ReadMe for Replication Code for "Between Wind and Water: Tradeoffs of Irrigation and Wind Projects" (Smith and Cooley)

This file provides an overview of the replication code for "Between Wind and Water: Tradeoffs of Irrigation and Wind Projects".

File Paths

Within the replication directory are four main subdirectories. "/data" contains .dta files necessary for replication. "/empirics" contains the necessary .do files. "/results" contains file structure where the outputs are to be stored, divided into "/results/figures", "/results/tables", and "results/intext". Finally, "/other_files" contains the non-Stata produced items and we provide the CPIS raster data output from the deep learning model.

Data

Descriptions of the data are included at the end of this document, summarizing the raw data sources and descriptions of the variables. Data are provided by spatial scale in four files contained in the data directory.

1. US_county_2010_Turbines_Irrigation_JAERE.dta
    - This file contains the county level variables utilized in the main text and appendices.
2. PLSS_Turbines_Irrigation_JAERE.dta
    - This file contains the PLSS, section level variables utilized in the main text and appendices.
3. WP_Data_JAERE.dta
    - This file contains the wind project level variables utilized in the main text and appendices.
4. turbine_JAERE.dta
    - This file contains the turbine level variables utilized in the appendices.

Empirics

Analysis for this paper was conducted using Stata/SE 18.0. Total run time on our machines ranged from 4 (Apple M2 Chip, 16GB) to 15 minutes (Intel i7 chip, 32GB).

Note: The following commands are drawn upon and may need downloaded and installed as well as any programs that they are built on:

1. reghdfe (created by Sergio Correia)
2. esttab (created by Ben Jann)

Note: The following .ado files are drawn and provided in the empirics/ado folder.

1. ols_spatial_HAC.ado (by Solomon Hsiang)

Empirical files are all provided in the "empirics" directory.

1. @Master.do
    a. This file sets the directories (***user needs to fill in the main directory***).
        i. If ols_spatial_HAC.ado is not installed, ***user needs to "uncomment" out the line to install it.***

b. This file also runs over all the other .do files and builds the tables and figures throughout the main text and appendices.
    i. Note that the following figures and tables are not a product of Stata and are excluded from .do files. We provide a table at the end of this file to summarize relevant information about them:
        1. Figure 1 – GIS map of wind power class and Ogallala Aquifer boundaries.
        2. Table 1 – Summary table of USDA cropland values and irrigated acres.
        3. Figure 2 – Conceptualization of irrigation effects on turbine placement consideration, field level aggregation.
        4. Figure 3 – Conceptualization of setbacks and CPIS.
        5. Figure 5 – Conceptualization of tradeoffs between CPIS and wind project layout.
        6. Figure 6a – GIS map of turbine locations relative to Ogallala Aquifer region.
        7. Figure 7 – Machine learning output.
        8. Figure A1 – Conceptualization of irrigation effects on turbine placement consideration, county level aggregation.
        9. Figure A5 – GIS maps of real turbine placement on satellite imagery of irrigated and non-irrigated areas.
        10. Figure D2 – Alternative section level CPIS orientations.

2. Setbacks/setback_simulation.do
    a. This file creates a data set to then illustrate the implications of setbacks on turbine placement within irrigated fields. This includes the acre effect (figure 4), percentage of field (figure A3), and scaling by the dollar values from table 1 (figure A4). Additionally, it produces a log file for specific numbers highlighted in section 2.
    b. Output (all output found in /results subdirectory):
        i. figures/fig4a_acres_quart_setback.pdf
        ii. figures/fig4b_acres_quart_setback.pdf
        iii. figures/figA3a_perc_quart_setback.pdf
        iv. figures/figA3b_perc_quart_setback.pdf
        v. figures/figA4a_cost_quart_setback.pdf
        vi. figures/figA4b_cost_quart_setback.pdf
        vii. intext/setback_numbers.log

3. County/County_Main.do
    a. This file conducts the primary county level analysis included in the main text. It produces the summary statistics by spatial zone (table 2), regression results for irrigation and center pivot irrigation on turbine installations (table 3), and the marginal effects from the Tobit model (table C2).
    b. Output (all output found in /results subdirectory):
        i. tables/tab2_county_balance.csv
        ii. tables/tab3_County_Irr_CPIS.csv (contains information for table C2, too)

