Effects of Wind Turbines, Groundwater Stocks, Irrigation on Land Values

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August 23, 2019

Introduction and motivation

- Value of land is one of most important assets in determining producer's wealth portfolio
  - Farm real estate represents about 75% of wealth (Mishra et al., 2002)
- Fluctuations in value of land can therefore have important implications for producer well-being
- Understanding how different factors affect land values also important for policymaking (e.g., cost-benefit analyses)

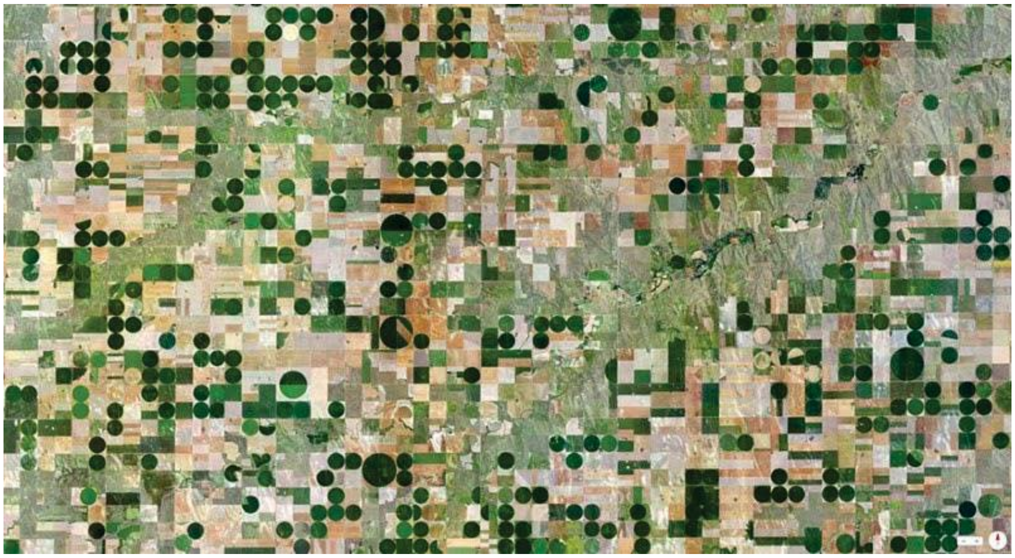
Objectives

- This session examines how agricultural land values are affected by:
  - Availability of irrigation
  - Groundwater stocks underlying the parcel
  - Proximity to wind turbines

Applications

- Availability of irrigation
  - How might irrigation curtailment or water rights retirement affect producer wellbeing?
- Groundwater stocks
  - How sensitive are farmland values to changes in aquifer levels?
  - Establish benchmark for comparing investments made toward groundwater conservation
- Wind
  - Diversifying farm income with wind lease payments

Part I: Irrigation and groundwater



Introduction and motivation

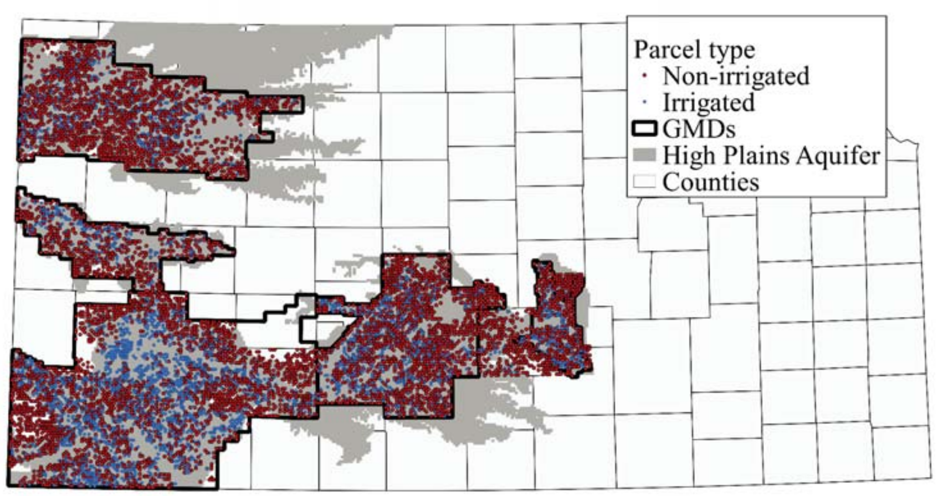
- Growing dependence on groundwater for agriculture causing aquifer depletion (Siebert et al., 2010)
- Depletion of Kansas High Plains Aquifer (HPA) especially problematic
- Lack of competitive markets makes it difficult to directly observe the value of groundwater

Practical applications

- What is the land value premium associated with having access to irrigation?
  - What might be expected impact from mandatory retirement or curtailment programs?
- How sensitive is irrigated farmland to changes in groundwater stocks?
  - Is an otherwise equivalent parcel (w/ water rights) worth more in region of abundant groundwater or scarce groundwater?
    - How much more?

