Headwind at the Ballot Box? - The Effect of Visible Wind Turbines on Green Party Support

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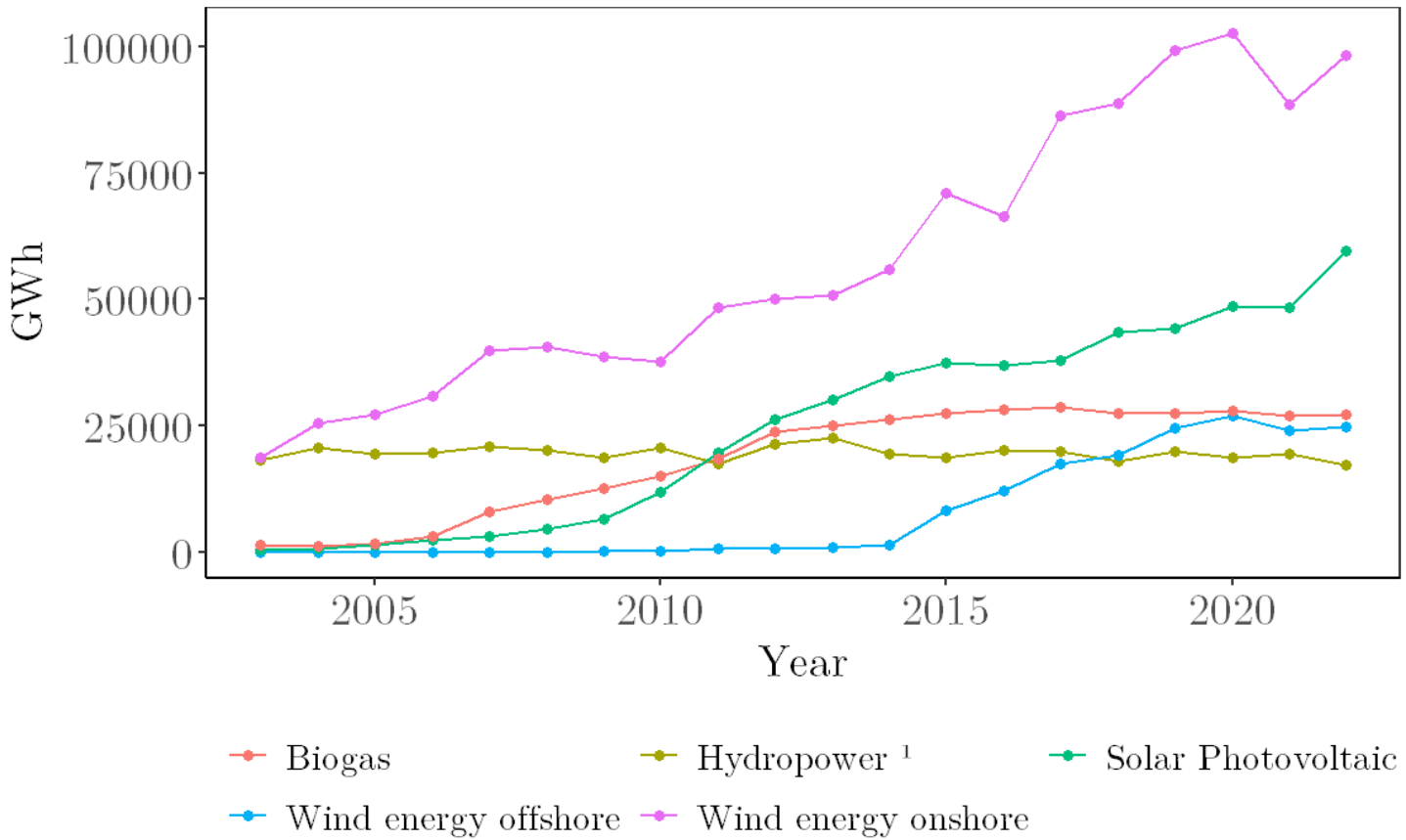
Wind energy expansion in Germany

- In line with the **Paris Climate Change Agreement**, the expansion of renewable energy is vital for obtaining climate neutrality.



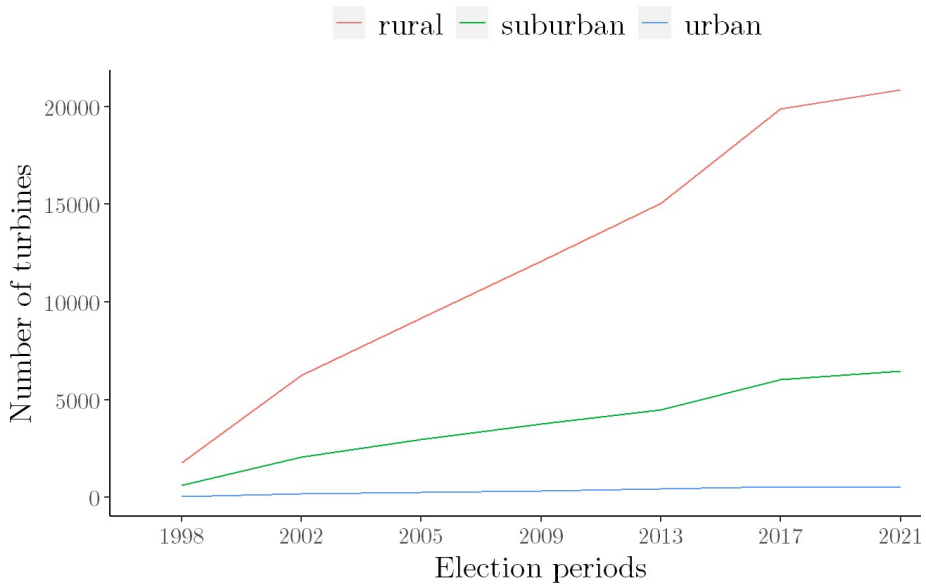
Acceptance for the expansion of renewables