4. PLSS/PLSS_Main.do
    a. This file conducts the primary PLSS section level analysis included in the main text. It produces the primary regression results that use county-fixed effects (table 4), alternative spatial fixed effect specification (figure 8), and the estimates for neighboring CPIS (figure 9). In addition, it produces the tabular support for figure 8 (table D1) and figure 9 (table D7) with the latter including additional neighbor CPIS specifications.
    b. Output:
        i. tables/tab4_PLSS_turb_CPIS_irr.csv
        ii. figures/fig8_plss_CPISIrr_FE_bin.pdf
            1. tables/tabD1a_PLSS_turb_FE.csv
            2. tables/tabD1b_PLSS_turb_FE.csv
            3. tables/tabD1c_PLSS_turb_FE.csv
        iii. figures/fig9_plss_CPIS_neighbors_bif_irr.pdf
            1. tables/tabD7_PLSS_turb_CPIS_neighbor_irr.csv
5. WP/WP_Main.do
    a. This file conducts the primary wind project level analysis included in the main text. It produces the average turbine distance to center pivot histogram (figure 10), visualization of the capacity factor regression on distance quintile (figure 11), and the robustness checks across covariates with "close" wind projects (turbines within 1.5 miles of CPIS) as the primary covariate (table 5).
    b. Output
        i. figures/fig10_wp_distance_distribution.pdf
        ii. figures/fig11_capfac_avt_tile_pan.pdf
        iii. tables/tab5_wp_capfac_pan_close.csv

6. County/County_Appendix.do
    a. This file conducts all the county level analysis included in the appendices aside from table C2 which is produced in the County_Main.do file. This includes the histogram of setbacks (figure A2), complete summary statistics (table B1), and descriptive aquifer share regressions (table C1). It produces a series of robustness checks including hazard model results (table C3), spatial HAC standard errors (table C4), alternative sample restrictions (table C5), results with alternative covariates (table C6). Last, it produces the auxiliary analysis of setbacks (table C7) and farm structure (tables C8 and C9)
    b. Output
        i. figures/figA2_psetback_dist.pdf
        ii. tables/tabB1_des_county.csv
        iii. tables/tabC1_County_Og_share.csv
        iv. tables/tabC3_County_haz.csv
        v. tables/tabC4_County_Irr_SpatialSE.csv
        vi. tables/tabC5a_county_irr_sampe.csv
        vii. tables/tabC5b_county_irr_sampe.csv
        viii. tables/tabC5c_county_irr_sampe.csv
        ix. tables/tabC6a_count_irr_cov.csv
        x. tables/tabC6b_count_irr_cov.csv

xi. tables/tabC6c_count_irr_cov.csv
xii. tables/tabC7_county_setback.csv
xiii. tables/tabC8a_County_farmstructure.csv
xiv. tables/tabC8b_County_farmstructure.csv
xv. tables/tabC9_County_farmstructure_wind.csv

7. PLSS/PLSS_Appendix.do
    a. This file conducts all the PLSS level analysis included in the appendices aside from tables D1 and D7 which are produced in the PLSS_Main.do file and figure D2 which is built in excel. This includes complete summary statistics (table B2) and a series of robustness checks; alternative spatial neighborhood standard errors (table D2), logit regressions (table D3), turbine count model (table D4), and alternative sample restrictions (table D5). It also provides the non-linear specifications of center pivot share including the histogram of shares and indicator variable definitions (figure D1 – illustration added ex-post in Adobe Pro), visualization of the point estimates of the non-linear regression (figure D3), and tabular results for non-linear specifications (table D6). Finally, it produces the numbers for the counterfactual of removing the center pivots on turbine installation drawn on in section 7 and information on within fixed effect variation.
    b. Output
        i. tables/tabB2_des_plss.csv
        ii. tables/tabD2_PLSS_turb_SE_rob_irr.csv
        iii. tables/tabD3_PLSS_turb_logit_irr.csv
        iv. tables/tabD4_PLSS_turb_count_irr.csv
        v. tables/tabD5_PLSS_turb_ind_sample_rob_irr.csv
        vi. figures/figD1_CPIS_share_histogram.pdf
        vii. figures/figD3_plss_CPIS_bin_irr.pdf
        viii. tables/tabD6_PLSS_turb_CPIS_ind_irr.csv
        ix. intext/tables/discussion_plss_turbine_counter.log
        x. intext/footnote28_within_variation.log

