The Cross-border Merit-order Effect: Impacts of German Renewable Promotion on Neighboring Countries

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Climate change...
Electricity Sector – Why is it important

- **28.2%** Energy industries
- **25.8%** Fuel combustion
- **24.6%** Transport
- **9.8%** Agriculture
- **8.4%** Industrial processes and product use
- **3.1%** Waste

Source: European Environment Agency (Share of GHG by source)
European Climate Policy

EU Emission Trading System

Renewable Promotion
What is the impact of (unilateral) renewable energy promotion schemes on neighboring countries?
Impacts of Renewable Energy Support

- Lower conventional generation
- Lower wholesale market prices «merit-order effect»
- Higher exports
- Lower prices in neighboring countries «cross-border merit-order effect»
- Shift from producer to consumer rent
Impact on Rents: The Case of Swiss Hydro (and Nuclear)

Subventionen auch für Wasserkraftwerke

Der Ständerat will bestehenden Grosskraftwerken in wirtschaftlicher Notlage unter die Arme greifen. Die Eigentümer und der betroffene Kanton müssen sich beteiligen.

- Renewable promotion in Germany (financed by German consumers)
- Cross-border trade leads to decreasing electricity prices in Switzerland
  ➔ Lower rents for Swiss producers
  ➔ Lower cost for consumers (on wholesale markets)
Impacts of renewable generation

- Lower conventional generation
  (Abrell et al. 2019; Kaffine et al. 2013; Novan 2015; Cullen 2013)

- Lower wholesale market prices «merit-order effect»
  (Abrell et al. 2019; Cludius et al. 2014; Wuerzburg et al. 2013)

- Lower prices in neighboring countries «cross-border merit-order effect»
Three research questions

1. **Merit-order effect**
   What is the impact of RE generation on the domestic electricity price?

2. **Cross-border merit-order effect**
   What is the impact of RE generation on neighboring electricity prices?

3. **Shift from producer to consumer rent**
   What is the impact of RE generation on (domestic and foreign) consumer and producer rents?
What do we already know?

Germany and its neighbors
Renewable Generation – Germany versus the others...
German Electricity Trade Capacities and Generation Shares

Note: Shown are NTC and generation shares. Area of pies provides total annual generation in 2018.
Sources: NTC: BNetzA, 2019, Generation: ENTSOE, BFE
Impact of renewable generation: Descriptive evidence
RE generation and day-ahead prices
German RE generation and net exports
German RE generation and neighbors’ day-ahead prices
Estimation model
What determines the electricity market price?

Demand $D$

$P$

$P^{\text{coal}}$

$P^{\text{gas}}$

$P^{\text{EUA}}$

Temperature $T$

Renewable $R$

Marginal cost $c$ [€/MWh]

 Installed capacity $k$ [MW]

Cost of marginal generator (perfect competition)

Nuclear/Hydro

Coal

Gas

$p_{tr}^{\text{ele}} = \alpha_r + \beta_{r1} R_{tr} + \gamma_{r1} D_{tr} + \gamma_{r2} P + \gamma_{r3} T_{tr} + D_t \delta_r + \epsilon_{tr}$
What determines the electricity market price?

\[ p_{tr}^{ele} = \alpha_r + \beta_{r1} R_{tr} + \beta_{r2} R_{tr} + \gamma_{r1} D_{tr} + \gamma_{r2} P + \gamma_{r8} T_{tr} + D_t \delta_r + \epsilon_{tr} \]
What determines the electricity market price?

Import

Marginal cost $c$ [€/MWh]

Demand $D$

Installed capacity $k$ [MW]

NTC

Congestion $C$

Nuclear/Hydro

Coal

Gas

Temperature $T$

Renewable $R$

Renewable $R'$

\[ p_{ele} = \alpha_r + \beta_{r1}R_{tr} + \beta_{r2}R_{trr} + \beta_{r3}C_{trr}R_{trr} + \gamma_{r1}D_{tr} + \gamma_{r2}P + \gamma_{r3}T_{tr} + D_t \delta_r + \epsilon_{tr} \]
Results
Merit-order effect
What is the impact of RE generation on the domestic electricity price?
Cross-country merit-order effect
What is the impact of German RE generation on neighboring prices?

€/MWh per GWh

CH  CZ  DE  DK  FR  NL  PL

Cross-border merit-order
Domestic versus Cross-Border Merit-Order Effect: Impact per GWh of RE generation

€/MWh per GWh

Merit-order
Cross-border merit-order

CH  CZ  DE  DK  FR  NL  PL
Domestic versus Cross-Border Merit-Order Effect: Total impact on electricity prices

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€/MWh

Merit-order  Cross-border merit-order

Average Hourly Renewable Generation (GW)

Jul 2016 - Jul 2018
Decrease in electricity prices due to cross-border merit-order effect: 5-25%

- Producers suffer from 5-25% lower revenues
- Consumers benefit from 5-25% (wholesale market!) prices

Limitations and future work
- Impact on generation in neighboring countries currently neglected
- More than two countries