Blowin' in the Wind:

The impact of wind farms on the housing market

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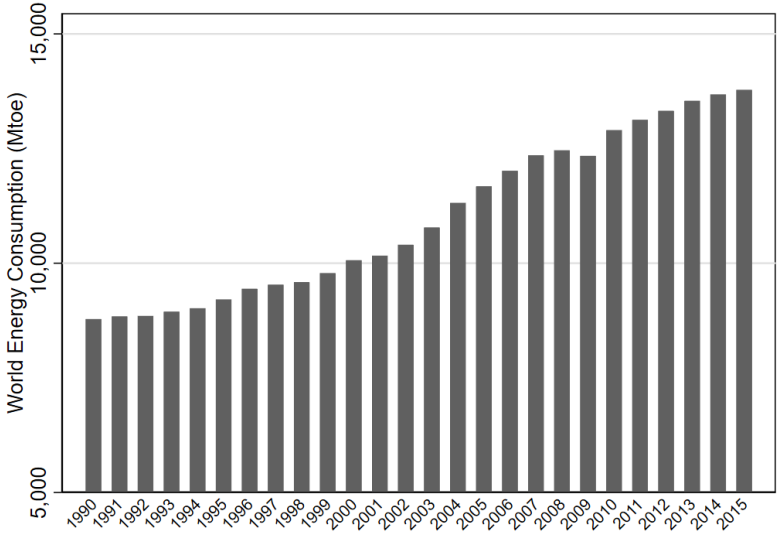
Introduction

Motivation

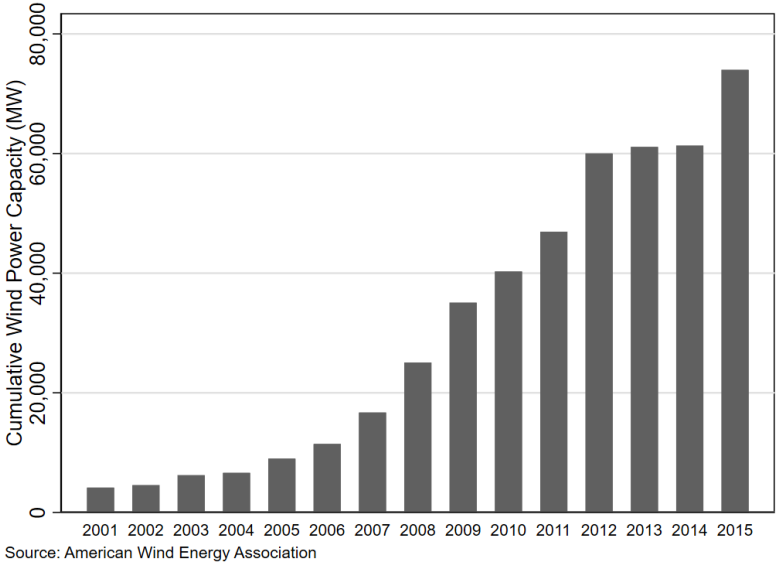
- Growing world overall energy consumption
- Response comes also through expansion of wind energy sector