8. WP/WP_Appendix.do
    a. This file conducts all the WP level analysis included in the appendices. This includes complete summary statistics (table B3), visualizations of the capacity factor regression on distance deciles and mile bins (figures E2 and E3) and tabular results of the underlying semi-parametric regressions (table E1). In addition, there is a series of robustness checks; different covariates with "closer" wind projects (turbines within 0.6 miles of CPIS) as the primary covariate (table E2), cross-sectional regressions for each individual year and average capacity factor (table E3), alternative spatial HAC standard errors (table E4), and measuring irrigation presence by the share irrigated and with CPIS of the expanded convex hulls (table E5). It also produces the output of the wind farm characteristic regressions on center pivot proximity (Table E6). Finally, it conducts the wind project counterfactual drawn on in section 7.
    b. Output
        i. tables/tabB3_des_wp.csv

ii. figures/figE2_capfac_avg_decile_pan.pdf
iii. figures/figE3_capfac_milebinavg_dist_pan.pdf
iv. tables/tabE1_wp_capfac_pan_bins.csv
v. tables/tabE2_wp_capfac_pan_closer.csv
vi. tables/tabE3a_wp_capfac_year_close.csv
vii. tables/tabE3b_wp_capfac_year_closer.csv
viii. tables/tabE4_wp_capfac_HAC.csv
ix. tables/tabE5_wp_irr_buffer.csv
x. tables/tabE6a_wp_con_close_var.csv
xi. tables/tabE6b_wp_con_close_var.csv
xii. intext/discussion_wp_cap_counter.log

9. Turbines/turbine_main_appendix.do
    a. This file conducts all analysis based on the turbine level data included in the main text and appendices. This includes the zonal aggregations of installed capacity over time (figure 6b), turbine distances from PLSS section centroids based on CPIS presence (figure E1 – illustration added ex-post in Adobe Pro), and regressions for turbine characteristics and center pivot proximity (table E7).
    b. Output
        i. figures/fig6b_a_cap_buffer.pdf
        ii. figures/figE1_turbine_centroid_distance_distribution.pdf
        iii. tables/tabE7a_turbine_cpis.csv
        iv. tables/tabE7b_turbine_cpis.csv
            1. Note that the coefficient is estimated as "close", so the sign of the coefficient is opposite to that reported in the appendix.

Non-Stata Display Items in the paper

Several items in the text and appendices are not created through Stata. The table below summarizes those items. Files can be found in "other_files".

Item	*Short Description*	*Software*	*File(s)*
Figure 1	Wind class and Ogallala	Made in ArcGIS Pro	fig1_US_Onshore_Ogallala.pdf
Table 1	USDA Values and Irrigation	Excel only	tab1_usda.xlsx
Figure 2	DAG-Section	Power Point	fig2_and_figA1.ppt
Figure 3	Setback illustration	Excel	fig3_fig5_figD2_CPISlayouts.xlsx
Figure 5	Trade off illustration	Excel	fig3_fig5_figD2_CPISlayouts.xlsx
Figure 6a	Spatial locations	Made in ArcGIS Pro	fig6a_extensive_og_map.pdf
Figure 7a	Machine Learning Groundtruth	Made in ArcGIS Pro	fig7a_Bluescale_image1_update.pdf
Figure 7b	Machine Learning Output	Made in ArcGIS Pro	fig7b_red_box_extent_Ogallala_Overview.pdf
Figure A1	DAG-County	Power point	fig2_and_figA1.ppt
Figure A5	Satelite overview	Made in ArcGIS Pro	extensitve.png, intensive.png, extensive_IL.png, intensive_IL.png
Figure D2	Alternative indicators	Excel only	fig3_fig5_figD2_CPISlayouts.xlsx

Machine Learning Output

In "other_files/machinelearning", we have provided the raster output of the machine learning process identifying center pivot locations in 2008 across the Ogallala region (+100 km beyond the border).

Additional Data Information

The following summarizes the sources of the data utilized. First, we provide a general guide mapping the variable type to its source, second we provide tables with specific information on how those raw data sources are transformed to variables at the distinct aggregations of observations, and third we provide the complete reference information.

