Research question:

- Does the implementation of the Intraday 15 Minute Call Auction increase the efficiency in the German electricity intraday market?

How to answer the question?

- Approximate counterfactual situation
- Compare trading volumes before and after implementation of auction
- Inspect price volatility
- Inspect time series properties
Motivation: The EPEX Trading Process

- **Coupled Day-Ahead Hourly auction**
- **EPEX SPOT Intraday Quarterly Call auction**
- **EPEX SPOT Continuous Quarterly Intraday**
- **EPEX SPOT Continuous hourly Intraday**

**Trading process**:
- 12pm: Start of Intraday nominations
- 2:30pm: 3pm
- 4pm: 45mn before delivery

**Purpose**:
- Hourly optimization
- Quarterly optimization
- Quarterly and hourly Continuous Re-balancing
Starting point: Power market transformation

- Significant increases in the market shares of intermittent renewable electricity generation (mainly solar and wind)
- Trading shifts from long to short term markets
- Rebalancing generation portfolios becomes more important because of strong supply variations and forecast errors

What is the contribution of an additional auction?

- The Intraday 15 Minute Call Auction complements the Day-Ahead Hourly Auction
- Gives market participants an early opportunity to optimize electricity production (smoothing of generation profiles)
- Intraday auction applies uniform price clearing (rather than pay-as-bid style in continuous trading)
Benefits of intraday auctions:

- Auctions allow for block bids and complex bids
- The Intraday 15 Minute Call Auction (15 minute slots) complements the Day-ahead Hourly Auction (1 hour slots),
- thereby allowing adjustments to the 1 hour slots.
- There is one uniform price for each time slot for all market participants.
- Under uniform pricing, bidding at marginal costs maximizes profits and welfare.
Motivation: Why implement an additional auction?

Challenges of intraday auctions:

- Do not allow reaction to unpredictable events (new information) like equipment failures.

Open questions:

- What is the optimal timing, assuming bilateral continuous trading is possible between auctions?
- How to solve the trade-off between the need for rebalancing and liquidity?
- What can be learned from the Italian and Spanish market, where there is no bilateral trading between auctions?
Source: EPEX (European Power Exchange)

- 3,023,912 observations on any trade in the EPEX SPOT Continuous Quarterly Intraday between January 2014 and April 2015

- 14,780 observations on every market outcome for the EPEX SPOT Intraday Quarterly Call Auction beginning December 10, 2014
Empirical analysis

Two-pronged empirical approach:

- **Approach 1:**
  - Find comparable time periods before and after the implementation of the EPEX SPOT Intraday Quarterly Call Auction
  - Test for differences in prices, volumes, price volatility, volume volatility
  - However, comparability issues when comparing same time periods from different years, e.g. first quarter 2014 vs. first quarter 2015
  - Compare periods closely before and after the implementation
  - We chose to compare the period 90 days before implementation with 90 days from January 5, 2015 onwards
  - Intuition: the closer together the compared periods, the higher their comparability
Two-pronged empirical approach:

- Approach 2:
  - Analyze time-series properties of prices and volumes from January 2014 through April 2015
  - Electricity generation exhibits seasonal components
  - For example, high solar electricity production in summer compared to low solar production in winter
  - Use SARIMA-model to estimate time-series properties
Results

Total trade volume

- First, we find that the total trade volume for 15 minute intervals was higher after the implementation of the new auction (1) than before (0):

  - This indicates that the new auction provides additional benefits.
  - Market participants trade once instead of continuously for 96 time periods.
  - The difference is economically as well as statistically significant.