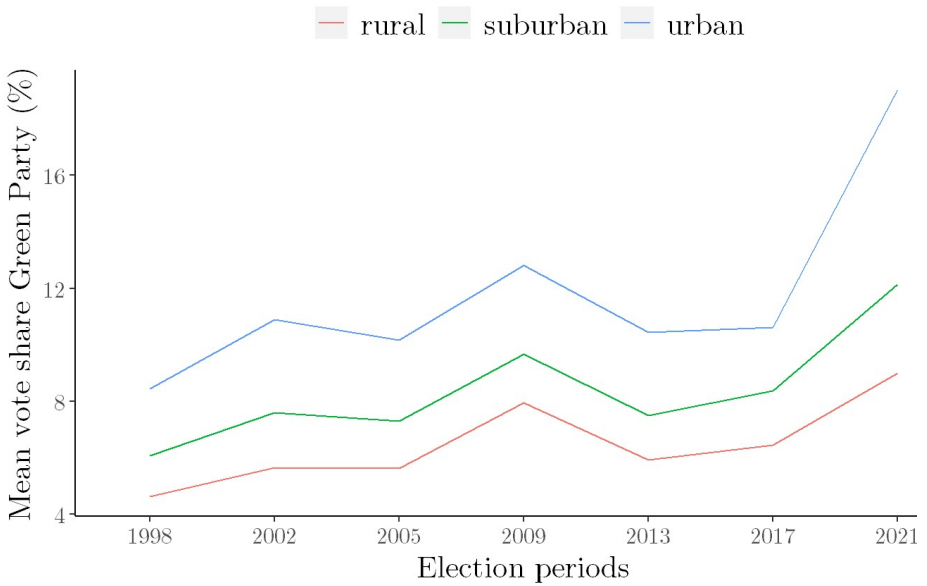
- Although wind energy generally has **strong support**, the siting of turbines can **create conflicts**:
  - Turbines can be seen as disamenities for those living in the vicinity
  - Increasing political polarization and small but strong local opposition may amplify a negative perception of the public
- Channels negatively influencing attitudes (among others):
  - Noise pollution
  - Bird endangerment
  - **Visibility** (e.g., Wolsink, 2000)

Wind Turbines and the Ballot Box

- **Do visible wind turbines influence the local residents' opinion on the energy transition?**
  - We use the vote share of the German Green Party as a **proxy for the support of renewables**
- Green party is strongly **associated with the climate topic** in the public opinion, more so than broader progressive parties in other countries
- Negative effects on the Green Party vote share suggest NIMBYism behavior, as potential Green Party voters are generally pro-renewables

Rural-Urban Devide





Our Contribution

- Previous empirical work focuses on the effect of turbines within administrative borders (e.g., voting districts, municipalities), finding mixed results (e.g., *Stokes* 2016 or *Germeshausen et al.* 2017).

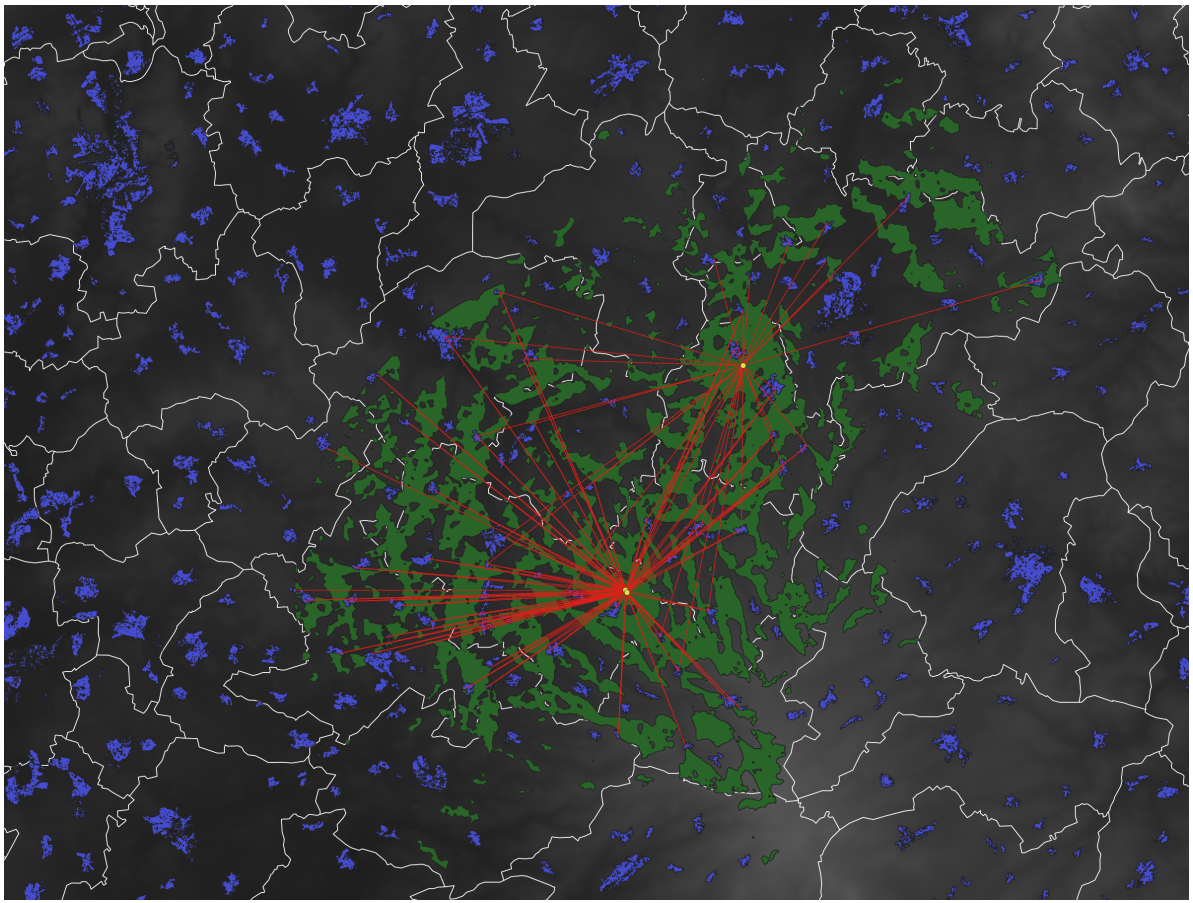
1. Crucially, we focus on **visibility** of a wind turbine from a settlement area rather than its mere presence within artificial borders.
2. More fine-grained geo-spatial **data** (Federal Network Agency, adjusted by Eichhorn et al., 2019)
3. The time frame investigated (1998 to 2021) covers 95 percent of all wind turbines installed in Germany
4. **Robust econometric methods** addressing self-selection concerns, anticipation and unobserved heterogeneity: Difference-in-difference methods with various combinations of treatment and control groups

