Forecasting electricity rates via EViews incorporating political decisions

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"Die Energie kann als Ursache für alle Veränderungen in der Welt angesehen werden", Werner Heisenberg, Physik und Philosophie

Main Concerns

Items to address:

- Modelling electricity rates: Key features of the electricity market

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- Electricity rates and EViews: Statistical Inference
- Stochastic supply and demand: Modelling electricity rates

First thoughts

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Limited capacities $\Rightarrow$ Access restricted

$\Rightarrow$ **Energy has a price**

Here: Focus on electricity rates

Can we model the price?

Energy Law in Germany: Two Landmarks

- till 1998: Energiewirtschaftsgesetz (1935): prevent competition due to "Demarkationsverträge"
  $\Longrightarrow$ locally monopolistic structure
  $\Longrightarrow$ Price determined by „individual proposal"
  Impossible to provide a "good model"
- from 1998: Gesetz zur Neuregelung des Energiewirtschaftsrechts: Liberalization of electricity market from 2005 onwards
  $\Longrightarrow$ Competition
  Existence of a market allows for modelling the electricity rates

Should we model the price?

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- Customer: Agree on prices in advance $\Longrightarrow$ No need for modelling the price?
- Energy Suppliers, Electricity Traders: Have to buy electricity on a regular basis

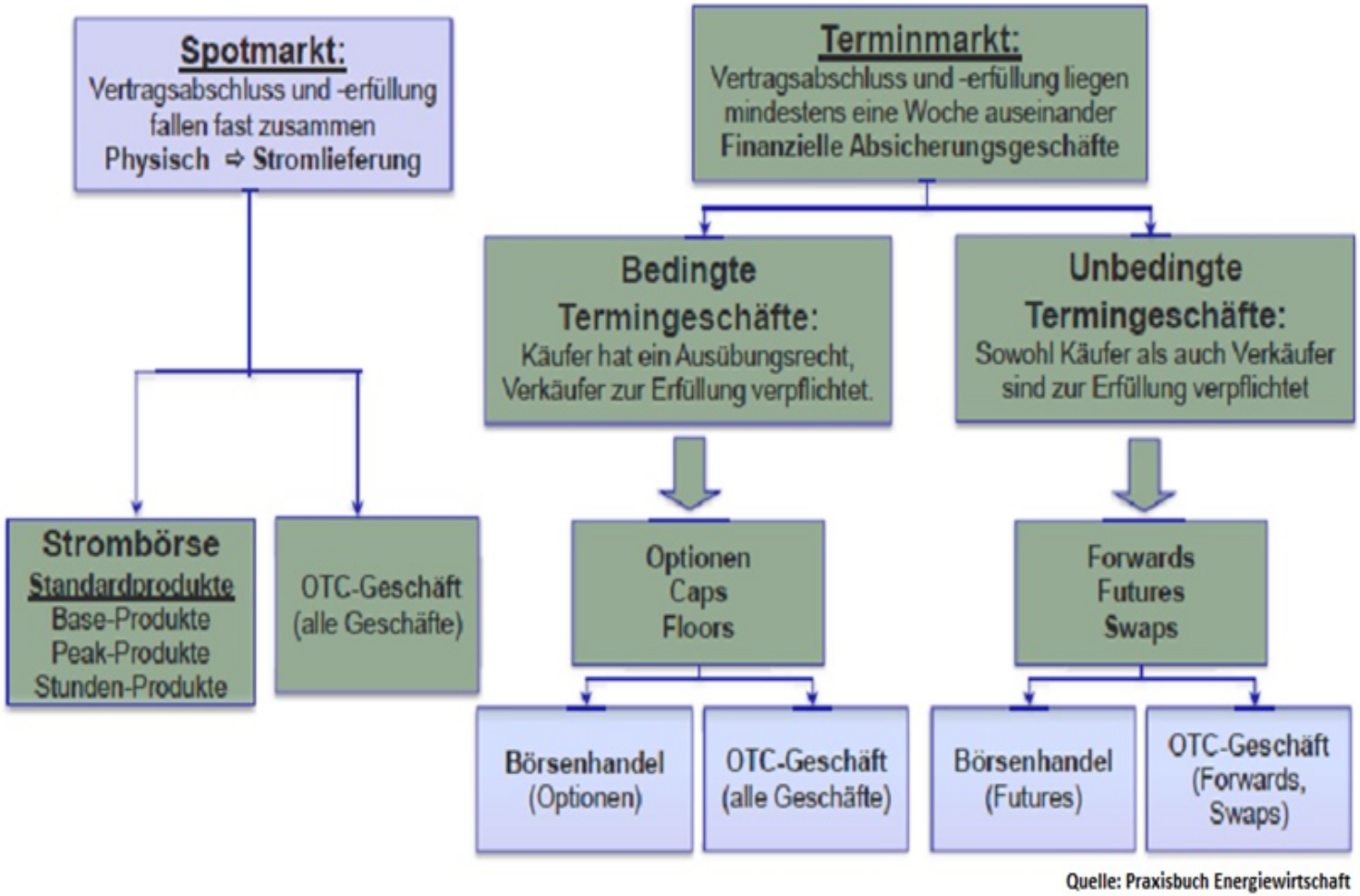
$\Longrightarrow$ We should model the price for electricity

