Discussion of

A Pricing Measure to Explain the Risk Premium in Power Markets

by Fred Espen Benth and Salvador Ortiz-Latorre

Eva Lütkebohmert

University of Freiburg

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Outline

1 Summary

2 Questions
Special Features of Electricity Markets

- Electricity is an essential commodity
- Power is a (mostly) non-storable asset and has to be transported in a transmission network
- Delivery takes place over a time period (swap contract)
- Rather large price variations over short time periods observable in power markets (spikes)
### Power Markets

#### Special Features of Electricity Markets
- Electricity is an essential commodity
- Power is a (mostly) non-storable asset and has to be transported in a transmission network
- Delivery takes place over a time period (*swap contract*)
- Rather large price variations over short time periods observable in power markets (*spikes*)

#### Consequences
- Necessity for real-time balancing of supply and demand
- Electricity is a not directly tradeable asset
- Forward price of electricity cannot be derived by classical buy-and-hold hedging arguments
Supply and Demand Curve

Source: Risø DTU
NordPool Spot Prices


Modelling Electricity Spot Prices

Typically modelled as two-factor mean reversion dynamics with

\[
X(t) = X(0) + \int_0^t (\mu_X - \alpha_X X(s)) \, ds + \sigma_X W(t),
\]

and

\[
Y(t) = Y(0) + \int_0^t (\mu_Y - \alpha_Y Y(s)) \, ds + L(t),
\]

where

\[
L(t) = \int_0^t \int_0^\infty z N_L(ds, dz)
\]

is a Poisson random measure, which models the characteristic spikes observed in power markets.
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- one factor an OU process driven by Brownian motion

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\[ Y(t) = Y(0) + \int_0^t (\mu_Y - \alpha_Y Y(s))ds + L(t), \]

where \( L(t) = \int_0^t \int_0^\infty zN^L(ds, dz) \) with \( N^L(ds, dz) \) a Poisson random measure,

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Modelling Electricity Spot Prices

**Arithmetic Spot Price Model**
Models the spot price directly as two-factor dynamics

\[ S(t) = \Lambda_a(t) + X(t) + Y(t), \quad t \in [0, T^*] \]

**Geometric Spot Price Model**
Models logarithmic spot price as two-factor dynamics

\[ S(t) = \Lambda_g(t) \exp (X(t) + Y(t)), \quad t \in [0, T^*] \]

\[ \Lambda_a, \Lambda_g : \text{deterministic processes accounting for seasonality in spot prices} \]
Valuation of Forward Contracts

Forward Price

Forward price at time $t$ for delivery in $T$ with $0 < t < T < T^*$ is

$$\mathbb{E}_Q[S(T)|\mathcal{F}_t] = \mathbb{E}_P[S(T)|\mathcal{F}_t] + R^F_Q(t, T)$$

where $Q$ is pricing measure, $P$ is physical measure and $R^F_Q(t, T)$ denotes a risk premium.
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Risk Premium

- Producers are willing to pay a premium for hedging their production $\Rightarrow$ creates a negative risk premium
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Risk Premium

- Producers are willing to pay a premium for hedging their production $\Rightarrow$ creates a negative risk premium
- Consumers may want to hedge the price risk using forward contracts which are close to delivery $\Rightarrow$ creates positive risk premium
Contributions

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- Can slow down speed of mean reversion.
- Can generate a stochastically varying risk premiums with stochastic non constant sign.
Contributions Cont’d

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Approach allows for empirically observed facts like

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### Contributions Cont’d

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#### Consequences

- Two-factor stationary spot price model can be directly fitted to power data
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Consequences

- Two-factor stationary spot price model can be directly fitted to power data
- Measure change can be calibrated by turning off (or slowing down) the speed of mean reversion
Questions

Spot Price Model

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   - Can mean reversion really capture the rapid decline of electricity prices after a spike?
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2. Are the trajectories generated by the model (after calibration) similar to those observed in the markets?
   - Can mean reversion really capture the rapid decline of electricity prices after a spike?
   - Using a time-inhomogeneous Lévy processes instead would allow to control for jump intensity (compare Weron (2008))
Weather conditions can lead to a high production of wind and solar energy in Germany ⇒ Over-production of energy is sold to neighboring countries (in 2012 about 22.8 TWh) Prices of green energy are then often much lower than those of nuclear power ⇒ Distressed power industry of neighboring countries

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How good do model implied risk premia fit to ex-post premia observable in the market?

Can the model be used to identify the main economic factors which drive the risk premia in energy markets?
Thank you!