Data source overview:

- *Turbine data (location, capacity, year, height, rotor swept area), Hoen et al. (2018)*
- *Wind project production, EIA (2021)*
- *Center pivot share, Cooley et al. (2021)*
- *Section-level irrigation status and shares, Pervez and Brown (2010)*
- *County farmland, cropland, and irrigated shares, Haines et al. (2018)*
- *Share cropland, forest, and developed, USDA NASS (2019)*
- *Wind power class, National Renewable Energy Laboratory (NREL) (2015)*
- *Elevation data, USGS (1996)*
- *Soil data, USDA NRCS (2006)*
- *Stream data, USGS (2014)*
- *Temperature and precipitation, PRISM Climate Group (2004)*
- *Population density, U.S. Census Bureau (2012)*
- *Transmission lines, U.S. DHS (2017)*
- *County/state borders, Minnesota Population Center (2011)*
- *PLSS section borders, Bureau of Land Management (2020)*
- *Ogallala Aquifer borders, USGS (2003)*
- *County setback rule, Winikoff (2022)*

Variable details:

1. ***County level variables*** (US_county_2010_Turbines_Irrigation_JAERE.dta) are all aggregated to counties as defined in Minnesota Population (2011).

Variable	Stata Name	Description
Ogallala Share	share_og	Share of county overlying the Ogallala aquifer (USGS 2003)
Central Ogallala Share	share_og_neg20	2003)
Ogallala Plus 63 Miles (100 km) Buffer Share	share_og_pos100	Share of county overlying the Ogallala aquifer plus a 63 mile (100 km) buffer (USGS 2003)
Average Wind Class	ave_wind_class	Spatial average of the wind class in the county (NREL 2015)
Max Wind Class	max_wind_class	Maximum wind class in the county (NREL 2015)
Center Pivot Share	cpis	Share of entire county area with center pivot pixels from the deep learning model (Cooley et al. 2021)
Irrigated Share	irrigated_a	Share of entire county area irrigated in 2007 according to the USDA Census (Haines et al. 2018)
Cropland Share	crop_a	Share of entire county area in cropland in 2007 according to the USDA Census (Haines et al. 2018)
Farmland Share	farm_a	Share of entire county area in farmland in 2007 according to the USDA Census (Haines et al. 2018)
Wind Capacity per Acre	t_cap_a	Total wind capacity installed (MW) divided by county acres as of 2020 (Hoen et al. 2018)
First Turbine Year	first_year	First year a wind turbine was installed in the county (Hoen et al. 2018)
Average Turbine Year	ave_year	The average year of all wind turbines installed in the county (Hoen et al. 2018)
Transmission Lines (miles/mile^2)	trans_length_a	Miles of transmission lines per square mile in the county (US DHS 2017)
Population Density	pop_density	Population per square mile (US Census Bureau 2012)
Average Elevation (ft)	elev	Spatial average of elevation for the county (USGS 1996)
Standard Deviation of Elevation (ft)	elev_std	Standard deviation of elevation for the county (USGS 1996)
Average Soil Class	soil	Spatial average of soil class (1-8, lower="better") for the county (USDA NRCS 2006)
Stream Access	stream_3_15	Share of county within 15 miles of a strahler order 3 or higher stream (USGS 2014)