Buy 'the' electricity for 'that' price

Where to buy electricity:

- EEX in Leipzig (Stock Exchange)
- OTC trading

"The" price: Net price (without tax load, grid charges etc.)

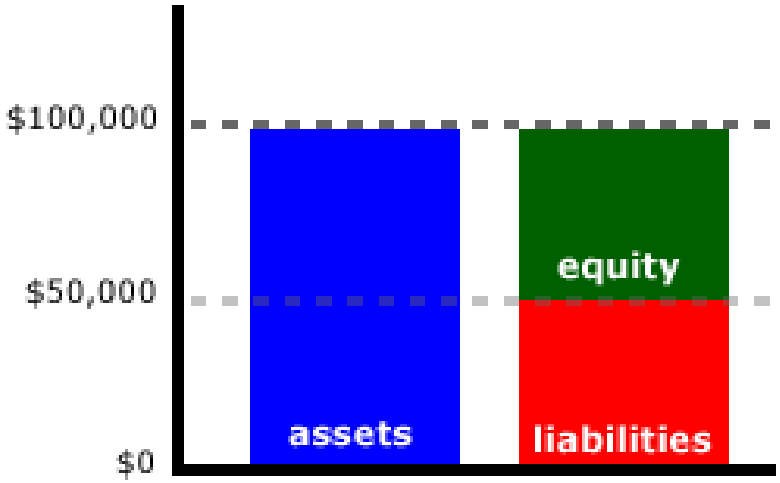


Quelle: Praxisbuch Energiewirtschaft

Economic Relevance I: Balance Sheet of an Energy Supplier

Legal requirements: Since 1998

- KonTraG (Gesetz zur Kontrolle und Transparenz im Unternehmensbereich):
  Companies are obliged to disclose their risk profile



Equity = the difference between total assets and total liabilities

Economic Relevance II

- Assets: Future Payments of Energy Consumer
- Liabilities: Suppliers have to buy electricity to meet their contract obligation - Two possibilities
  Spot market: Buy energy in future at spot market - non-hedged risk
  Derivative market: Ensure to be able to buy energy in the future for a certain price which does not depend on the market developments - hedged risk

Amount of Liabilities depend on future electricity prices

Summary I

A good model for electricity rate propagation will be of key importance

1. Improve corporate risk control (reduce risk capital)
2. Meet increasing legal requirements

Electricity Rates

Let's have a look at real data from the EEX: A very short introduction using EViews

How to find a model for electricity prices?