Visibility of New Wind Turbines from Settlements

- How many potential viewers can see a turbine from a given distance in a given election period?
- We calculate the **viewshed** of all installed turbines
  - Area around the turbine from which it can be seen by a person with 1.6m eye height
  - To do so, combine geo-coded turbine locations with digital surface model EU-DEM (elevation including ground features)

$\Longrightarrow$ **Binary viewshed grid shows in which area in Germany a turbine can be seen and since when**
$\Longrightarrow$ **Superimpose the European Commission's Global Human Settlement Layers (GHSL) to calculate which settlement areas are visually exposed to turbines**

Visibility of New Wind Turbines from Settlements



Intervisibility network of turbines constructed in 2013 (yellow dots) and residential areas (blue polygons) in the state of Hesse. The green area represent the viewshed of the turbines and the red lines the distances between the settlements and all visible turbines

Difference-in-Differences

- **Difference-in-Difference** methods can control for nationwide trends in Green party support as well as time invariant differences between groups
- Wind turbines constructed gradually over time $\Longrightarrow$ **Staggered treatment** of municipalities
- Group-Time Average Treatment Effect (Callaway and Sant'Anna, 2021)
  - Estimating the effect for each group of municipalities treated at the same time separately
  - Avoid the issues associated with the two-way fixed effects estimator in settings with multiple periods and treatment timings (Abrahams and Sun, 2018)
- Seven timing groups g: Municipalities first visually exposed to wind turbines in the same four-year election periods from 1995-1998 to 2018-2021

Baseline Model: Seen versus unseen

- **Treatment group:** Wind turbines visible for the first time in >10 % of the municipal residential areas up to 6km (*Breuner* 2001, *CPRW* 1999).
  - To avoid treatment spillover: No visual exposure up to 7 km (buffer zone) in the pre treatment period ($t = g - 1$).
- **Level treatment variable:**

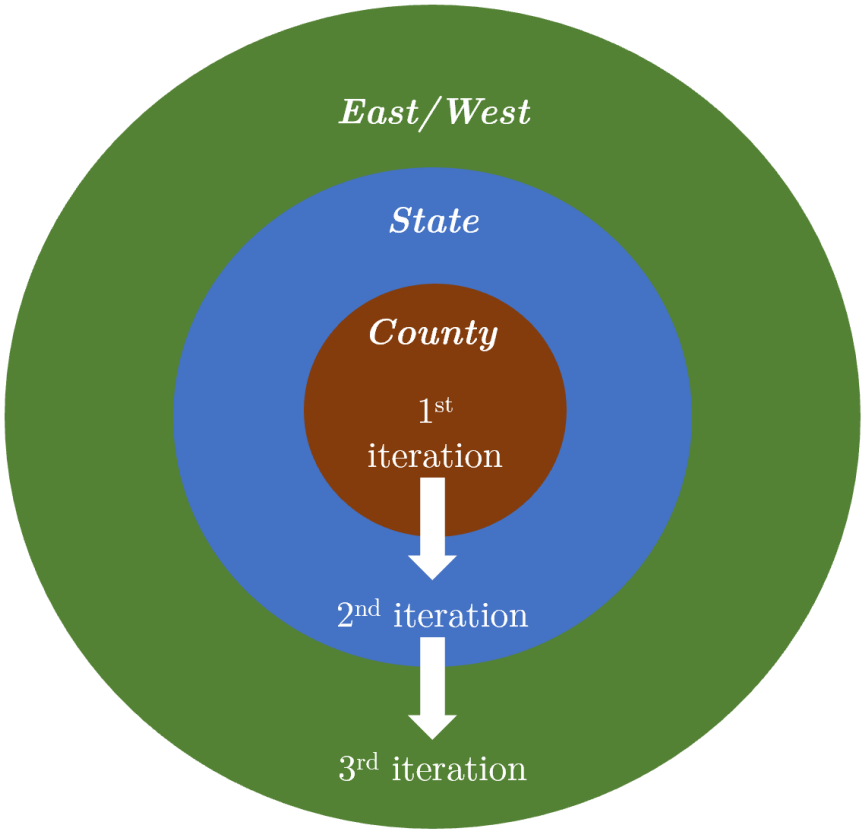
$$D_{mt} = \begin{cases} 1 & \text{if } sharevisible_{mt} > 0.1 \\ 0 & otherwise \end{cases}$$

- **Level Effect:** Average effect of voters seeing a wind turbine from their neighbourhood for municipalities of timing group g visually exposed for the first time:

$$ATT(g) = E[Y_g - Y_{g-1}, G = g, D_g = 1] - E[Y_g - Y_{g-1}, G \neq g, D_g = 0] \quad (1)$$