Average Temperature (^{o}F)	tmean	Spatial average of the 30-year average temperature (PRISM 2004)
Average Precipitation (inches)	ppt	Spatial average of the 30-year average of annual precipitation (PRISM 2004)
Latitude	lat_county	Centroid Latitude (Minnesota Population Center 2011)
Longitude	lon_county	Centroid Longitude (Minnesota Population Center 2011)
Spatial Error Cluster	cluster_km	Arbitrary 93x93 mile spatial grid membership based on wind project county
Property Setback (ft)	pback18	Property setback requirement in the county (Winikoff 2022)
Structure Setback (ft)	sback18	Structure setback requirement in the county (Winikoff 2022)
Ogallala County	og	Indicator equal to one if over 50 percent of county is over the Ogallala Aquifer (USGS 2003)
Central Ogallala County	central_og	Indicator equal to one if over 50 percent of county is over the central Ogallala Aquifer, defined as 20 miles (32 km) inside the official border (USGS 2003)
Border Ogallala County	og_ring	Indicator equal to one if over 50 percent of county is over the Ogallala Aquifer, but not over the central portion (USGS 2003)
Beyond Ogallala County	non_og	2003)
Beyond Sample County	beyond_samp	Indicator equal to one if county is in an Ogallala State, but with zero percent over the 63 miles (100 km) buffer around the Ogallala aquifer border (USGS 2003)
Farm Value per Farm Acre (logged)	lnfarmvalue_a	Log of farm value per county acre (Haines et al. 2018)
Rate of Change in Farm Value	perdeltafarmvalue_a	Rate of change in farm value per farm acre, 1959 to 2007 (Haines et al. 2018)
Crop Value per Crop Acre (logged)	lncropvalue_a	Log of crop value per county acre (Haines et al. 2018)
Rate of Change in Crop Value per Acre	perdeltacrop_val_a	Rate of change in crop value per crop acre, 1959 to 2007 (Haines et al. 2018)
Average Farm Acreage (logged)	lnave_farm	Log of average farm acres (Haines et al. 2018)
Rate of Change in Average Farm Size	perdeltaave_farm	Rate of change in average farm size, 1959 to 2007 (Haines et al. 2018)
Tenant Operated Share of Acres	ttenant_a	Tenant operated acres per county acre (Haines et al. 2018)
Rate of Change in Tenant Acres	perdeltattenant	Rate of change in tenant acreage share, 1959 to 2007 (Haines et al. 2018)
Rate of Change in Farm Acres	perdeltafarm	Rate of change in farm share of county, 1959 to 2007 (Haines et al. 2018)
Rate of Change in Crop Acres	perdeltacrop	Rate of change in cropland share of county, 1959 to 2007 (Haines et al. 2018)
Cropping Intensity	farmintens	Crop acreage share of farm acres (Haines et al. 2018)
Rate of Change in Crop Intensity	perdeltafarmintens	Rate of change in crop share of farm land, 1959 to 2007 (Haines et al. 2018)
Change in Irrigated Share	deltairrigated	Change in irrigated share of county, 1959 to 2007 (Haines et al. 2018)
Change in CPIS Share	deltacpis	Change in CPIS share of county, 1959 to 2008 (Haines et al. 2018 and Cooley et al. 2021)
County Name	name10	County Name
County FIPs Code	geoid10	County FIP code
State FIPs Code	statefp10	State FIP Code