Essentially two approaches:

1. First approach: Apply existing models to the situation at hand and take the one with the best fit.
2. Investigate the problem and get a deeper understanding of the price-determining factors

First Approach

Discriptive and inference statistics with EViews:

- Visualize the Data
- Fit a model
- Forecast

Remarks

So far, we have seen that

1. Statistic Software can help you to visualize the data
2. Statistic Software allows for statistical inference

PART II

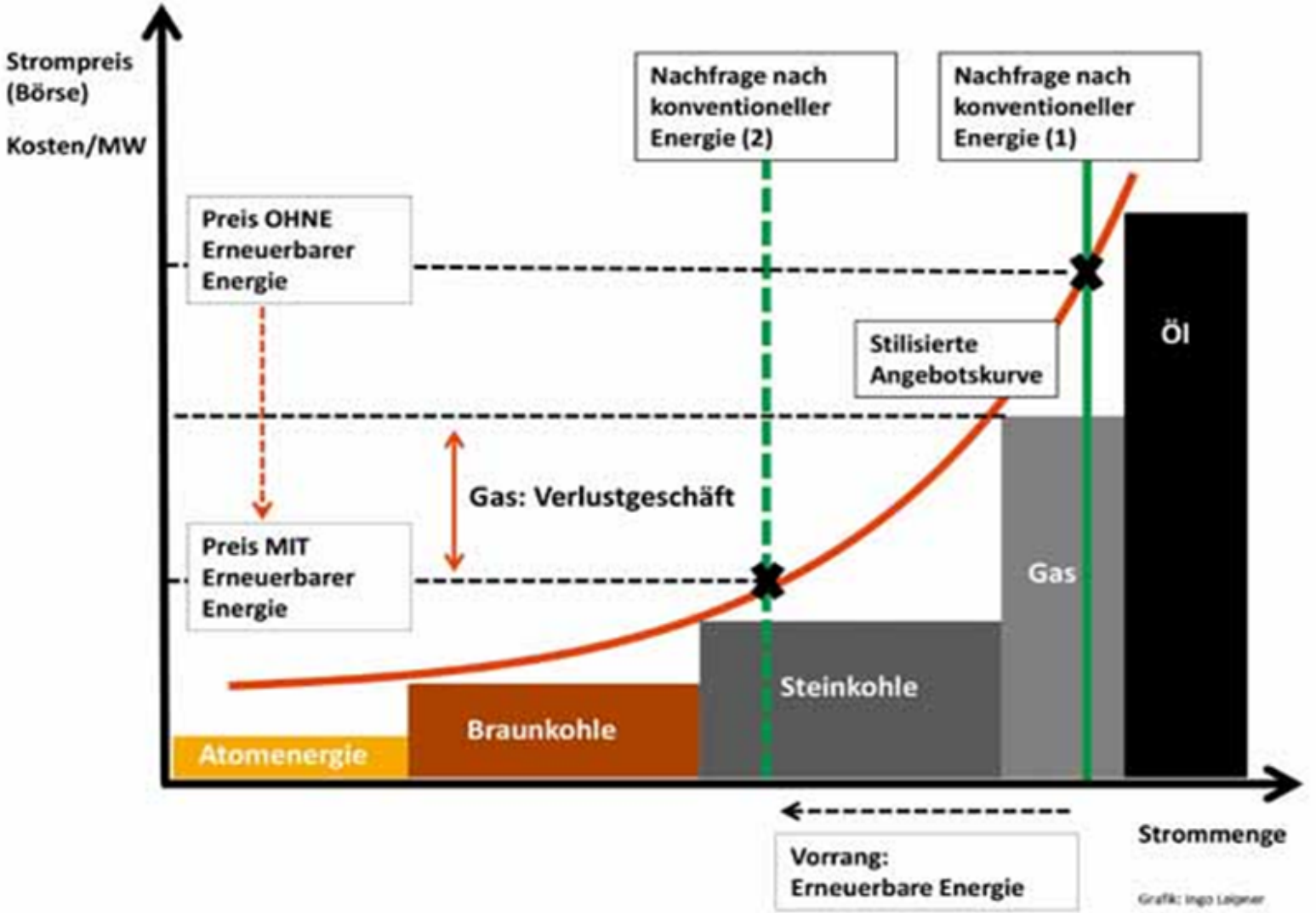
Find a good model

Supply and Demand

Fundamental economic principle: Supply and Demand

- Demand Curve: Price inelastic (as long as prices remain positive)
  Predictable (small volatility)
- Supply Curve: Merit Order Rule (next slide) $\Longrightarrow$ Supply Curve is price elastic