Control Groups

- Municipalities close to the treated ones but have no turbines in sight

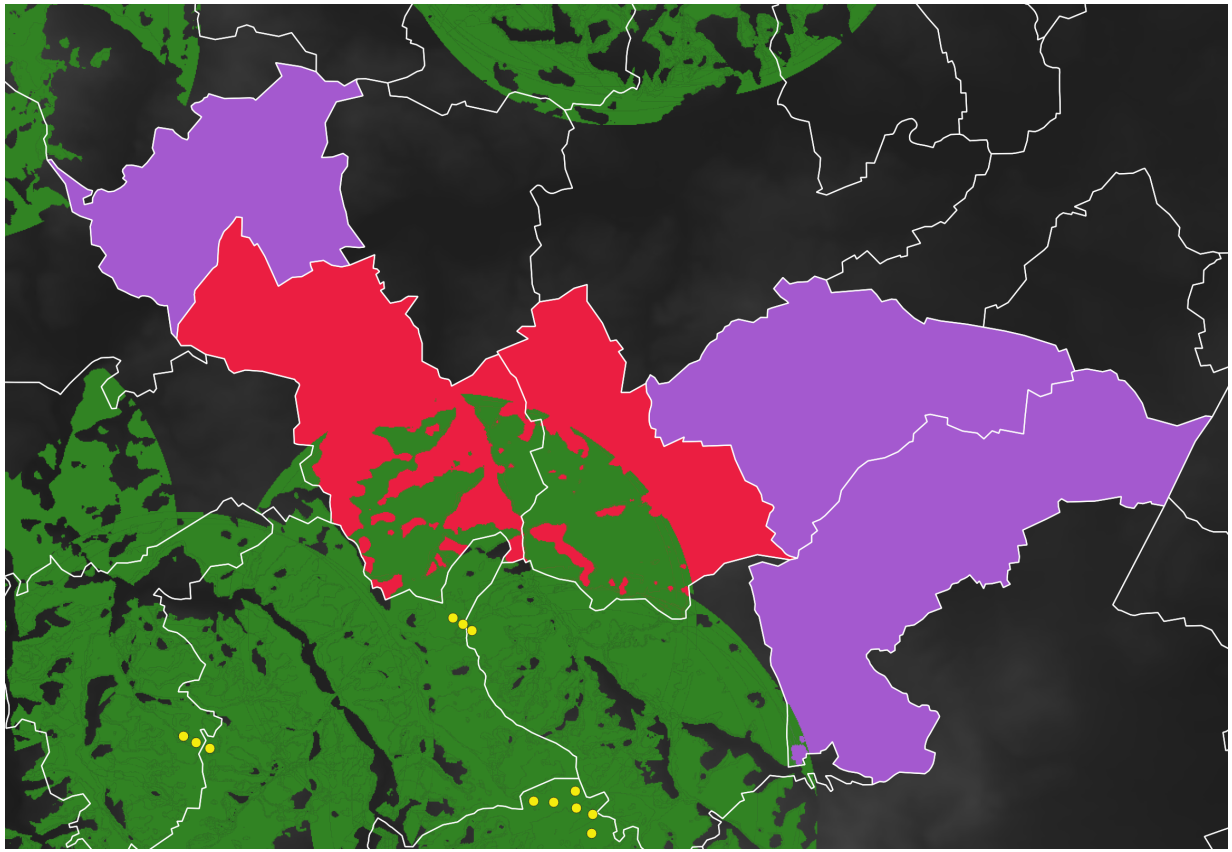


- Iteratively match without replacement
  - Match pairs with the smallest distance
  - If no control found, go to next administrative level
- Matching limit to:
  - Same urbanisation status
  - No citizens' initiative formed in municipality

External Exposure Model: Inter-municipal visibility

- Potential endogeneity?
  - Reverse causality and omitted variable bias: Turbines are not constructed randomly
- Unobservable heterogeneity?
  - Differences in agreements with the turbine operators, the municipal administration and its residents
- **External Exposure Model: Treatment and control groups are limited to municipalities without turbines within their territory**
  - Visual Exposure is more random for people living in a municipality without turbines
  - Turbines may be perceived more homogeneous

External Exposure Model: Example



2021 Timing Group (red) and the Control Group (purple) with nearby turbines (yellow points) and their viewshed (green) in the State Hesse.

Estimation

- Pre-treatment period ($t = g - 1$): No municipality is visually exposed to a turbine up to 7km (buffer or treatment zone)
- Post-treatment period ($t = g$): Wind turbines are visible within 6 km in the treatment group but not in the control group up to 7 km.
- **Estimation:**

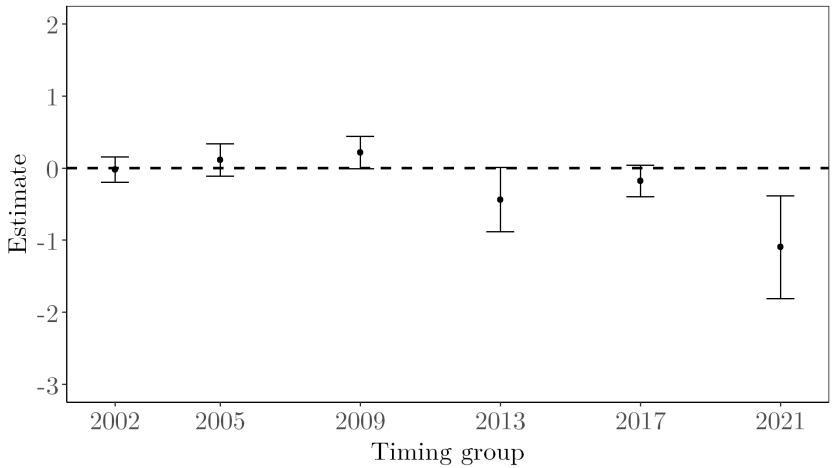
$$Y_{m_g t} = \eta D_{m_g} + \alpha post_t + \beta(D_{m_g} * post_t) + X'_{m_g t}\gamma + \epsilon_{m_g t} \quad (2)$$

where Y is the Green party vote share, D is the treatment variable and X captures the controls.

