Time recurrence structures of electricity markets: the case of United Kingdom

A. Facchini, Enel Foundation, Rome, Italy, +39 333 7841703

A. Rubino, University of Bari, Faculty of Economics, Italy, +39 338 3982240

Overview

In the recent history of UK electricity market, there have been several occasion of major transition, one of the most prominent was represented by the change of Gate Closure interval, that was moved from 3.5 to 1 hour before real time in July, 2 2002. We demonstrate that this change has determined a permanent shift in price dynamics, providing more certainty on market fundamentals.

We use the Recurrence Plots and Recurrence Quantification Analysis [3] to investigate the dynamics of electricity spot markets in the United Kingdom from 2001 to 2008. We make the assumption that the evolution of the spot price is governed by an unknown complex dynamical system, that depend crucially on the information available on market conditions and system fundamentals, and our aim is to characterize its evolution in order to evaluate how significant modification in the regulatory design were able to determine the amount of information available to market operators, and therefore spot price trends and dynamics.

Methods

The Recurrence Plot (RP) and the Recurrence Quantification Analysy (RQA) are nonlinear methods originally designed to investigate temporal recurring patterns and nonstationarities in time series[1,3]. As recurrence is one of the most important features of nonlinear systems [2] RPs and RQA allow for a reliable characterization of time series that are short, corrupted by noise and nonstationary, providing to the experimentalist important insight on the underlying dynamics of the time series. Together with the nonlinear methods, we have computed and compared the volatility of the time series for time intervals ranging from 10 to 90 days

Results

Both volatility and the recurrence quantification measure Determinism [3] show that the three different regions can be clearly identified: in the beginning of the observation period, from the April 2001 to March 2002, the recordings are characterized by highly irregular dynamics (low values of Determinism) and high stochasticity (high values of volatility), while from January 2004 to July 2008, the dynamics becomes significantly more regular and the stochasticity is consistently reduced (high determinism values and low volatility values). These two regions are separated by a transition region, from January 2002 to January 2004, showing continuosly decreasing and incresing values for volatility and determinism, respectively. The literature on nonlinear systems dynamics and recurrence plots suggests that a structural transition occurred to the unknown system governing the price [6,7].

Conclusion

Our empirical results confirm that the change of the regulatory framework has directly impacted the structure of the market, deeply influencing the dynamics of the spot price, both under the dynamical and under the statistical point of view. This fact is demonstrated by the change of both DET and volatility. An higher determinism suggests that the spot prices become more regular, following with greater precision the national baseload curve, while lower values of volatility suggest that a reduction of the gate closure to 60 minutes ahead of real time also decreases the uncertainty around market fundamentals, resulting in a reduced oscillation of the prices. Market operators after July 2002 were able to operate closer to real time, thus with a better understanding upon existing market conditions. In electricity markets, information does not flow at the same time of trading[1]. Traders buy and sell electricity at different hours of the day mainly to fulfil their industrial, commercial or consumption needs. But the sequence of forward markets crucially depend on the accuracy by which balancing markets operates in real time.

[1] J.P. Eckmann, S.O. Kamphorst, and D. Ruelle. Recurrence plot of dynamical systems, *Europhysics Letters*, 5, 973-977, 1987.

[1] With the exception of balancing markets.

[2] J.H. Poincaré. Sur la probleme des trois corpes et les équation de la dynamique, *Acta Mathematica*, 13, 1-271, 1890.

[3] N. Marwan, M.C. Romano, M. Thiel, and J. Kurths. Recurrence plots for the analysis of complex systems, *Physics Report*, 428, 237-329, 2007.

[4] A. Giuliani, L.L. Trulla, J.P. Zbilut, C.L. Webber. Recurrence quantification analysis of the logistic equation wit transients Physics Letters A, vol 8, 223:255, 1996

[5] C.L. Webber and J.P. Zbilut. Dynamical asessment of physiological systems and states using recurrence plot strategies, *Journal of Applied Physiology*, 76, 965-973, 1994.

[6] A. Facchini, F. Rossi, and C. Mocenni. Spatial recurrence strategies reveal different routes to Turing pattern formation in chemical systems, *Physics Letters A*, 373, 4266-4272, 2009.

[7] Strozzi F, Gutierrez Tenreiro E, Noe C, Rossi T, Serati M, Zaldivar Comenges J *Measuring Volatility in the Nordic Spot Electricity Market Using Recurrence Quantifcation Analysis*, EUROPEAN PHYSICAL JOURNAL-SPECIAL TOPICS 164; 2008. p. 105-115.

[8] Bassembinder, H., Lemmon, M.L., *Equilibrium Pricing and Optimal Hedging in Electricity Forward Markets*, the journal of Finance, Vol. 57, pp 1347-82.