Methodology

Location of all parcel sales data used in the analysis.



Methodology

- Approach: use regression analysis to estimate irrigation premiums and value of an acre-foot of groundwater stored under the parcel
  - Exploit ~17,000 farmland transactions from 1988-2015 for parcels overlaying the High Plains Aquifer
  - All parcels at least 40 acres in size
  - Arms-length transactions
  - At least 75% cropland by area
  - Exclude all value of improvements

Methodology

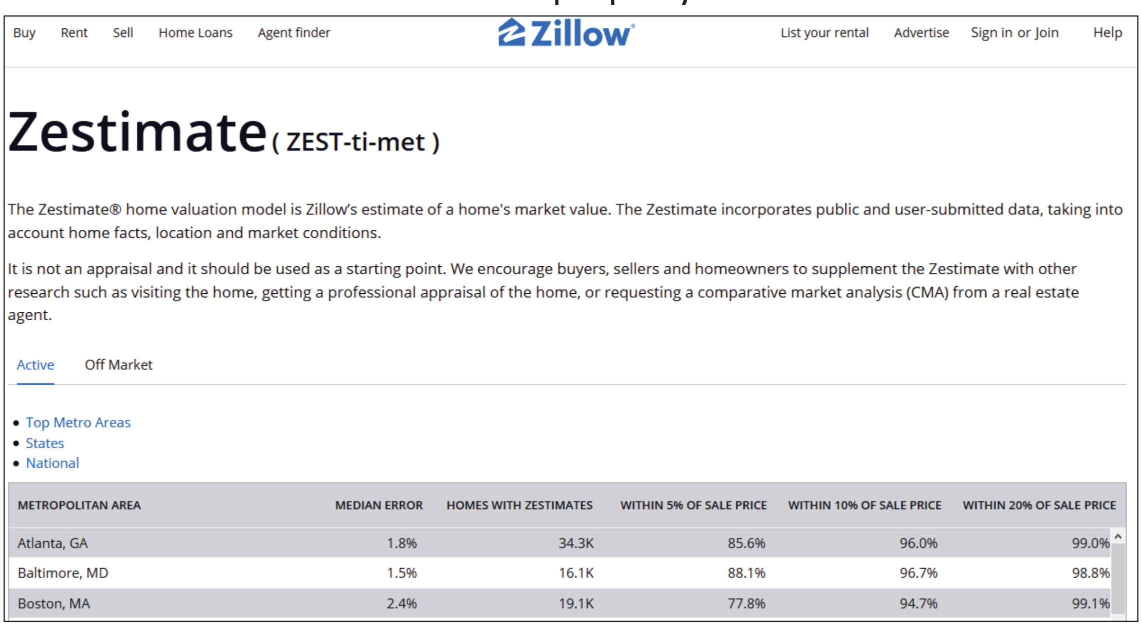
- Suppose we observe 1 irrigated transaction and 1 non-irrigated transaction.
  - Irrigated parcel sells for $3,000/acre
  - Non-irrigated parcel sells for $2,000/acre
  - If the parcels are otherwise equivalent, then the difference in price is due to the availability of irrigation.
    - Irrigation premium is $1,000/acre, or 50% more than non-irrigated.

Methodology

- Complication: other factors likely to influence land values
- Need to control for these factors in the analysis
  - Soils: soil organic carbon, soil pH, water storage
  - Climate: historical temperature and precipitation
  - Hydrology: saturated thickness (i.e., amount of water stored in aquifer in given location)
  - Urban influence: commute times to cities of 10,000+ or 40,000+ populations

Methodology

- Approach here is analogous to Zillow's zestimate algorithm
  - Estimates values based on property characteristics & location



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Zestimate (ZEST-ti-met)

The Zestimate® home valuation model is Zillow's estimate of a home's market value. The Zestimate incorporates public and user-submitted data, taking into account home facts, location and market conditions.