Merit Order Rule



Erneuerbare Energien Gesetz (EEG)

EEG: Renewable energy will be at first fed into the grid Implies Supply Curve with high volatility depending on

1. Solar radiation
2. Wind force and wind direction

The price equation

Definition

Energy price=costs for the finally generated KWh

Theorem

The price is determined by the following formular:

$$P_t = \min(p_t(j) : j = \min\{u : f_t(u) := \sum_{i=1}^{u} S_t(i) \geq D_t\}, \quad (1)$$

$S_t(i) =$ *amount of electricity generated by unit* i.
$D_t =$ *electricity demand at time* t.
$p_t(j) =$ *unit* j*'s cost for producing one kWh.*

Observation: P_t is in general not a continuous variable

Demand Curve:

$$D(P) = \begin{cases} D^1(P) & P \leq 0 \\ D^0 & P \geq 0 \text{ no price sensitivity} \end{cases} \tag{2}$$

Supply Curve:

$$S(P) = \begin{cases} S^0 & P \leq 0 \text{ no price sensitivity} \\ S^1(P) & P \geq 0 \end{cases} \tag{3}$$

Toy Example

Demand and Supply Curve with continuous paths:
Demand Curve:

$$D(P) = \begin{cases} D_t^0 + \sqrt[\beta]{-P} & P \leq 0 \\ D_t^0 & P \geq 0 \end{cases} \tag{4}$$

Supply Curve:

$$S_t(P) = \begin{cases} S_t^0 & P \leq 0 \\ \sqrt[\alpha]{P} + S_t^0 & P \geq 0 \end{cases} \tag{5}$$

Macroeconomic Theorem of Price

Theorem

The observed market price is the price for which

$$S_t(P_0) = D_t(P_0). \tag{6}$$

Plug in (5) and (4) to (6):

$$P(S_t^0, D_t^0) = \begin{cases} -(S_t^0 - D_t^0)^\beta & D_t^0 \leq S_t^0 \\ (D_t^0 - S_t^0)^\alpha & D_t^0 \geq S_t^0 \end{cases} \tag{7}$$

So far...

Our aim: Understand the mechanism that determines the price. We

- Explained the basic shape of the Demand Curve and the Supply Curve
- Derive an exact formular for the price

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- Explained the basic shape of the Demand Curve and the Supply Curve
- Derive an exact formular for the price Difficult to apply directly, since $S_t(i), D_t$ and $p_t(j)$ not known
- Use the toy example (continuous paths!) $\Longrightarrow$ Allows to derive an exact formula for the price

Is this a stochastic model?

We have

- Have Supply and Demand Curve
- Intersection yield uniquely determined price P_0

Where is the randomness?
Recall formular for the price:

$$P(S_t^0, D_t^0) = \begin{cases} -(S_t^0 - D_t^0)^\beta & D_t^0 \leq S_t^0 \\ (D_t^0 - S_t^0)^\alpha & D_t^0 \geq S_t^0 \end{cases} \tag{8}$$

Minimal Supply and Demand

Up to now: No definition of S_t^0

- Recall D_t^0: Electricity demand depending on t (constant in P for $P_0 > 0$)
- $S_t^0 =$ Minmial amount of energy feed into the grid (solar energy, wind energy, nuclear power etc.)