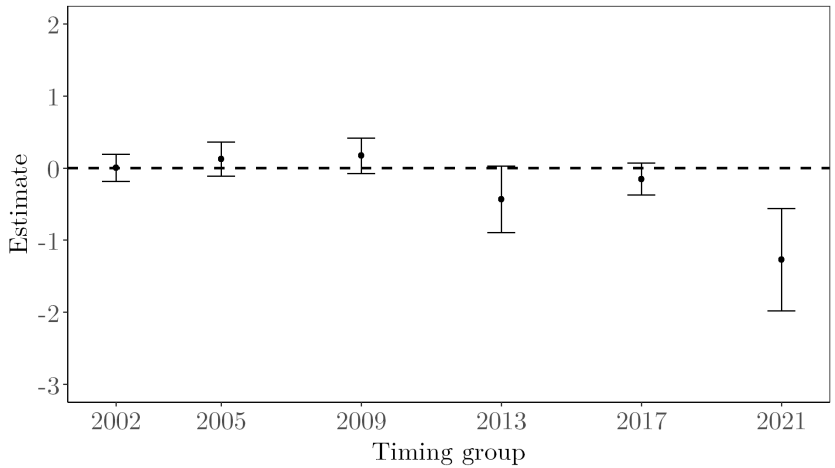
  - Based on the election outcome literature, the **control variables** are
    - ★ (Log) population (N)
    - ★ Share of population with university degree (county level)
    - ★ (Log) Distance to the nearest metropolis (meter)
    - ★ (Log) Per person income tax revenue

Summary of preliminary results

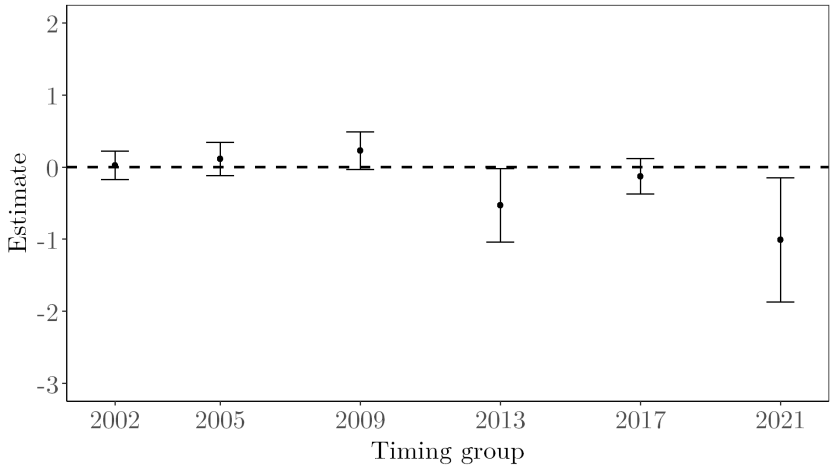
Baseline without cov.



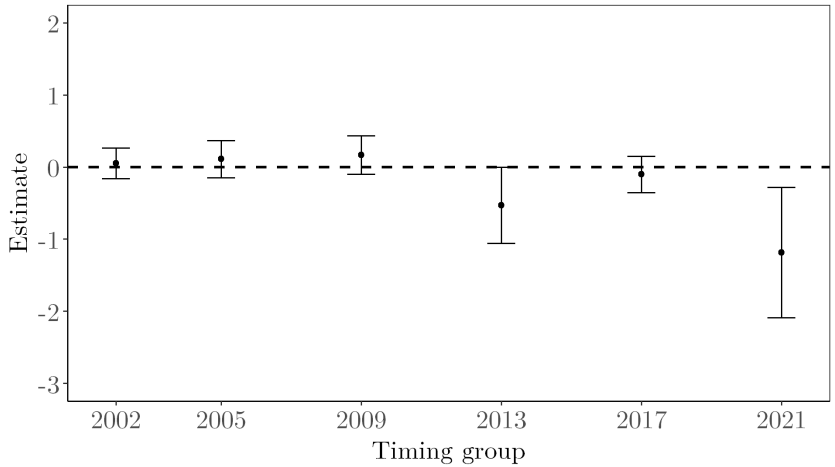
Baseline with cov.



External Exposure without cov.



External Exposure with cov.



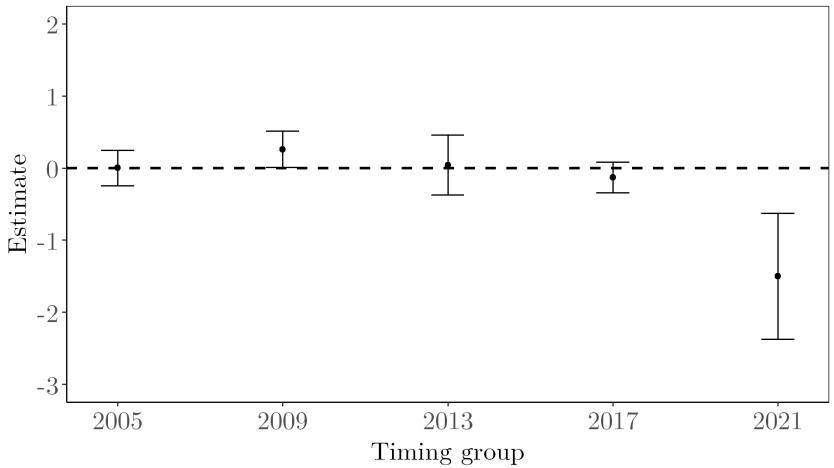
Anticipation

We account for **potential anticipation** effects as the average planning and approval duration of a wind turbine is 4.75 year (FA Wind). We shift the base pre-treatment period from $g-1$ to $g-\delta-1$ where δ is the number of anticipation periods (e.g. an anticipation of one election period ($\delta = 1$).

