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Measuring anti-correlations in the nordic electricity spot market by wavelets

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Abstract

We consider the Nordic electricity spot market from mid-1992 to the end of year 2000. This market is found to be well approximated by an anti-persistent self-affine (mean-reverting) walk. It is characterized by a Hurst exponent of $H \simeq 0.41$ over three orders of magnitude in time ranging from days to years. We argue that in order to see such a good scaling behavior, and to locate cross-overs, it is crucial that an analyzing technique is used that *decouples* scales. This is in our case achieved by utilizing a (multi-scale) wavelet approach. The shortcomings of methods that do not decouple scales are illustrated by applying, to the same data set, the classic R/S- and Fourier techniques, for which scaling regimes and/or positions of cross-overs are hard to define.

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1. Introduction

Over the last ten years, or so, dramatic changes have occurred, and are still on-going, in the energy sectors of the world. What used to be well-established monopolies in many countries and regions, were deregulated in such a way that consumers could buy their electricity from other sources then their local provider. These changes opened up for competition on the price of electric energy. Energy exchanges were created, as a result, as places where such organized transactions could take place.

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One of the first electricity markets in the world to be deregulated was the Norwegian, that was fully deregulated by 1992. The same year a Norwegian commodity exchange for electric power was established. Here one could trade short and long term electricity contracts in addition to contracts for next-day (24 h) or immediate physical delivery. This market place, which now also includes the other Nordic countries, is today known as NordPool—the Nordic Power Exchange [1].

The next-day electricity market, i.e., where contracts for 24 h delivery are traded, is known as the *spot market*. This market, administrated by NordPool, is open 24 h a day 7 days a week all year around, and the (spot) price is fixed for each hour separately. In this market, participants (i.e., the buyers and sellers) tell the market administrator (NordPool) how much, and to what price and at what time they want to sell or buy a given amount of electric power. From these bid and ask data the administrator creates a *market cross* which sets the spot price for that particular hour. The market cross is obtained by forming the cumulative volume histograms, $V_s(p)$ and $V_b(p)$, that give respectively the total amount of electric energy that sellers (buyers) want to sell (buy) at a price higher (lower) then p. The spot price, S, is then defined as the price at which $V_s(S) = V_b(S)$ (if such a point exists). Thus, the spot price is set such that the total volume of sold and bought electric power is balanced. All sellers asking a price $p \leqslant S$, as well as all buyers willing to pay $p \geqslant S$ will get a transaction *at the* spot price for that particular hour. In all other cases no transactions will take place. If no market cross can be defined from the bid and ask data, no transactions will take place and the spot price for that particular hour remains unset.

Recently, it has been suggested that the electricity spot price process is a so-called mean-reverting process [2,3]. Here, the degree of mean-reversion was quantified for the Californian spot power market by measuring its Hurst or roughness exponent by the R/S-analysis [4,5]. However, in order to perform this analysis, Weron and Przybyłowicz [2] had to consider the daily average returns instead of the hourly returns. This is due to a shortcoming of the R/S-method when analysing multi-scale time series as we will see explicitly in the discuss below.

In this paper, however, we suggest to use another technique—a wavelet based analyzing technique that does not suffer from this shortcoming. The method is demonstrate on data from NordPool—the oldest multi-national power exchange in the world. It is found that the Nordic electricity power market is anti-persistent (mean-reverting), and the (Hurst) exponent characterizing the market is found to be $H = 0.41 \pm 0.02$ for time scales ranging from days to years, where the error indicated is the regression error.

2. The data set

The data we analyzed are the official NordPool spot price data (system price) [1] collected over the period from May 4, 1992 to December 31, 2000. They cover more then eight and a half years of hourly logged data, which corresponds to somewhat more then 75 000 data points for the whole data set.

The analyzed data set is depicted in Fig. 1. From this figure one easily observes the daily and seasonal trends that are characteristic of the spot price. Such trends are