World energy consumption



Source: Global Energy Statistical Yearbook 2016

US wind energy capacity



Source: American Wind Energy Association

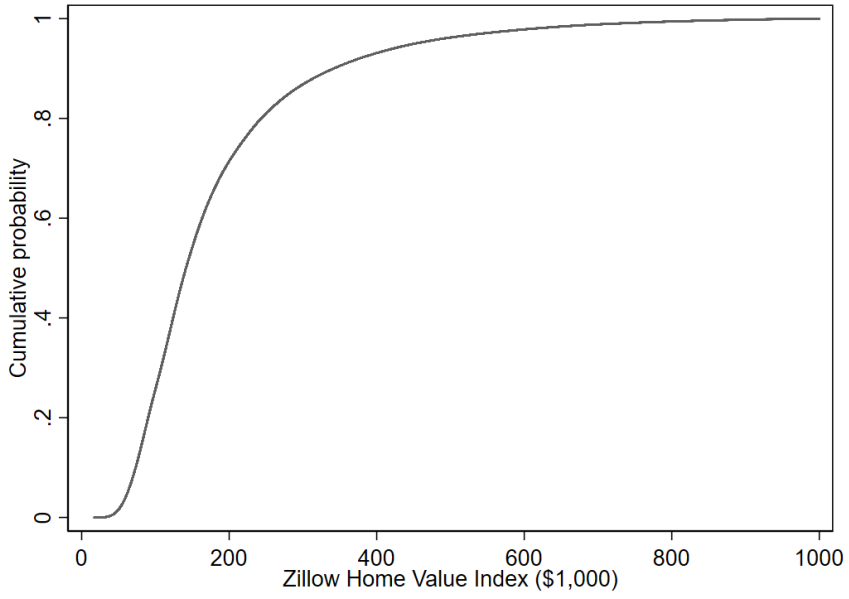
Motivation

- Local communities concerned about visual and aural impact of wind turbines on house prices
- Literature
  - ◇ Non-significant effects: Sims et al. (2008), Hoen et al. (2013), Lang et al. (2014)
  - ◇ Negative effects: Droes & Koster (2014), Gibbons (2015), Sunak & Madlener (2016)
- Large majority of the previous attempts based on DD framework, here IV approach

Data and identification

Main variables

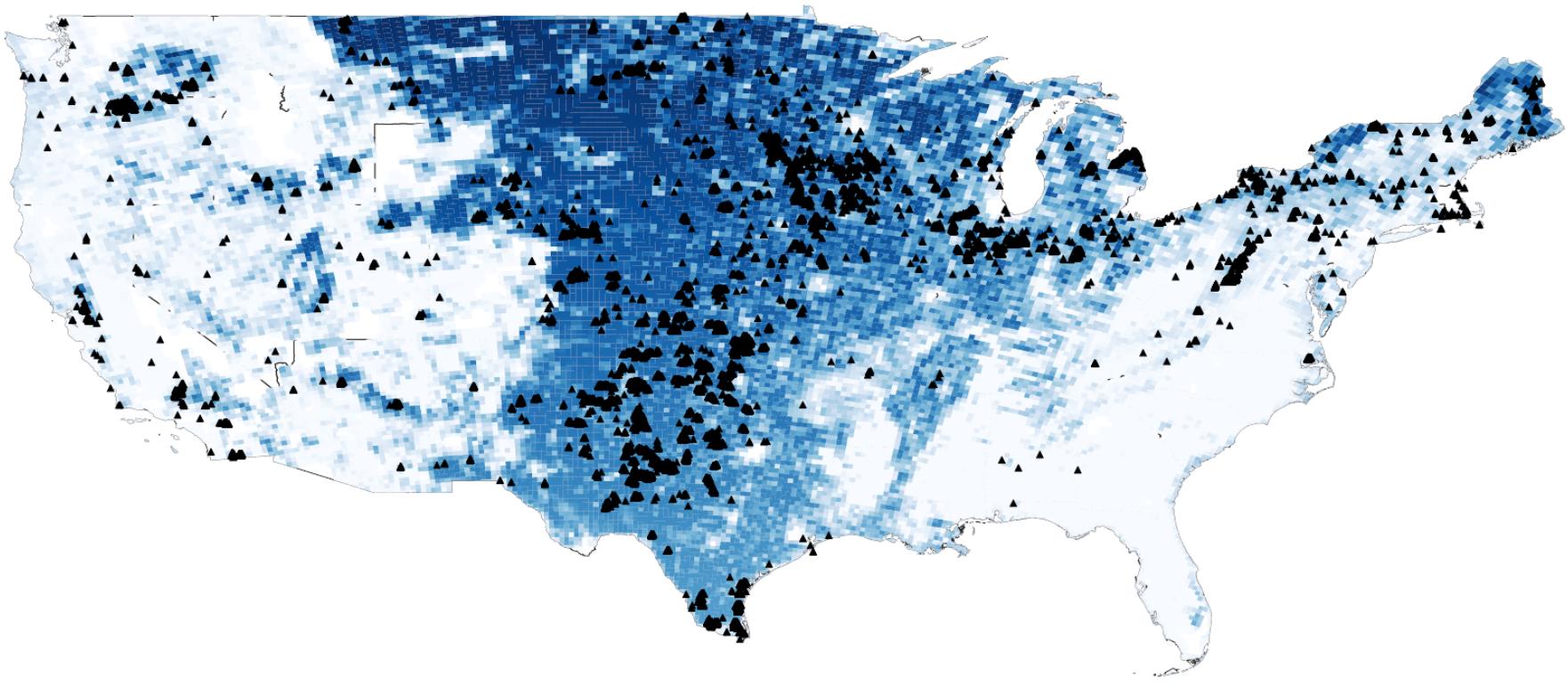
- Zillow data on median selling price per square foot for all homes in a given area
  - ◇ Finest level of aggregation: Zip Code, but only sample of US Zip Codes covered (although more than 10,000 zip codes out of 30,000)
  - ◇ Monthly time series from January 2000 to July 2016



