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Some statistical investigations on the nature and dynamics of electricity prices

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Abstract

This work analyzes the log-returns of daily electricity prices from the NordPool day-ahead market. We study both the unconditional growth rates distribution and the distribution of residual shocks obtained with a non-parametric filtering procedure based on the Cholesky factor algorithm. We show that, even if the Subbotin family of distributions is able to describe the empirical observations in both cases, the Subbotin fit obtained for the unconditional growth rates and for the residual shocks reveal significant differences. Indeed, the sequence of log-returns can be described as the outcome of an aggregation of Laplace-distributed shocks with time-dependent volatility. We find that the standard deviation of shocks scales as a power law of the initial price level, with scaling exponent around -1. Moreover, the analysis of the empirical density of shocks, conditional on the price level, shows a strong relationship of the Subbotin fit with the latter. We conclude that the unconditional growth rates distribution is the superposition of shocks distributions characterized by decreasing volatility and fat-tailedness with respect to the price level.
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1. Introduction

As an outcome of the liberalization policies pursued in several countries since the 1980s, the so-called day-ahead electricity market provides us with a very challenging phenomenon. Electricity cannot be economically stored, which implies that withdrawals from and injections into the transmission network must be continuously balanced. Rather complex market systems have been set up, with the aim of reaching a reasonable trade-off between economic efficiency and system reliability. These systems are built around the so-called day-ahead market, a wholesale market wherein each day 24 simultaneous auctions determine prices and quantities for each of the 24 hours of the subsequent day. For a more detailed description of the day-ahead market design, see Ref. [1].

In this paper, we investigate the distributional properties of electricity price dynamics. More in detail, we characterize the probability density functions of daily electricity log-returns, and of the underlying shocks from the NordPool market (see Sections 4 and 5, respectively), through a very flexible and general family of distributions, namely the Subbotin family. In doing so, we follow the lead of previous works which established fat tails as a robust stylized fact in the field (see Section 3). Our study contributes some novel features and results. First, we find that volatility scales as a power law of the price level, with scaling exponent around -1. Second, prices can be seen as outcomes of the time aggregation of Laplacian shocks, whose volatility is time dependent. Finally, we uncover some heterogeneity in the distributional shapes of the shocks. Conditional on prices below some threshold, shocks are approximately Laplacian, and closer to Gaussian above that.

2. Data and variables

In this study, we focus on the NordPool, the market covering Norway, Sweden, Finland and Denmark, for the 1997–1999 period (1095 price observations per hour),

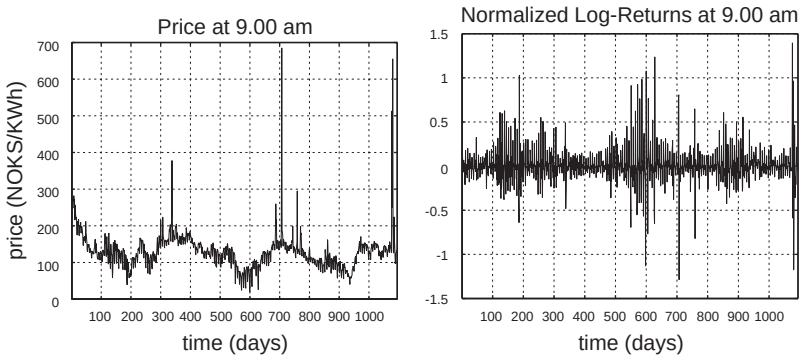

Fig. 1. Time series of price P (left panel) in NOKs/KW h, and of log-returns r (right panel) at 9 a.m., for the sample period January 1997–December 1999.

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