Amount cannot be determined in advance for

- Solar Energy
- Wind Energy

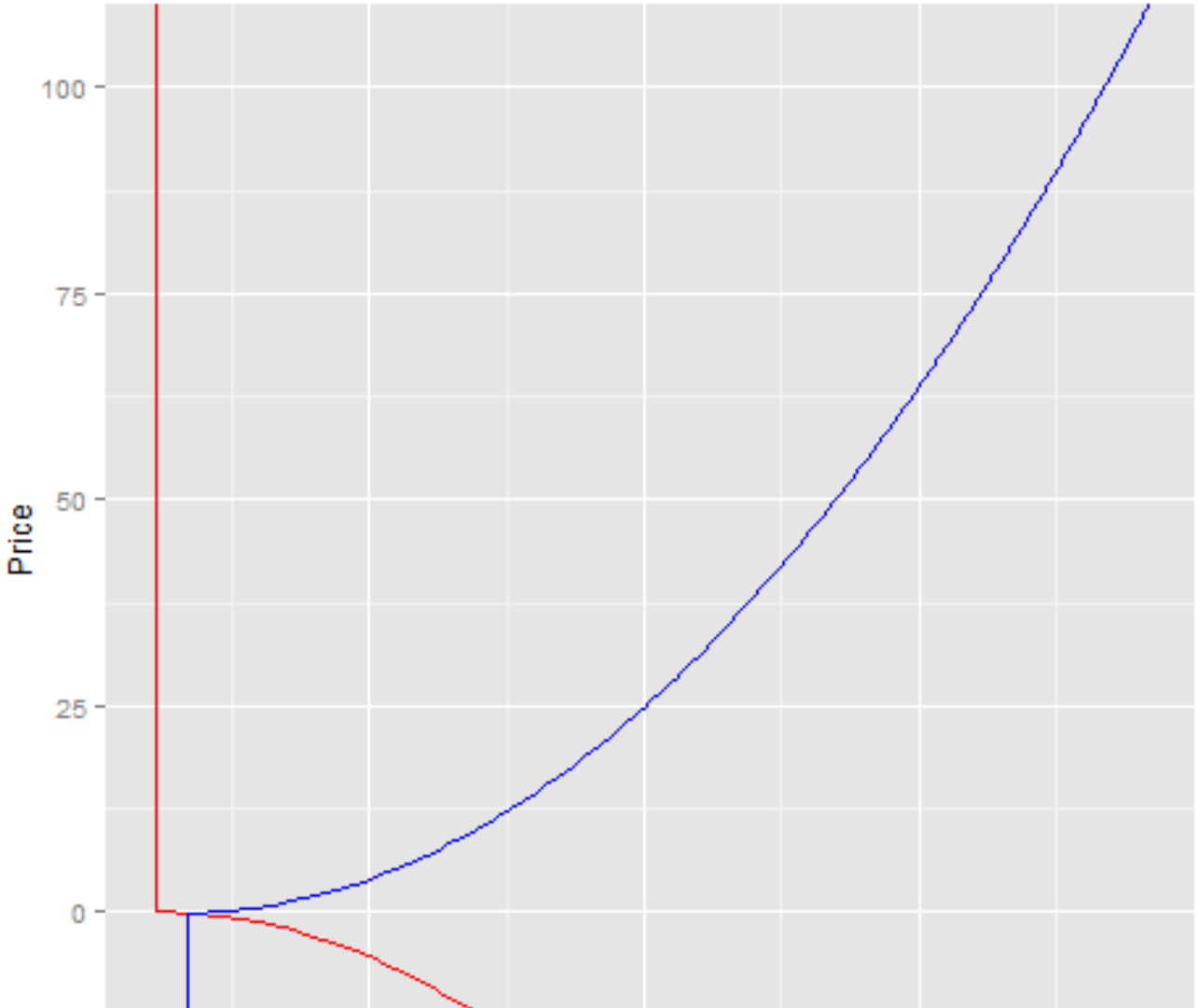
Toy Example II

Supply and Demand as Stochastic Processes

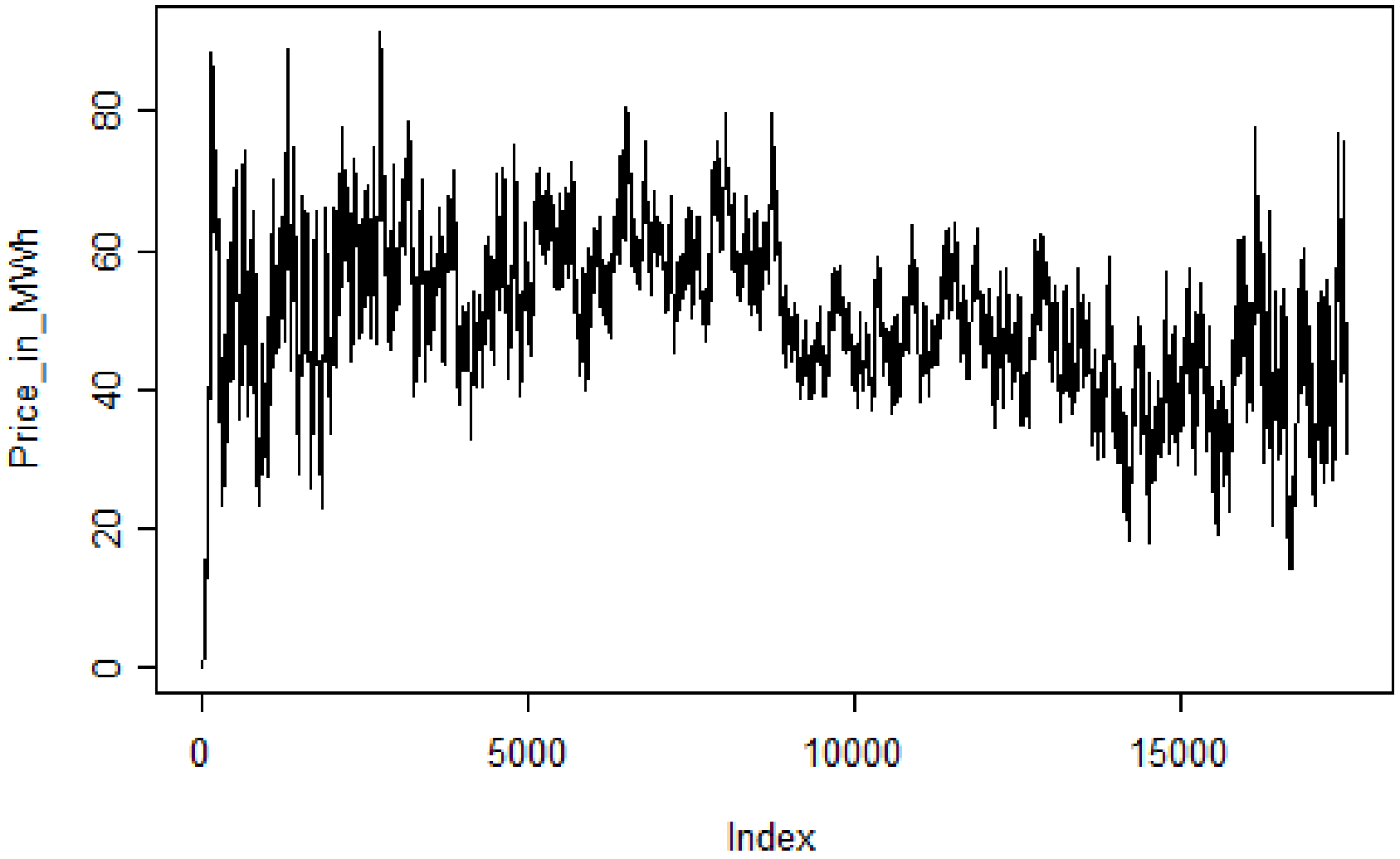
$$dD_t^0 = MeanReversion_D * (D_t^0 - NormalLevel_t)dt + \sigma dW_t. \quad (9)$$

$$dS_t^0 = MeanReversions_S * (S_t^0 - NormalLevel_t)dt + \rho dB_t. \quad (10)$$

Toy Model II: Simulating Supply and Demand



Toy Model III: The derived Price Curve



Final Conclusions

Two approaches for modelling electricity

- Approach I: Calibrate existing models to the data
- Approach II: Develop a new model for electricity

We have seen

- There is an explicit - stochastic - formula for the price, but not all parameters are known!
- $\Longrightarrow$ Toy model: explicit model for Supply and Demand
- Results: Merit Order together with EEG will increase volatility in the market
- But where are political decisions incorporated in the model?

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Thank you for your Attention