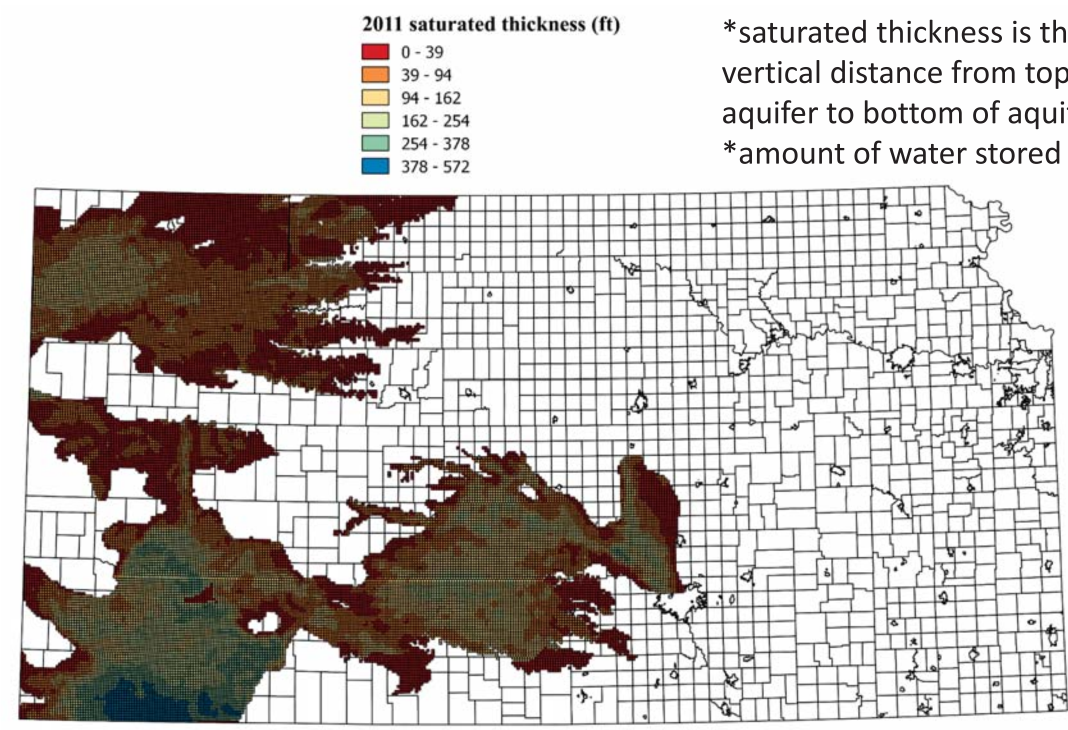
It is not an appraisal and it should be used as a starting point. We encourage buyers, sellers and homeowners to supplement the Zestimate with other research such as visiting the home, getting a professional appraisal of the home, or requesting a comparative market analysis (CMA) from a real estate agent.

Active Off Market

- Top Metro Areas
- States
- National

METROPOLITAN AREA	MEDIAN ERROR	HOMES WITH ZESTIMATES	WITHIN 5% OF SALE PRICE	WITHIN 10% OF SALE PRICE	WITHIN 20% OF SALE PRICE
Atlanta, GA	1.8%	34.3K	85.6%	96.0%	99.0%
Baltimore, MD	1.5%	16.1K	88.1%	96.7%	98.8%
Boston, MA	2.4%	19.1K	77.8%	94.7%	99.1%

Data – groundwater stocks



*saturated thickness is the vertical distance from top of aquifer to bottom of aquifer
*amount of water stored

Summary data

Variable (units)	Irrigated Mean	Non-irrigated Mean
Price per acre ($/acre)	2,811.8	1,681.4
Saturated thickness (ft)	167.2	91.5
Commute time to 10,000 population (hrs)	0.9	1.0
Commute time to 40,000 population (hrs)	2.6	2.3
Root Zone Available Water Storage (mm)	252.5	267.1
Soil Organic Carbon (kg/m^2)	8,091.8	9,280.3
Acidic soils (proportion of land)	0.2	0.1
Basic soils (proportion of land)	67.8	68.9
Growing season precipitation (inches)	15.4	16.4
Evapotranspiration (inches)	36.2	35.7
Degree days between 10 and 32 Celsius (degrees*days)	1,987.7	1,962.2
Degree days over 32 Celsius (degrees*days)	47.1	44.5