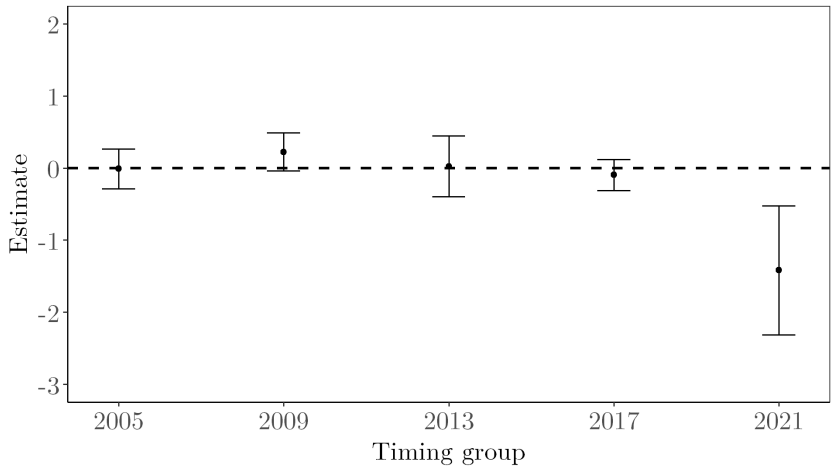
$$ATT(g,\delta) = E[Y_g - Y_{g-\delta-1}, G = g, D_{g+\delta} = 1] - E[Y_g - Y_{g-\delta-1}, G \neq g, D_{g+\delta} = 0] \quad (3)$$

Summary preliminary results accounting for anticipation

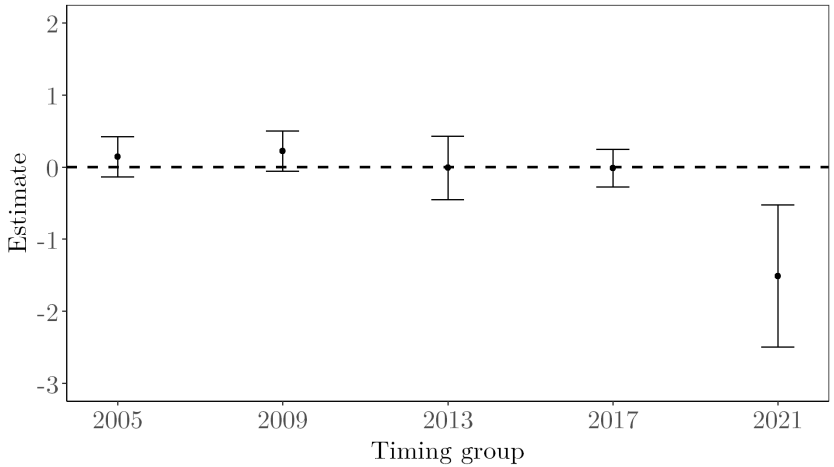
Baseline without cov.



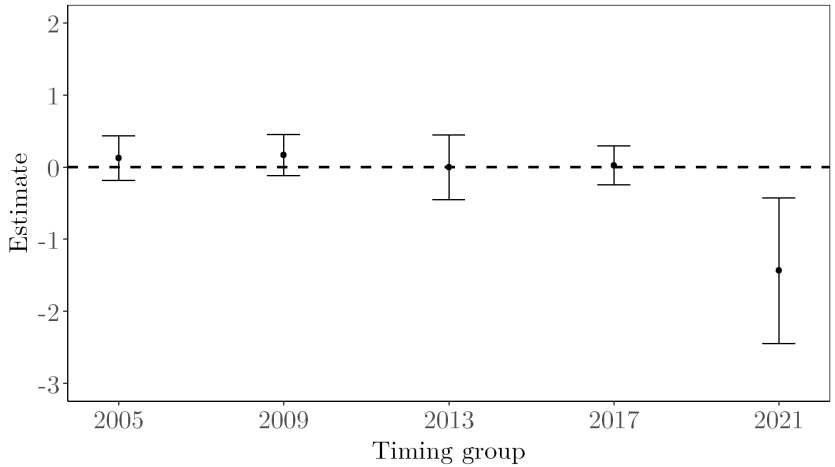
Baseline with cov.



External Exposure without cov.



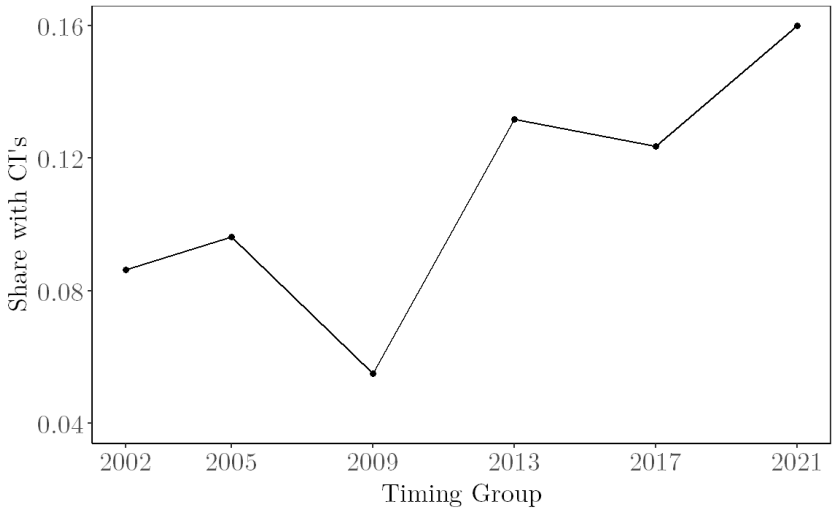
External Exposure with cov.