2. ***PLSS section level variables*** (PLSS_Turbines_Irrigation_JAERE.dta) are all aggregated to the PLSS section, first division ID, as defined in BLM (2020).

Variable	Stata Name	Description
Ogallala Share	share_og	Share of section overlying the Ogallala aquifer (USGS 2003)
Central Ogallala Share	share_og_neg20	2003)
Ave. Wind	ave_wind_class	Spatial average of the wind class in the section (NREL 2015)
Max Wind	max_wind_class	Maximum wind class in the section (NREL 2015)
Center Pivot Share	CPIS_per	Share of section with center pivot pixels from the deep learning model (Cooley et al. 2021)
1[Center Pivot]	cpis_ind2	Indicator whether the center pivot share is greater than the equivelant of a quarter-quarter section (≥ 0.05) (Cooley et al. 2021)
Equivalent CPIS Quarter Sections	CPIS_bin	Categorical variable of the equivalent number of quarter-sections (160 acres) served by a CPIS, omitting those with less than 0.05 share CPIS (Cooley et al. 2021)
No. Neighbors with CPIS	cpis_neighbors	2021)
Distance to Nearest CPIS Not on Section (miles)	othercpis_dist	Distance to the nearest CPIS that is not on the section iteslf (Cooley et al. 2021)
Irrigated Share	irr_mean	Share of section with irrigation pixels from MIrAD (Pervez and Brown 2010)
1[Irrigated]	irrigated	Indicator whether the irrigated share is greater than the equivelant of a quarter-quarter section (≥ 0.05) (Pervez and Brown 2010)
Cropland Share	sharecropland	Share of the section covered in some crop from CropScape data in 2008 (USDA NASS 2019)
1[Turbine]	turbine	Indicator whether a turbine is present on a section as of 2020 (Hoen et al. 2018)
Turbine Count	turbine_count	Number of turbines present on a section as of 2020 (Hoen et al. 2018)
Turbine Year	p_year	The year (or average year if more than one) of the turbine on a section (Hoen et al. 2018)
Average Elevation (ft)	elev_mean	Spatial average of elevation for the section (USGS 1996)
Standard Deviation of Elevation (ft)	elev_std	Standard deviation of elevation for the section (USGS 1996)
Average Soil Class	soil	Spatial average of soil class (1-8, lower="better") for the section (USDA NRCS 2006)
Distance to Stream (miles)	stream3_dist	Distance from a stream of strahler order 3 or higher (USGS 2014)
Average Temperature (°F)	tmean	Spatial average for the section of the 30-year average temperature (PRISM 2004)
Average Precipitation (inches)	ppt_mean	Spatial average for the section of the 30-year average of annual precipitation (PRISM 2004)
Share Developed	sharedeveloped	Share of the section "developed" as classified by CropScape data in 2008 (USDA NASS 2019)
Share Forested	shareforest	Share of the section forested as classified by CropScape data in 2008 (USDA NASS 2019)
Distance to Transmission Lines (miles)	powerlines_dist	Distance to nearest transmission line (US DHS 2017)
State of Section	state	State the section is in (BLM 2020)
County of Section	county_id	County the section is in (BLM 2020)
PLSS Township ID	plssid	Township the section is in (BLM 2020)
PLSS Section ID	frstdivid	First division the section is (BLM 2020)
PLSS Section Number	section_nr	Section number of the section (BLM 2020)
Wind Project Name	p_name	Name of wind project the turbine is from (Hoen et al. 2018)
Non-String State ID	alt_state_id	Variable for state fixed effects
Within State Variation	turb_alt_state_id_ind	model
Non-String County ID	alt_county_id	Variable for county fixed effects
Within County Variation	turb_alt_county_id_ind	Indicator equal to one for counties with variation within county of turbines for inclusion in logit model
Non-String Township ID	alt_plssid	Variable for township fixed effects
Within Township Variation	turb_alt_plssid_ind	Indicator equal to one for townships with variation within township of turbines for inclusion in logit model
Non-String Township Thirds ID	fe_town_3	Variable for township thirds fixed effects, defined as "horizonal" 6x3 thirds (sections 1-12, 13-24, 25-36)
Non-String Township Fourths ID	fe_town_4	Variable for township fourths fixed effects, defined 3x3 sub-squares of townships
Non-String Township Ninths ID	fe_town_9	Variable for township ninths fixed effects, defined 2x2 sub-squares of townships
Spatial Error Cluster	cluster_km	Arbitrary 93x93 mile spatial grid membership based on the county the section is in
Latitude	lat	Latitude of the centroid of the section (BLM 2020)
Longitude	lon	Longitude of the centroid of the section (BLM 2020)

3. ***Wind project level variables*** (WP_Data_JAERE.dta) are all aggregated to the convex hull formed by the wind turbines in each project defined by Hoen et al. (2018) and calculated in ArcGIS.