Main variables

- Information on wind turbines collected by Federal Aviation Administration (FAA)
  - ◇ Records on 39,242 turbines in 1,296 distinct zip codes
  - ◇ Data includes geographic position, date in which the turbine is built, power capacity
- Annual average wind power made available by National Renewable Energy Laboratory (NREL)

Wind power class and turbines



Additional controls

- Demographic variables from Census 2000 available at block group level; matched to zip codes using ArcGIS
  - ◇ Total population, income per capita, sex, race, education level
- Distance from coastline available from the Stanford EarthWorks database
- Land altitude

Sample characteristics

Table 1: Covariates balance

	(1) Full sample	(2) Wind farm	(3) No wind farm	(4) Col 2-3
Average income	58.2017	48.3708	58.4192	-10.0484
	(38.2850)	(13.5401)	(38.6258)	(0.8478)
Black percentage	0.0893	0.0212	0.0908	-0.0697
	(0.1596)	(0.0402)	(0.1609)	(0.0027)
Elevation	280.8244	476.2126	276.5009	199.7117
	(376.2553)	(398.3224)	(374.6171)	(23.1825)
Distance to coast	212.7294	314.2890	210.4821	103.8069
	(265.0478)	(312.1312)	(263.4821)	(18.1322)
Number of ZCTA	13904	301	13603	13904

Identification strategy

- Estimate the impact of wind turbines on house prices

$$\triangle ln\left(y_{zt}\right) = \alpha + \beta WF_{zt} + \mathbf{X}_{zt}\boldsymbol{\theta} + \tau_t + \varepsilon_{zt}$$

  - $\triangle ln\left(y_{zt}\right)$ percent change in median selling price for homes in Zip Code z and month t
  - WF_{zt} presence of wind farm
  - Time fixed effects
  - $\mathbf{X}_{zt}$ vector of demographic controls measured in 2000 (and time independent geographic covariates)

Identification strategy

- Estimate the impact of wind turbines on house prices

$$\triangle ln\left(y_{zt}\right) = \alpha + \beta WF_{zt} + \mathbf{X}_{zt}\boldsymbol{\theta} + \tau_t + \varepsilon_{zt}$$

  - ◇ Biased: wind turbines are not randomly allocated to zip codes
  - ◇ Infrastructure projects are usually targeted towards growing economic poles or influenced by political variables

Identification strategy

- Use instrumental variable (IV) approach

  First stage: $WF_{zt} = \pi_0 + \pi_1 Z_{zt} + \mathbf{X}_{zt}\boldsymbol{\pi_2} + \tau_t + \nu_{zt}$

  Second stage: $\triangle ln\left(y_{zt}\right) = \alpha + \beta WF_{zt} + \mathbf{X}_{zt}\boldsymbol{\theta} + \tau_t + \varepsilon_{zt}$

  - Z_{zt} is the percentage of the area of zip code z having annual average wind level of power class equal to three or more

Geographic evidence

- Map?

Results

First stage

Table 2: First stage regression

	(1)	(2)
	Wind farm	Wind farm
Percentage area ZCTA	0.0004	0.0004
with wind capacity $> 30\%$	(0.0000)	(0.0000)
Controls	No	Yes
Number of ZCTA	13904	13904
Number of ZCTA-months	3642848	3642848