Main results

- We find that irrigated parcels sell for about 53% more than non-irrigated parcels, on average across the HPA
  - Ability to irrigate represents substantial contribution to wealth (via land premium)
- For irrigated parcels, value of parcel increases as abundance of groundwater increases
  - Estimate that an extra acre-foot of groundwater stored would increase parcel value by $3.42

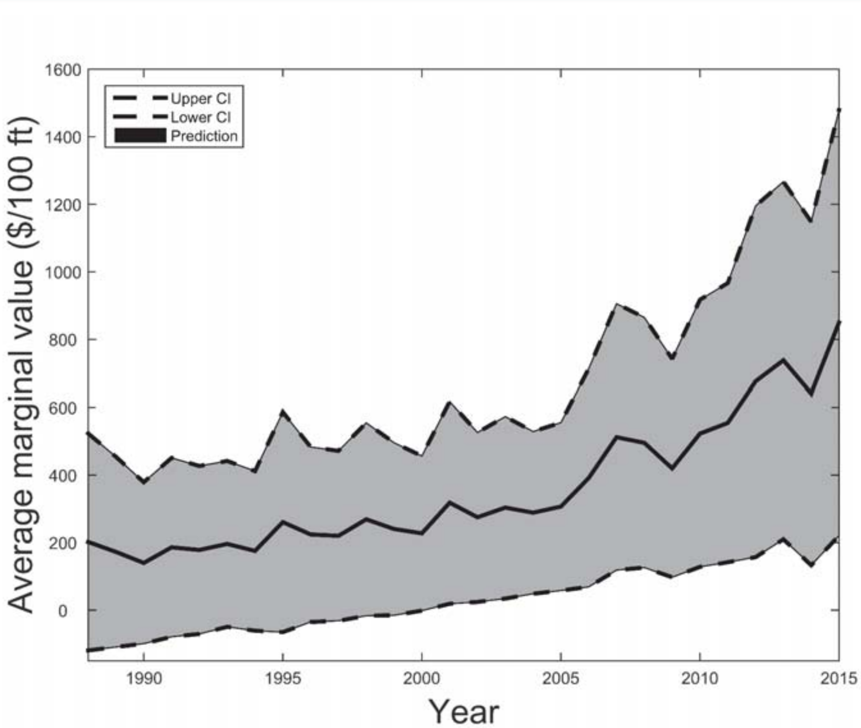
Change through time

- Have irrigation premiums been constant or changing over time?
- Data covered 1988-2015
- Estimate that irrigation premium has <u>grown</u> over time by about 1 percentage point per year
  - Value of irrigated land is growing faster than the value of non-irrigated land over time

Change through time

- Estimate that value of water stored in aquifer grew from 1988 to 2015
  - Average rate of increase for an acre-foot stored in the aquifer is $0.25/year
  - Increased from about $2/acre-foot in 1988 to about $8/acre-foot in 2015.
    - In 2015, an additional acre-ft of water under the parcel adds $8 in land value

