Graphical and statistical analysis of intraday electricity prices for PHELIX, year 2015 (stochastic component)

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Oslo, August 2016
<table>
<thead>
<tr>
<th>Quarter of hour</th>
<th>Number of trades</th>
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<tr>
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<tr>
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<tr>
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<td>8000</td>
</tr>
<tr>
<td></td>
<td>10000</td>
</tr>
<tr>
<td></td>
<td>12000</td>
</tr>
<tr>
<td></td>
<td>14000</td>
</tr>
<tr>
<td></td>
<td>16000</td>
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</table>

Total number of trades per quarter of hour in 2015

![Graph showing the total number of trades per quarter of hour in 2015.](image-url)
Start trading across quarter of hours (1st day)

Quarter of hour
Number of minutes passed up to the first trade

Quarter of hour
Start trading across peak quarter of hours (1st day)
Start trading across quarter of hours (1st quarter)
Start trading across peak quarter of hours (1st quarter)
Start trading across quarter of hours (2nd quarter)

Number of minutes passed up to the first trade

Quarter of hour

Quarter of hour

0 10 20 30 40 50 60 70 80 90 100
0
100
200
300
400
500
600
700
800
900
1000
Start trading across peak quarter of hours (2nd quarter)
Start trading accross quarter of hours (3rd quarter)

Number of minutes passed up to the first trade

Quarter of hour

Quarter of hour

Number of minutes passed up to the first trade

Quarter of hour
Quarter of hour
Number of minutes passed up to the first trade
Start trading across peak quarter of hours (3rd quarter)
Observation

1. It is hard to grid all 96 hour-quarterly prices, as trading starts much later occasionally.
2. We could grid the data for quarter-hourly prices belonging to the same trading block.
Vola patterns
ID prices for quarter 1 of hour 1 at 01.01.2015

![Chart showing ID prices vs. time to maturity in minutes. The x-axis represents time to maturity in minutes, ranging from 0 to 450, and the y-axis represents ID price, ranging from -10 to 20. Data points are scattered across the chart, indicating a positive correlation between time to maturity and ID price.](chart.png)
ID prices for quarter 1 of hour 11 in 2015
ID prices for quarter 1 of hour 12 in 2015
Volatility in time to maturity, Q1H1
Volatility in time to maturity, Q1H1
Volatility in time to maturity, Q1H8
ID seasonality effect Hour 4

Time to maturity in minutes

Quarters of hour 4

Volatility
ID seasonality effect Hour 7

Volatility

Time to maturity in minutes

Quarters of hour 7
ID seasonality effect Hour 12

Volatility vs. Time to maturity in minutes vs. Quarters of hour 12
Volatility of ID prices with 30 minutes before the delivery starts
Autocorrelation function of squared ID prices
Series are stationary, autocorrelated and have ARCH/GARCH effects
VAR analysis of block product late morning (10—12)

Main idea:

• We consider that intraday prices for a certain hourly block (as traded at EPEX) is a system in equilibrium;
• Thus, the price for a certain delivery period within one block is not exogenous, but it is the result of all other price dynamics for neighboring delivery periods (quarters of hours) within the block.
• The equilibrium of the block intraday system is given by common needs of market participants to balance out their production, given common weather condition and other factors which jointly impact the price level within the block
• We look at cross-section correlations between quarters within one block
VAR model formulation

\[ y_t = v + A_1 y_{t-1} + \ldots + A_p y_{t-p} + u_t, \quad t = 0, \]

where \( y_t = (Q4H12, Q3H12, \ldots, Q1H10)' \) is the vector of our intraday prices for each quarter of hour within one block.

Impulse response analysis:

- In case our VAR is stable, (polynomial roots lie inside the unit circle), we can employ the impulse-response analysis to produce the time path of the dependent variables in the VAR to shocks from all other explanatory variables.
Winter February day
Correlation matrix of grid data at 21 February

12 quarters of hours 10--12 block
Inverse Roots of AR Characteristic Polynomial
## Multivariate autocorrelation test in residuals

VAR Residual Portmanteau Tests for Autocorrelations

Null Hypothesis: no residual autocorrelations up to lag h

Date: 08/14/16   Time: 11:41
Sample: 1 105
Included observations: 102

<table>
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<tr>
<th>Lags</th>
<th>Q-Stat</th>
<th>Prob.</th>
<th>Adj Q-Stat</th>
<th>Prob.</th>
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<td>205.9178</td>
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*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution
Summer July day
Correlation matrix of grid data at 01 July
VAR is stable
VAR 12—11 reduced sample
VAR 11—10 reduced sample
Observations

1. VAR 12—11 11—10 shows similar impulse-responses:
   - Bidding behavior for neighboring quarter-hourly products similar
   - Quarters 1 and 4: positive response in both directions; for both it is more difficult to balance out disequilibria (higher volumes of trades); mid-quarters have flatter responses (closer to the mean day-ahead price)
   - Neighboring hours: not significant responses
Correlation matrix of residuals after the estimation of VAR for one day in July

12 quarters of hours 10--12 block
Autocorrelation function VAR (July intraday), Q1—4H10
Autocorrelation function VAR (July intraday), Q1—4H11
Residuals VAR summer (4) Q4H10
NIG VAR summer 4 (focus only on high trading periods, exclude zeros) Q4H10
NIG VAR summer 4, include zeros Q4H10