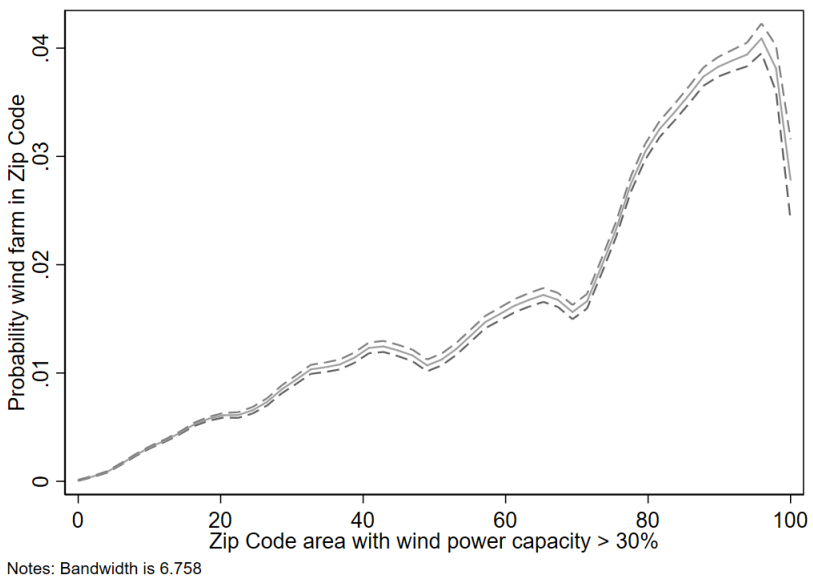
OLS and IV

Table 3: OLS and IV regressions

	(1) $\triangle ln(p)$	(2) $\triangle ln(p)$	(3) $\triangle ln(p)$	(4) $\triangle ln(p)$
Wind farm	-0.0004	-0.0002	-0.0341	-0.0213
	(0.0002)	(0.0002)	(0.0074)	(0.0046)
Controls	No	Yes	No	Yes
Number of ZCTA	13904	13904	13904	13904
Number of ZCTA-months	3268653	3268653	3268653	3268653

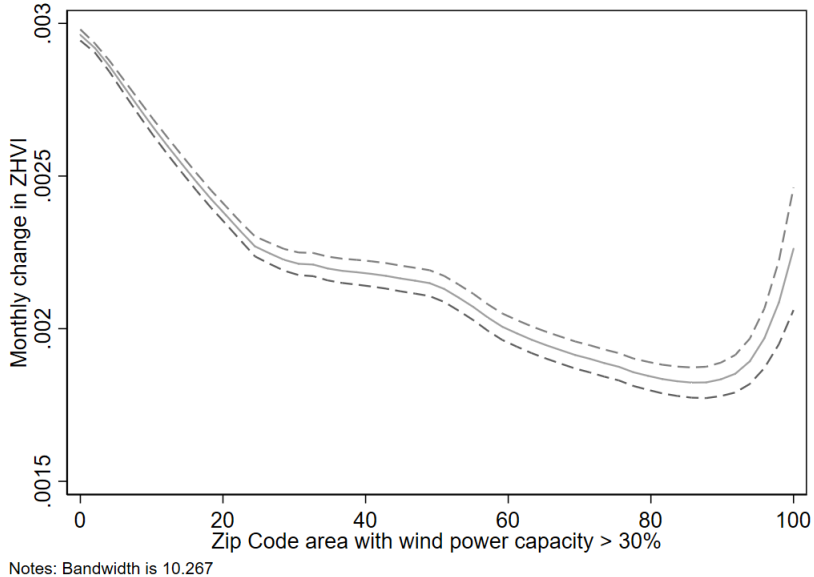
Graphic representation

First stage



Notes: Bandwidth is 6.758

Second stage



Notes: Bandwidth is 10.267

Conclusions

- The absence of a consensus in the existing literature calls for investigation of the relation between wind turbines and house values
- Using an IV approach, wind turbines are found to have a negative effect on local home selling prices
- Instrumenting for wind turbine presence with the percentage of the area of a zip code having wind level of at least category 3 likely satisfies the exclusion restriction and monotonicity assumption
- Second stage estimates are larger than OLS coefficients: possibly due to measurement error

Next steps

- Use as control Zip Codes where wind farm was not build due to
- Take "treatment intensity" (i.e. number of wind turbines) in a given area into account
- Distinguish between turbines of different height/size
- Look for differential effects on bottom-tier, middle-tier and top-tier houses and/or on different home categories (single family residence vs condominium)