Two-sample t test with equal variances

<table>
<thead>
<tr>
<th>Group</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Err.</th>
<th>Std. Dev.</th>
<th>[95% Conf. Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8640</td>
<td>586.6931</td>
<td>4.442985</td>
<td>412.9826</td>
<td>577.9838 - 595.4025</td>
</tr>
<tr>
<td>1</td>
<td>8636</td>
<td>857.8489</td>
<td>5.289729</td>
<td>491.5749</td>
<td>847.4797 - 868.218</td>
</tr>
<tr>
<td>combined</td>
<td>17276</td>
<td>722.2396</td>
<td>3.604544</td>
<td>473.7748</td>
<td>715.1743 - 729.3049</td>
</tr>
<tr>
<td>diff</td>
<td>-271.1557</td>
<td>6.907788</td>
<td>473.7748</td>
<td>-284.6957 -257.6158</td>
<td></td>
</tr>
</tbody>
</table>

\[ \text{diff} = \text{mean}(0) - \text{mean}(1) \]
\[ \text{degrees of freedom} = 17274 \]

- Pr(T < t) = 0.0000
- Pr(|T| > |t|) = 0.0000
- Pr(T > t) = 1.0000
Trade volume for quarters 1 and 4

- Second, we find that the average trade volume for quarters 1 and 4 has also significantly increased.

Two-sample t test with equal variances

<table>
<thead>
<tr>
<th>Group</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Err.</th>
<th>Std. Dev.</th>
<th>[95% Conf. Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>90</td>
<td>37546.39</td>
<td>727.3104</td>
<td>6899.873</td>
<td>36101.24 38991.54</td>
</tr>
<tr>
<td>1</td>
<td>90</td>
<td>53207.09</td>
<td>959.3272</td>
<td>9100.977</td>
<td>51300.92 55113.25</td>
</tr>
<tr>
<td>combined</td>
<td>180</td>
<td>45376.74</td>
<td>838.3534</td>
<td>11247.69</td>
<td>43722.41 47031.07</td>
</tr>
<tr>
<td>diff</td>
<td></td>
<td>-15660.69</td>
<td>1203.864</td>
<td>-18036.38</td>
<td>-13285.01</td>
</tr>
</tbody>
</table>

diff = mean(0) - mean(1)

Ho: diff = 0
t = -13.0087
degrees of freedom = 178

Pr(T < t) = 0.0000  Pr(|T| > |t|) = 0.0000  Pr(T > t) = 1.0000

- This indicates that the new auction provides additional benefits.
- The difference is economically as well as statistically significant.
Trade volume for quarters 2 and 3

- Third, we find that the average trade volume for quarters 2 and 3 has also significantly increased.
- The increase, however, is smaller compared to the volume of the quarters 1 and 4.

<table>
<thead>
<tr>
<th>Group</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Err.</th>
<th>Std. Dev.</th>
<th>[95% Conf. Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>90</td>
<td>20139.35</td>
<td>334.9324</td>
<td>3177.447</td>
<td>19473.85 - 20804.85</td>
</tr>
<tr>
<td>1</td>
<td>90</td>
<td>29108.28</td>
<td>563.9066</td>
<td>5349.688</td>
<td>27987.81 - 30228.75</td>
</tr>
<tr>
<td>combined</td>
<td>180</td>
<td>24623.81</td>
<td>468.2846</td>
<td>6282.697</td>
<td>23699.75 - 25547.88</td>
</tr>
</tbody>
</table>

| diff | -8968.927 | 655.8737 | -10263.22 - 7674.638 |

\[
\text{diff} = \text{mean}(0) - \text{mean}(1) \\
\text{Ho: diff} = 0 \\
\text{Ha: diff < 0} \\
\text{Pr}(T < t) = 0.0000 \\
\text{Ha: diff ! = 0} \\
\text{Pr}(|T| > |t|) = 0.0000 \\
\text{Ha: diff > 0} \\
\text{Pr}(T > t) = 1.0000
\]
Price volatility

• We tested the impact of the implementation of the auction on the price volatility of the continuous trade between the hours 16 pm and 17 pm.
The introduction of the EPEX SPOT Intraday 15min Auction increases market efficiency

- From a theoretical point of view, adding an additional option cannot reduce efficiency.
- When additional options are made use of, the efficiency must increase.
- While no counterfactual can be approximated, the increase in trade volumes indicates increased efficiency.
- At the same time, no economically relevant impact can be discerned with respect to the price volatility regarding the continuous trade.