Renewable Risk and Its Impact on Market Prices:
The German Case

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Motivation

- Increase of renewable capacity has many facets
  - Merit-order effect (Ketterer, 2014)
  - Firm behavior with diversified portfolios (Acemoglu et al., 2017)
  - Balancing of forecast errors (Kiesel & Paraschiv, 2017)

- Two-stage market setup
  - Large share of electricity is sold day-ahead
  - Only forecasts for renewable generation available at this point

- Do renewable firms react to risk in weather predictions?
Incentive to withhold capacity

- Consider a risk-averse firm with renewable capacity in a competitive market
- Reacts to both individual output risk and aggregate price risk (Bessembinder & Lemmon, 2002)
- Hedge against price risk by reducing output at the day-ahead stage
- Withholding of renewable electricity will increase the day-ahead price via the merit-order effect
  - Day-ahead price will contain a risk premium

- Renewable firms in Germany are exposed to the market price via the market premium model
  - 95% (25%) of total wind (solar) electricity produced in 2018 (Fraunhofer, 2019)
Price impact of output risk

High price impact

Low price impact
The data

- Hourly data for Germany, 2015 - 2018
- Day-ahead and intraday price
- Forecasted and realized renewable production and demand
- Projected wind speed and solar radiation
- Measure for risk derived from meteorological model (COSMO-DE-EPS)
How to measure forecast risk?

- COSMO-DE-EPS is an ensemble model
- 20 different predictions for every point in time
- Example for wind in region 23:

```
Lower risk: 30.8.2016, 4am-5am
Higher risk: 18.1.2018, 11pm-12am
```
Regional information

- 95 regions allow for cluster identification

Wind capacity shares

Solar capacity shares
Explanatory variables of interest

- **Continuous:**
  - Capacity-weighted average output risk
  - Split into high & low price impact regions
    - High if capacity share exceeds 90th percentile

- **Binary:**
  - High output risk in high and low price impact regions
    - High if risk exceeds 90th percentile

- Both for wind and solar
- Qualitative results unaffected by threshold
Regression analysis: Price difference

- Dynamically complete time series regression
- No support for direct price effect of renewable risk
- Main drivers of price difference are forecast errors
Renewable withholding?

- Calculate curvature at market clearing point
- Should increase with renewable withholding, ceteris paribus
Regression analysis: Curvature

- Dynamically complete time series regression
- No support for withholding effect of renewable risk
- Main drivers of curvature are levels of predicted weather
Conclusions

► Do not find evidence in favor of hypothesis in Germany based on
  – Price premium
  – Shape of supply curve

► Possible explanations
  – Firms do not have access to this information
  – Output risk is not considered to be relevant information (Rational Inattention)
  – Expected benefits do not exceed costs of acquiring knowledge
Thank you

Please reach out:

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Coefficients of main interest: price difference

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## Coefficients of main interest: Curvature

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