Variable	Stata Name	Description
Annual Output (MWh)	mwh_*	The annual output of the wind project, 2010-2020 (EIA 2021)
Annual Capacity Factor	capfac_*	The annual output/(project capacity*8,760), 2010-2020 (EIA 2021)
Average Output (MWh)	ave_mwh	The average annual output of the wind project, 2010-2020 (EIA 2021)
Turbine Count	p_tnum	Number of turbines in the wind project (Hoen et al. 2018)
Project Capacity (MW)	p_cap	Wind project total capacity (Hoen et al 2018.)
Project Capacity (MW), logged	lnp_cap	Natural log of wind project total capacity (Hoen et al. 2018)
Average Capacity Factor	capfac	Average output/(project capacity*8,760) for 2010-2020 (EIA 2021)
Total Acres	area_con	Area of the convex hull for the wind project, calculated in ArcGIS (Hoen et al. 2018)
Capacity per Acre	power_area_con	Wind project capacity divided by area (Hoen et al. 2018)
Turbines per Acre	density_con	Number of turbines in the wind project divided by area (Hoen et al. 2018)
Ave. Power Capacity (kW)	t_cap	Total capacity of wind project divided by the number of turbines (Hoen et al. 2018)
Ave. Height (ft)	t_hh	Average height of turbines in the wind project (Hoen et al. 2018)
Ave. Swept Area (ft^2)	t_rsa	Average rotor swept area of turbines in the wind project (Hoen et al. 2018)
Project Year	min_p_year	Year that the wind project became operational (Hoen et al. 2018)
Ave. Wind	ave_wind_class_con3	Spatial average of the wind class in the convex hull (NREL 2015)
Max Wind	max_wind_class_con3	Maximum wind class in the convex hull (NREL 2015)
Average Distance to CPIS (miles)	avg_dist	Averge distance of all turbines in the project from the edge of a center pivot (Cooley et al. 2021)
First Quintile of CPIS Distance	closer	Equal to one if wind project is in the closest average distance to CPIS quintile bin
First Two Quintiles of CPIS Distance	close	Equal to one if wind project is in the closest to average distance to CPIS quintile bin
Avg. Distance Binned by Quintile	avg_tile	Average turbine distance of project split into equal quintiles
Average Distance Binned by Decile	avg_decile	Average turbine distance of project split into equal deciles
Avg. Distance Binned by Mile	milebinavg_dist	Average turbine distance of project split into miles, combining 10 or more
Center Pivot Share	shareCPIS_con	Share of convex hull with center pivot pixels from the deep learning model (Cooley et al. 2021)
Share Irrigated Buffer	irrigated_buffer	Share of the convex hull plus 1.5 mile buffer with irrigation (Pervez and Brown 2010)
Share of CPIS Buffer	cpis_buffer	Share of the convex hull plus 1.5 mile buffer with irrigation (Cooley et al. 2021)
Cropland Share	sharecropland_con3	Share of the convex hull covered in some crop from CropScape data in 2008 (USDA NASS 2019)
Average Elevation (ft)	elev_mean_con3	Spatial average of elevation for the convex hull (USGS 1996)
Standard Deviation of Elevation (ft)	elev_std_con3	Standard deviation of elevation for the convex hull (USGS 1996)
Average Soil Class	soil_con3	Spatial average of soil class (1-8, lower="better") for the convex hull (USDA NRCS 2006)
Distance to Stream (miles)	stream3_dist_con3	Distance from a stream of strahler order 3 or higher (USGS 2014)
Average Temperature (^oF)	tmean_con3	Spatial average for the convex hull of the 30-year average temperature (PRISM 2004)
Average Precipitation (inches)	ppt_mean_con3	Spatial average for the convex hull of the 30-year average of annual precipitation (PRISM 2004)
Share Developed	sharedeveloped_con3	Share of the convex hull "developed" as classified by CropScape data in 2008 (USDA NASS 2019)
Share Forested	shareforest_con3	Share of the convex hull forested as classified by CropScape data in 2008 (USDA NASS 2019)
Distance to Transmission Lines (miles)	powerlines_dist_con3	Distance to nearest transmission line (US DHS 2017)
Wind Project	wp_name	Name of wind project (Hoen et al. 2018)
EIA ID Number	eia_id	EIA ID number for the wind project (EIA 2021 and Hoen et al. 2018)
State	state	First non-missing State for a turbine in the wind project (Hoen et al. 2018)
Multiple State	multi_s	Equal to one if turbines of the project are in more than one State (Hoen et al. 2018)
County	county	First non-missing county for a turbine in the wind project (Hoen et al. 2018)
Multiple County	multi_c	Equal to one if turbines of the project are in more than one county (Hoen et al. 2018)
Spatial Error Cluster	cluster_km	Arbitrary 93x93 mile spatial grid membership based on wind project county
Latitude	ylat_con3	Latitude of Convex Hull Centroid (Hoen et al. 2018)
Longitude	xlong_con3	Longitude of Convex Hull Centroid (Hoen et al. 2018)
Area of Wind Project	area_con	Acreage of the convex hull of the wind project (Hoen et al. 2018)

4. ***Turbine level variables*** (turbine_JAERE.dta) are based on individual turbines (and their locations) as defined in Hoen et al. (2018)