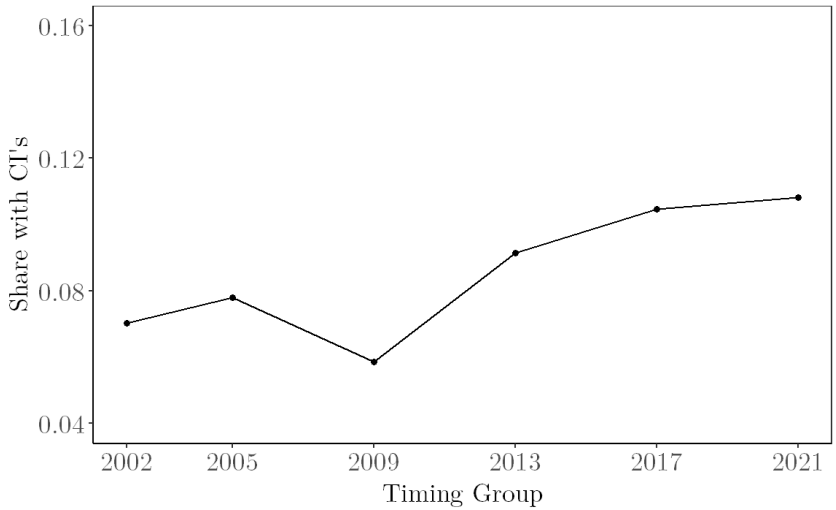


Discussion Preliminary Results

- No decrease in vote share for the Green party in most of the 1998-2021 period but a tendency towards the end (especially the 2021 Timing Group). Why?
  - More polarizing political debate (Leiren et al., 2020)
    - ★ E.g. "Fridays for Future" since 2019, raised awareness but also controversy
  - Expansion of wind energy to less supportive regions?
    - ★ Low-hanging fruits have been grasped. Positive evaluation bias of early adopters (Allcott, 2015)
    - ★ Highest share of citizens' initiatives in the 2021 Timing Group

Share of municipalities with a citizens' initiative per Timing Group





- Left: Baseline-Model, right: External Exposure Model

Discussion of External Exposure Results

- Similar pattern to baseline estimate results, but stronger negative effect in 2021
- Residents arguably participate less in the siting decision and operation of the turbines they are visually exposed to
  - Results might reflect less upward bias due to self selection
  - Less participation in the decision might lower the acceptance (Lienhoop, 2018 or Schwarz, 2020)
  - Same economic costs (e.g., decreased tourism demand (Broekel and Alfken, 2015)) but lower benefits (e.g., from an increase in municipal tax revenue or other financial benefits)
- **Next step:** Investigate turbine operator structures and participation opportunities for visually exposed municipalities

Conclusion

- We study the reactions of voters after the construction of a wind turbine in their visual proximity
- **Preliminary results:** Constructing a wind turbine that is visible from a nearby settlement is not followed by a decrease in the Green party's local vote share in most of the last decades.
- But a backlash in the latest election periods - and possibly in the future if further expansion towards less supportive areas?
- Lower participation opportunities might further reduce approval for the wind energy expansion.
- **Local acceptance by those affected is essential to the success of global policy**

Thank you!

Further research and discussion

- Estimate the effect on vote share incumbent local politician
  - Punishment of (perceived) responsible entity versus change in general support for renewables
- Identification of causes for heterogeneity
  - Who owns the turbine?
  - Further analysis of Citizen initiatives

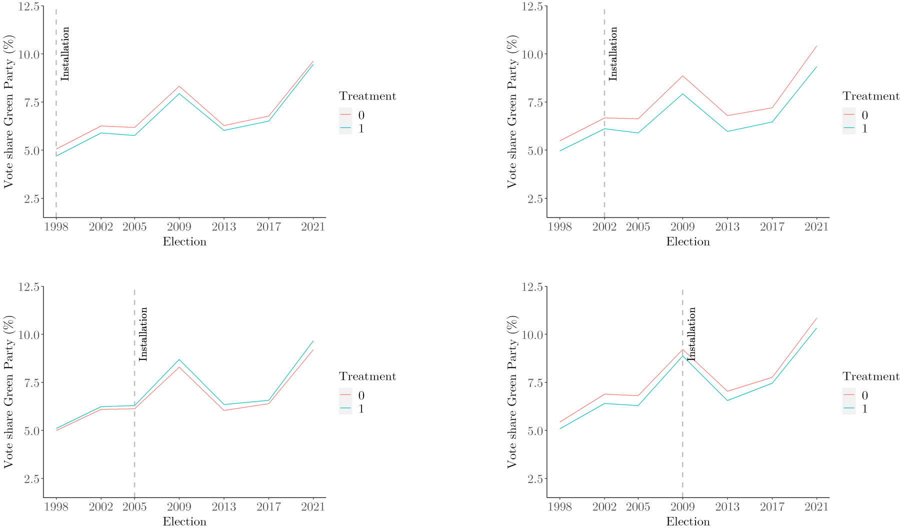
Endogeneity

- Reverse causality and omitted variable bias: Turbines are not constructed randomly
  - Estimation is biased if turbine construction is more likely in where support for the Green Party is high
- Approach: Restrict the control group to "not yet treated" municipalities
  - For temporal endogeneity even further restrict municipalities to those treated in the next period (or the period after next when accounting for anticipation):