Change through time

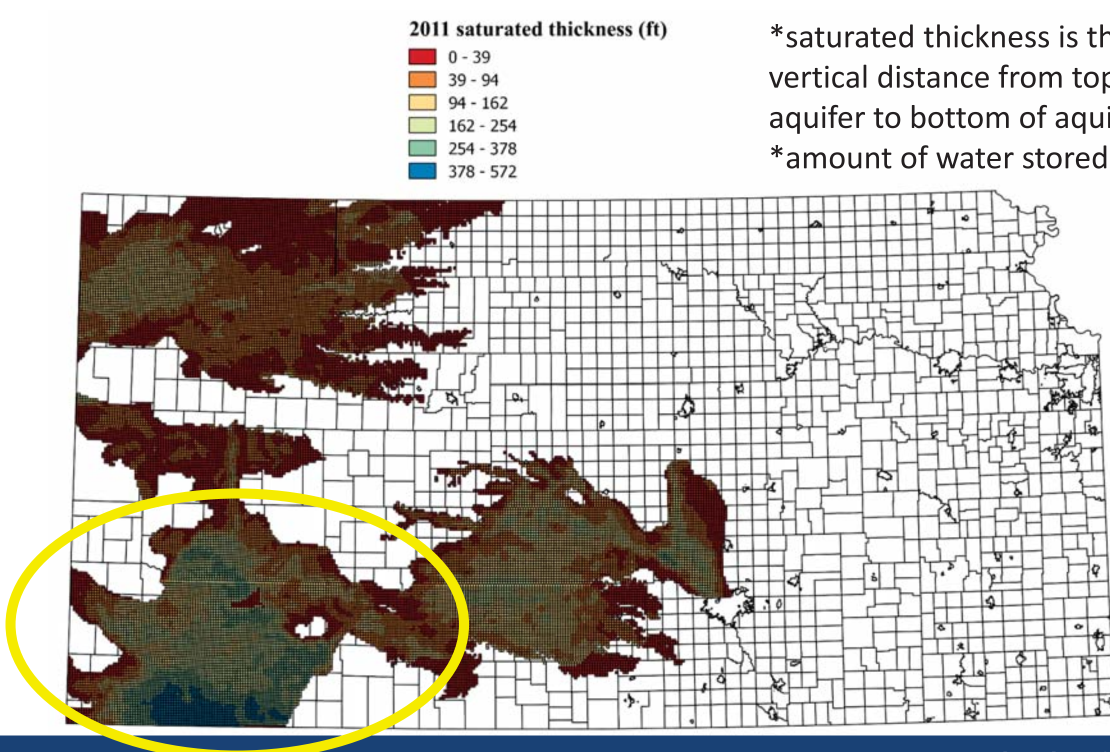


- Value of an acre-foot of water stored in the aquifer
- Grew from about $2/acre-ft in 1988 to $8/acre-ft in 2015

Change across space

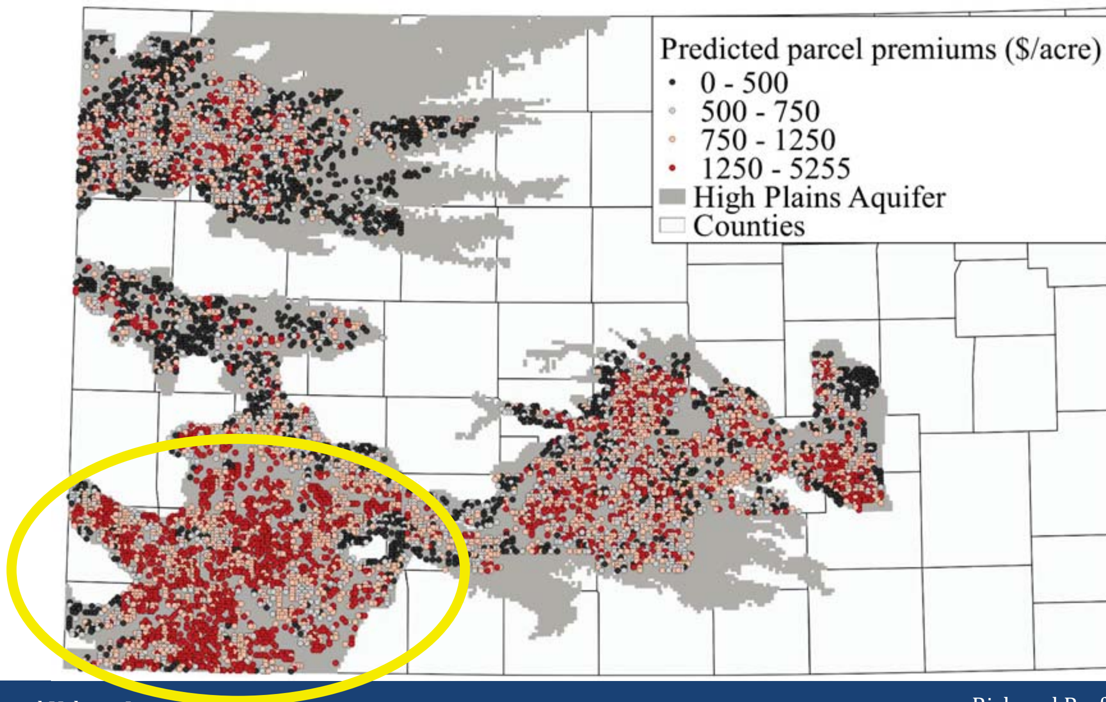
- Are irrigation premiums the same in each region of the HPA?
  - No - substantial differences in aquifer characteristics give rise to differences in premiums
- Estimate that irrigation premiums are largest in southwest and southcentral Kansas
  - Why? These regions have the greatest groundwater stocks
    - Generally more than 100 feet of saturated thickness

Data – groundwater stocks



*saturated thickness is the vertical distance from top of aquifer to bottom of aquifer
*amount of water stored

