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Regime jumps in electricity prices

Ronald Huisman*, Ronald Mahieu

Erasmus University Rotterdam, Room F4-18, P.O. Box 1738, Rotterdam 3000 DR, The Netherlands

Abstract

Many countries are liberalizing their energy markets. Participants in these markets are exposed to market risk due to the characteristics of electricity price dynamics. Electricity prices are known to be mean-reverting very volatile and subject to frequent spikes. Models that describe the dynamics of electricity prices should incorporate these characteristics. In order to capture the price spikes, many researchers have introduced stochastic jump processes, but we argue and show that this specification might lead to potential problems with specifying the true amount of mean-reversion within the process. In this paper, we propose a regime-switching model that models price spikes separated from normal mean-reverting prices.

JEL classifications: N70; C51

Keywords: Energy markets; Electricity price modelling; Regime switching models; Spikes

1. Introduction

Participants in electricity markets face enormous market risks due to the highly volatile electricity markets. Daily volatilities of 29% are common; for comparison international stock indices have volatilities close to 20%, but on a yearly basis. For risk management, portfolio management and option pricing issues it is crucial to have a good insight in the dynamics of electricity prices. Researchers have examined these dynamics and have indicated various stylised facts of electricity prices: high volatility, mean-reversion (prices tend to fluctuate around a long term equilibrium mean), seasonality (for example high summer prices in Arizona due to huge demand for power from air conditioning usage), and frequent extreme jumps in prices that

*Corresponding author. Tel.: +31-10-408-1450; fax: +31-10-408-9017.
E-mail addresses: r.huisman@fbk.eur.nl (R. Huisman), r.mahieu@fbk.eur.nl (R. Mahieu).

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die out rapidly (result of fluctuations in demand and low elasticity of supply, due to system breakdown and limited inventory capacities).[1]

In this paper, we also focus on modelling electricity prices and concentrate on estimating the extreme jumps. Jumps in electricity prices are characterized by their short existence; prices fall back to a normal level sometimes after even one day (for example in case of system breakdown). The motivation for our study comes from past studies that have applied a stochastic jump model in combination with mean-reversion to model the jumps. The mean-reversion component is used to force the price of electricity to fall back to a normal level after a shock or jump has occurred; mean-reversion is directly associated with the jump process. However, it might well be that mean-reversion exists only in the 'normal' price process; the normal mean reverting process is then not specified correctly in traditional jump models. We argue that a stochastic jump process with mean-reversion might lead to an erroneous specification of the true mean-reversion process.

In this paper, we show the existence of such a normal mean reverting process that is not directly associated with jumps. In the regime jump model, we assume that the electricity price is in one out of three different regimes at each point in time. We identify a normal regime that can contain a mean-reversion component. In addition, we identify two extra regimes: the first regime models a price jump and a second regime models the way the process falls back to the normal process. Markov transition matrices specify the probabilities that the electricity prices move from one regime to another from one time point to the next. The advantage of the regime-switching framework is that we can explicitly model the short-lived characteristics of power spike, which is not captured by stochastic jump models.

Our results indicate that the electricity prices process exhibits significant mean-reversion in its normal process and we show that the regime jump process performs better in modelling the jumps in combination with mean-reversion than a stochastic jump model. We therefore conclude that the regime jump model is a much richer specification of the electricity price dynamics than the other models used.

This paper is organized as follows. We explain the methodology in Section 2. In Section 3, we present summary statistics of the data we use. Section 4 shows empirical estimates from applying the model to electricity prices from several international markets. Section 5 concludes.

2. Electricity price modeling

Following Lucia and Schwartz (2002), we model the movement in the natural logarithm of the spot price for electricity as follows. Let $s(t)$ be the natural logarithm of the spot price at day t. We model the spot price as the sum of a deterministic component $f(\cdot)$ and a stochastic component $x(\cdot)$:

$$s(t)=f(t)+x(t), \quad \text{where } t=1,\ldots,T. \tag{1}$$

[1] See Pilipović (1998) and Clewlow and Strickland (2000) for results on stylised facts of electricity price dynamics.