Variable	Stata Name	Description
Turbine Capacity (kW)	t_cap	Turbine nameplate capacity (Hoen et al. 2018)
Turbine Height (ft)	t_hh	Turbine height (Hoen et al. 2018)
Turbine Swept Area (ft^2)	t_rsa	Rotor swept area of the turbine (Hoen et al. 2018)
Turbine Year	p_year	Year the project the turbine is in was installed (Hoen et al. 2018)
Project Name of Turbine	p_name	Name of wind project the turbine is part of (Hoen et al. 2018)
Buffer Zone Name	buffer_zone	Area relative to the Ogallala border the turbine is located in: inner (-20 miles), main buffer (+/- 20 miles), beyond outer (+20 miles)
Buffer Zone Membership	local	Numeric code of the Ogallala buffer zones
Area of the Entire Buffer Zone (acres)	area_local	Area of the three buffer zones
Distance to Nearest CPIS (miles)	cpis_miles	Distance from the turbine to the nearest CPIS raster (Cooley et al. 2021)
Indicator if Turbine is with 0.1 Miles of CPIS	close	Indicator equal to one if the turbine is within 0.1 miles of a CPIS raster
Distance to Centroid of Section (ft)	centroid_dist	Distance of the turbine to the centroid of the PLSS section it is located in (BLM 2020)
Equivalent CPIS Quarter Sections	CPIS_bin	Of the PLSS section the turbine is in, the categorical variable of the equivalent number of quarter-sections (160 acres) served by a CPIS, omitting those with less than 0.05 share CPIS (Cooley et al. 2021)
Spatial Error Cluster	cluster_km	Arbitrary 93x93 mile spatial grid membership based on wind turbine county
Latitude	ylat	Latitude of the wind turbine
Longitude	xlong	Longitude of the wind turbine
State of Turbine	t_state	State the turbine is located in (Hoen et al. 2018)
Model of Turbine	t_model	Manufacturer and model of the wind turbine (Hoen et al. 2018)
County of Turbine	t_county	County the turbine is in
FIP Number of County Turbine is in	t_fips	County FIP code
EIA ID for Wind Project	eia_id	EIA ID number for the wind project (Hoen et al. 2018)

Data References

Bureau of Land Management (2020). BLM National Public Land Survey System Polygons – National Geospatial Data Asset (NGDA).

Cooley, Daniel, Reed M. Maxwell, and Steven M. Smith. 2021. Center Pivot Irrigation Systems and Where to Find Them: A Deep Learning Approach to Provide Inputs to Hydrologic and Economic Models. Frontiers in Water.

EIA. 2021. Form EIA-923 detailed data with previous form data (EIA-906/920).

Haines, Michael, Price Fishback, and Paul Rhode. 2018. United States Agriculture Data, 1840 - 2012.

Hoen, B.D., J.E. Diffendorfer, J.T. Rand, L.A. Kramer, C.P. Garrity, and H.E. Hunt. 2018. United States Wind Turbine Database (USWTDB).

Minnesota Population Center. 2011. National Historical Geographic Information System: Version 2.0.

National Renewable Energy Laboratory (NREL). 2015. Wind Data: United States Wind Power Class - no exclusions.

Pervez, Md Shahriar, and Jesslyn F Brown. 2010. Mapping irrigated lands at 250-m scale by merging modis data and national agricultural statistics. Remote Sensing 2 (10): 2388–2412.

PRISM Climate Group. 2004. PRISM Climate Data.

U.S. Census Bureau. 2012. County Intercensal Tables: 2000-2010.

U.S. DHS. 2017. Electric Power Transmission Lines, Homeland Infrastructure Foundation-Level Data.

US EIA. 2021. Monthly Energy Review and Electric Power Monthly.

USDA NASS. 2019. USDA National Agricultural Statistics Service Cropland Data Layer.

USDA NRCS. 2006. Digital General Soil Map of US: Tabular Digital Data and Vector Digital Data.

USGS. 1996. USGS EROS Archive - Digital Elevation - Global 30 Arc-Second Elevation (GTOPO30).

USGS. 2003. Principal Aquifers of the 48 Conterminous United States, Hawaii, Puerto Rico, and the US Virgin Islands: Digital Data.

USGS. 2014. USGS Small-scale Dataset - 1:1,000,000-Scale Hydrographic Geodatabase of the United States - Conterminous United States 201403 FileGDB 10.1.

Winikoff, Justin B. 2022. Learning by regulating: The evolution of wind energy zoning laws. The Journal of Law and Economics 65 (S1): S223–S262.