mean and volatility density characteristics of the System Price settled by the Nordic/Baltic Spot electric power market (1993-2017). The main purpose of this paper is an analysis of the nonlinear impulse-response features (shocks) in the non-storable commodity market. Initially, we extract all deterministic seasonality and non-stationary trend and scale features from the series. A strictly stationary model reports serial correlation for the mean and clustering, asymmetry and level effects for the volatility. For the mean, the impulse-response analysis reports linear and symmetric mean reversion for any price movements. For the volatility, small price movements report symmetric and decreasing volatility. In contrast, for larger absolute price movements, the volatility show a non-linear increase as well as fast-growing negative asymmetries. The impulse persistence is therefore relatively short. For the entrance of renewables in the energy market, the sub-period 2008-2017 reports major systematic changes for the mean, the volatility, the asymmetry and the persistence. In fact, the renewables era has made changes to all the fundamental features of the Nordic/Baltic electricity market.

Methods

The methodology is the semi-nonparametric time series analysis (SNP) introduced by Gallant & Tauchen (1987, 1992, 2014). The method employs an expansion in hermite functions to approximate the conditional density of the time series processes. The leading term of the model expansion process is therefore an established parametric model already known to give a reasonable approximation to the process; higher order terms (hermite functions) capture departures from the model (Robinson, 1983). The SNP model is fitted using conventional maximum likelihood together with a model selection strategy (BIC (Schwarz, 1978)) that determines the appropriate order of expansion. The model is well designed for the computation of nonlinear functionals of the densities .

Results

For comparison between the periods 1993-2017 and 2008-2017, Figure 19 Plot A shows mean differences and Figure 19 Plot B shows volatility differences. For the mean in Plot A the general picture is that negative impulses have produced positive returns while the positive impulses has produced negative returns. The correction/overreaction result for the sub-period 2008-2017 is therefore manifested. For the volatility in Plot B the general picture is lower volatility for small price impulses while large price impulses have produced higher volatility. Moreover, the asymmetry for large price changes has increased. Figure 19 Plot B shows that the volatility differences are much higher for negative than for positive price impulses. In fact, for all price impulses, the negative asymmetry is much larger for the sub-period 2008-2017 than for 1993-2017. The negative asymmetry for price impulses of -20% and 20% and zero and on steps-ahead are 171 and 564 larger for the period 2008-2017, respectively. The same negative asymmetry numbers for price impulses -60% and 60% are 214 and 866 larger, respectively.

Conclusions

We have modelled and estimated an ARMA-GARCH-in-Mean model specification for the conditional mean and variance for the so-called system price in the Nordic electric power market for the period 1994 to 2016 (12). The time series are adjusted for systematic seasonal, trend and scale effects and all the estimated conditional specifications are BIC preferred. Our model captures the serial correlation structure in the return series, the effect of "thick distribution tails" (leptokurtosis) and residual risk in the conditional mean. The conditional variance equation captures shock, persistence, and asymmetry and the two-equation specification control for conditional heteroscedasticity. The battery of statistical model specification tests cannot reject the BIC-optimal SNP specification. We summarise our results below.

The drift is close to zero. We find serial correlation structures up to 14 days after an adjustment procedure that accounts for seasonal, trend and scale effects. Moreover, mean reversion in clearly visible in the time series. The volatility equation rejects conditional homoscedasticity. The empirical impulse-response analysis confirms immediate dissipation (one day) suggesting linearity in the conditional mean equation. The impulse-response analysis reveals quite different conditional volatility responses from small to large impulses. For small price movements (impulses), the volatility show modest increases relative to the period 1993-2017 (small responses). In contrast, for large price movements the volatility show quite large responses.

As the impulse-response analysis is very well suited for assessing the empirical importance of asymmetry, our results show low negative asymmetry for small absolute price movements. However, the asymmetry becomes severe as price movements grows large. The persistence of shock for the period 1993-2017 is about 22.5 trading days with a standard deviation of 8 days. For the sub-period 2008 to 2016, the density mass around small negative and zero price movements for the conditional mean has increased relative to the 1993-2017 period. The impulse response functions for the mean suggests a change from positive for the period 1993-2017 to negative serial correlation for the period 2008-2017 (overreaction/correction). From price impulses for the period 2008-2017, the non-linear volatility report both higher responses and stronger negative asymmetry. The persistence of shock for the period 2008-2017 has fallen considerably and is about 12.9 trading days with a stand deviation of 3 days.

For future research, the extension is multi-variate impulse-response analysis of contemporaneous spot prices and wind, consumption, production and perturbation forecasts. For example, as a starting point, a bivariate analysis of wind forecast and spot price movements may clarify strategic bidding behaviour from existing and flexible power producers (mainly hydro) in the Nordic/Baltic electricity market

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