Change across space



Discussion

- Land values 53% higher for irrigated parcels, on average
  - Premium grew by 1.0 percentage point per year
- Value of one acre-ft stored under the parcel is about $3.42
  - Increased through time
    - $2/acre-ft in 1988
    - $8/acre-ft in 2015
- Highest irrigation premium in areas having abundant groundwater

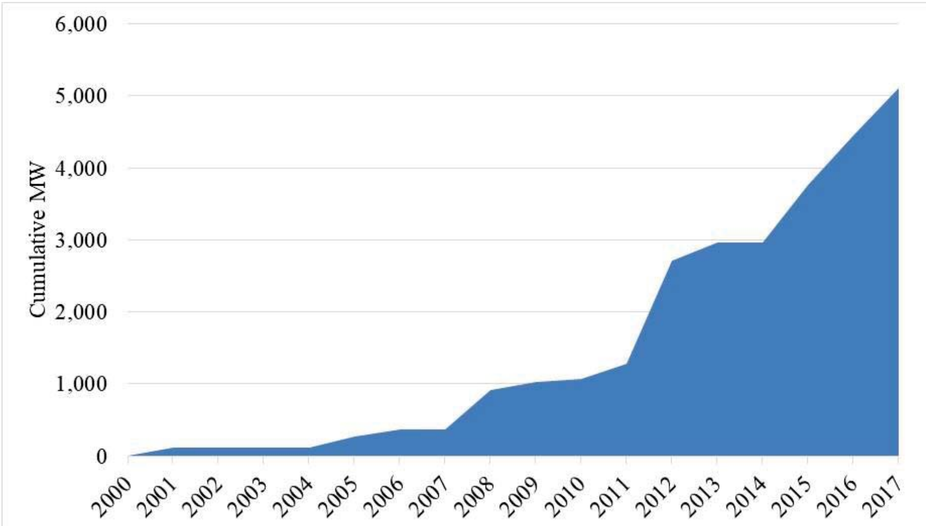
Part II: Wind turbines

Background

- Over one-third of electricity in Kansas was generated from wind power in 2017
- As of 2018: 2,996 wind turbines generating 5,500 MW of electricity
  - An additional 1,600 MW is under construction or development
- Controversy over turbine placement
  - + Job creation, tax revenues, lease payments
  - – Noise, blocking views, <u>impacts to land values</u>