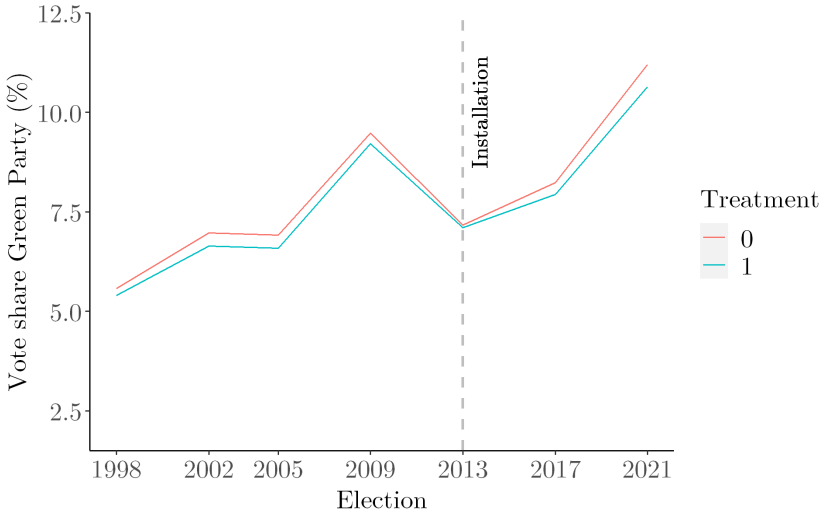
$$ATT(g) = E[Y_g - Y_{g-1}, G_g = 1] - E[Y_g - Y_{g-1}|D_g = 0, D_{g+1} = 1] \quad (4)$$

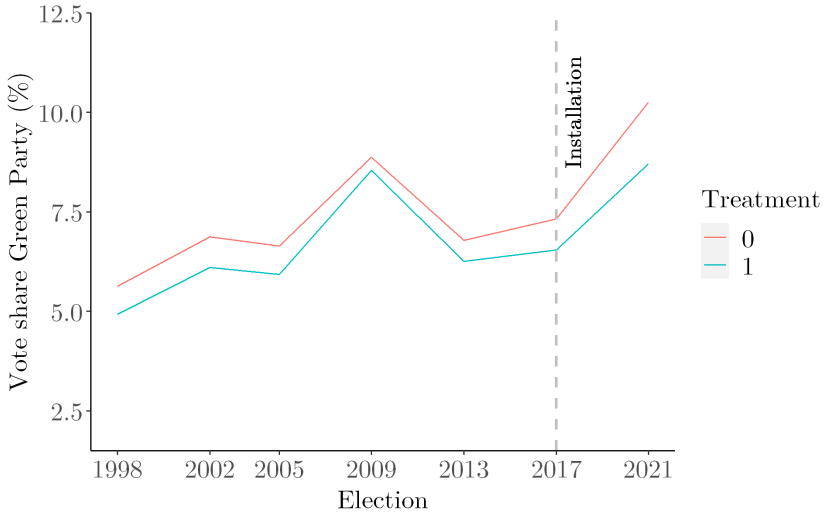
$$ATT(g, \delta) = E[Y_g - Y_{g-\delta-1}, G_g = 1] - E[Y_g - Y_{g-\delta-1}|D_{g+\delta} = 0, D_{g+\delta+1} = 1] \quad (5)$$

Parallel trends 2002 to 2013

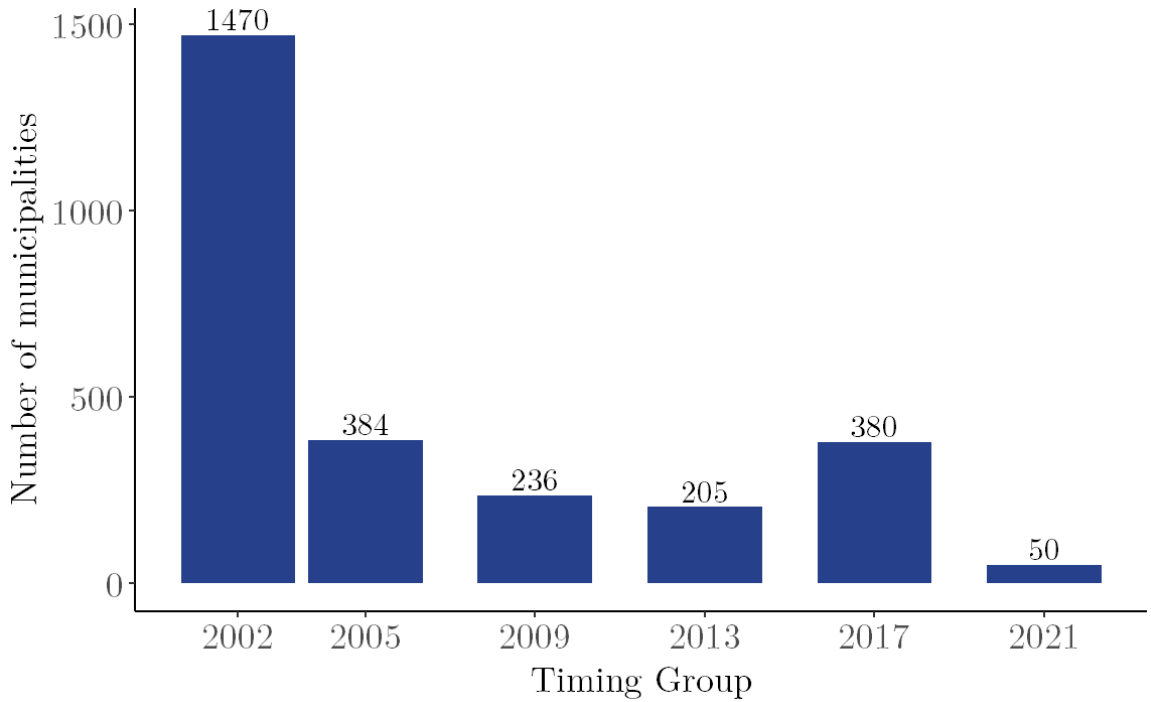


Parallel trends 2017 and 2021





Number of municipality visually exposed up to 6km



Robustness: Falsification Test

- We shift the treatment timing for each timing group to all possible t<g pre treatment election periods
- We aggregate the results in event time

$$\theta(e) = \sum_{g=2}^{T} 1\{g + e \leq T\} ATT(g, g + e) P(G_g = 1 | g + e \leq T) \tag{6}$$

P = relative group size of g

- Small and insignificant results support the parallel trend assumption

Event Study estimator (Lags)