Background

Installed wind capacity over time in Kansas



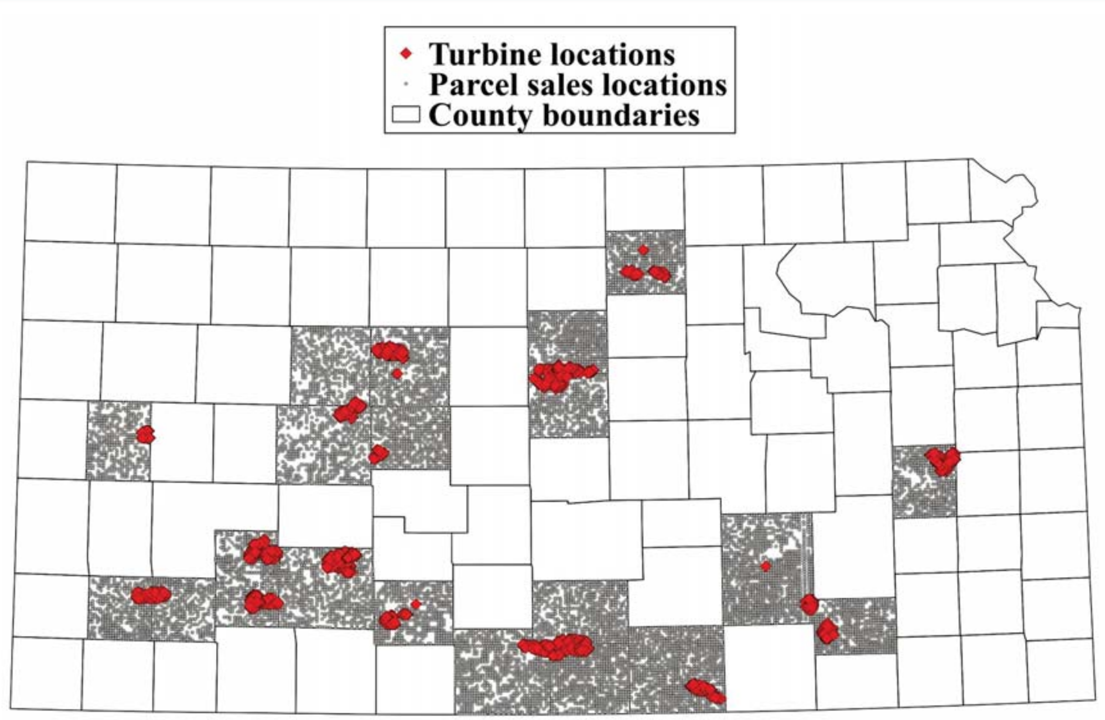
Background

County	Capacity (MW)	Turbines	Startup Year	2010 Population	Parcel Sales	Average Sales ($/acre)	Corn and soybean acres (1000s)
Gray	507.8	342	2001	6,006	867	3,193	93.7
Clark	429	208	2016	2,215	378	2,828	1.4
Ford	417.2	235	2006	33,848	767	2,255	53.7
Harper	281.6	176	2012	6,034	745	1,930	5.7
Lincoln	264.3	165	2008	3,241	632	2,168	12.3
Pratt	208.3	121	2016	9,656	529	2,265	73.2
Ellis	206.5	115	2013	28,452	524	1,948	3.5
Cloud	201.4	70	2008	9,533	530	2,417	48.0
Elk	199.8	111	2011	2,882	571	3,246	14.2
Coffey	199	95	2015	8,601	524	2,099	96.6
Ellsworth	186	124	2008	6,497	460	1,890	3.6
Barber	183.2	92	2009	4,861	670	4,134	5.4
Ness	168.3	94	2015	3,107	504	1,923	4.3
Butler	151	101	2005	65,880	1,299	3,142	80.0
Sumner	150	75	2015	24,132	1,153	2,170	68.0
Haskell	136.9	74	2013	4,256	622	4,557	108.4
Kiowa	116.6	76	2010	2,553	414	2,796	36.3
Grant	112.9	61	2013	7,829	705	3,013	49.1
Kingman	104	65	2012	7,858	586	2,071	19.0
Wichita	99	33	2009	2,234	354	2,094	34.9
Marshall	72	36	2016	10,117	605	3,194	168.0
Rush	46	20	2015	3,307	453	1,148	9.0
Trego	30.4	17	2015	3,001	356	1,603	8.9

Research questions

- How does proximity to wind turbines affect agricultural land values?
- Two different types of effects:
  - What is the effect of having turbines directly on the parcel?
  - What is the effect of having turbines close to a parcel (but not on it)?

Methodology



Methodology

- Similar as before
- Approach: use regression analysis to estimate effect that proximity to turbines has on land value
  - Exploit ~14,000 farmland transactions from 2001-2017 for parcels in counties having at least one utility-scale wind turbine
  - Data on all 2,506 utility-scale turbines in Kansas that are operational by 2017

Methodology

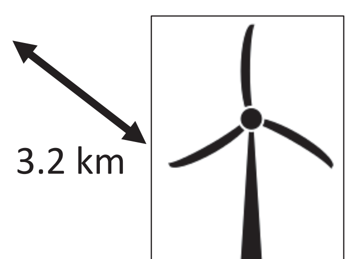
- Different types of proximity impacts
  - Turbines directly <u>on</u> the parcel
    - Landowner collects stream of lease payments from wind company
    - Lease terms range from 20 - 30 years and $1,500 - $9,500 per turbine per year
  - Turbines <u>near</u> the parcel
    - Possibly impacted by inconvenience/noise/etc
    - Measure proximity by:
      - Continuous distance measure (i.e., how many km away)
      - Set of fixed concentric rings
        - » 0-2km, 2-4km, 4-6km

Methodology

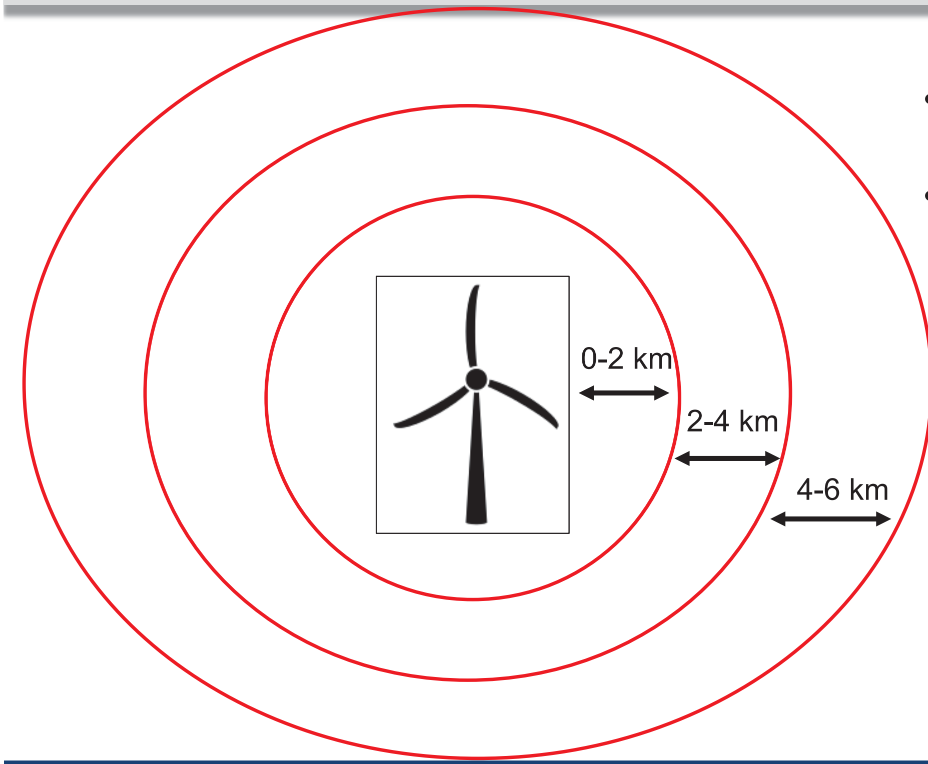
Turbines on the parcel

Methodology

Turbines near the parcel (continuous measure)



Methodology



- Turbine near the parcel
- Concentric ring measure

Methodology

- Suppose we observe 1 transaction for a parcel with turbines on it and 1 transaction for a parcel without turbines.
  - Parcel with turbines sells for $2,000/acre
  - Parcel without turbines sells for $2,000/acre
  - If the parcels are otherwise equivalent, then conclude that having turbines on a parcel does not significantly affect land value.

Methodology

- Need to control for these factors in the analysis
  - Soils: soil organic carbon, soil pH, water storage
  - Climate: historical temperature and precipitation
  - Urban influence: commute times to cities of 10,000+ or 40,000+ populations

Data

Turbine proximity measure	Mean	Std.D	Max/Count
Average distance to nearest turbine (km)	97.0	100	438.7
Turbine on parcel	0.003	0.056	44
Turbine 0-2km away	0.013	0.111	178
Turbine 2-4km away	0.014	0.116	193
Turbine 4-6km away	0.022	0.147	314

Data

Variable	Turbine on parcel	Turbine not on parcel
Price per acre	2,475.8	2,602.7
	(198.4)	(23.0)
Commute time to 10,000 population (hrs)	0.74	0.80**
	(0.020)	(0.003)
Commute time to 40,000 population (hrs)	1.65	1.63
	(0.058)	(0.007)
Proportion of parcel irrigated	5.5	8.3*
	(1.4)	(0.2)
Root Zone Available Water Storage (mm)	236.6**	228.1
	(4.40)	(0.50)
Soil Organic Carbon (kg/m^2)	9.59	9.63
	(0.17)	(0.03)
Acidic soils (proportion of land)	0.0	0.8*
	(0.0)	(0.1)
Basic soils (proportion of land)	58.3***	50.2
	(3.2)	(0.4)
Slope (%)	3.5	3.5
	(0.17)	(0.02)
Elevation (ft)	584.8	591.7
	(13.4)	(1.9)
Growing season precipitation (inches)	17.7	17.9
	(0.27)	(0.03)
Evapotranspiration (inches)	34.6	34.4
	(0.11)	(0.01)
Degree days between 10 and 32 Celsius (degrees*days)	2,054.6	2,051.7
	(6.04)	(0.92)
Degree days over 32 Celsius (degrees*days)	42.1	42.9
	(0.56)	(0.09)

Estimation results

- Do not find any overwhelming evidence that proximity to turbines affect agricultural land values
  - Parcels having a turbine onsite do not sell for any more or less than comparable parcels
  - Parcels with a turbine nearby are not negatively affected in terms of land value

Discussion

- Results suggest that turbines have not (yet) had any impact on agricultural land values
- Land owners interested in contracting with wind energy companies should not expect an increase or decrease in land value
- Wind energy is still relatively recent
  - Small number of land transactions with turbines onsite or nearby
  - Need to revisit the analysis as more data becomes available