

RENEWABLE ENERGY AND LOCAL ECONOMIC GROWTH: THE EFFECT OF WIND FARMS ON EMPLOYMENT AND INCOME

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Abstract

This paper examines the local economic effects of wind farm development in the United States. Using state-level panel data from 1998-2021, this paper estimates the impact of wind power expansion on employment and per capita income, measured by two proxies for renewable energy investment: the number of wind turbines and wind power capacity (in megawatts). The empirical strategy exploits variation across US states and over time, controlling for state and year fixed effects, to identify the effects of wind energy growth. The results show that wind power development significantly increases local employment but has little effect on per capita income overall. However, wind power deployment significantly increases local employment and income in the ten states with the largest wind energy capacity. These findings imply that, beyond environmental gains, renewable energy investment can create local economic benefits, particularly when reaching sufficient scale.

Keywords: Wind energy, Renewable energy, Local economic growth, Regional development

JEL Codes: Q56 (Environment and Development), O44 (Environment and Growth), E24 (Employment and Wages), J23 (Labor Demand)

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Introduction

There has been a rapid surge in wind power development globally over the years. Although wind energy contributed only a small share of total electricity generation in 2008 (1.9% in the U.S. and 1.5% worldwide), the sector has grown dramatically since then (Wiser & Bolinger, 2009). By the end of 2023, the U.S. total wind capacity reached 147.5 GW, accounting for roughly 12% of the total electricity capacity (Morey & Jell, 2024; Climate Central, 2024). The growth of wind energy has been even more rapid in China, which currently holds over 40% of the world's capacity (Wiser & Bolinger, 2011; Ember, 2025).

A range of government policies has primarily driven this remarkable growth of wind energy. In the U.S., the Production Tax Credit (PTC) has played a central role by providing a tax credit for electricity produced by eligible wind facilities during their first decade of operation. The Inflation Reduction Act (IRA) of 2022 extended and enhanced this financial incentive (EPA, 2024). In addition, the European Union's 2020 Climate and Energy Package, enacted in 2009, established binding renewable energy targets requiring member states to generate at least 20% of their energy from renewable sources by 2020 (Costa & Veiga, 2021). At the state level, Renewable Portfolio Standards (RPS), first introduced by Iowa in 1983, have also created long-term markets for wind energy by mandating that utilities procure a specific share of electricity from renewable resources (NCSL, 2021).

Wind power is known for its significant environmental benefits. Wind turbines enable electricity generation without combustion and thus help reduce carbon dioxide emissions and air and water pollution (GWE Council, 2016). Furthermore, wind energy reduces dependence on fossil fuels and mitigates fuel supply risks. Finally, because wind turbines require relatively small footprints, wind energy deployment can coexist with agricultural activity in rural areas. Because of these attributes, wind power has the potential to become a critical part of global decarbonization strategies.

Beyond its environmental benefits, wind energy has increasingly been considered as a potential driver of local economic development. Wind projects create substantial short-term employment during construction and permanent operation and maintenance jobs after completion (Hartley et al., 2015; Costa & Veiga, 2021). The International Renewable Energy Agency (IRENA) reported in 2019 that the wind power industry employed approximately 1.15 million people worldwide in 2017, across both onshore and offshore segments. Additionally, wind farms can generate tax revenue for local governments and contribute to public funding for schools and infrastructure (Costa & Veiga, 2021). Moreover, thanks to the wind turbine lease payments, landowners in rural areas now have stable additional income (Gonçalves et al., 2020).

Nevertheless, public opinions on wind farm development are mixed. While surveys generally show broad public support for renewable energy, opposition often arises during the siting and permitting process (Wolsink, 2000; Firestone & Kempton, 2006). These concerns include visual intrusion from large turbines, loud noise, and perceived effects on nearby property values (Hoen et al., 2009). These issues highlight the importance of understanding not only the environmental benefits but also the economic and social consequences of wind energy projects.

Despite strong policy interest, evidence on the long-term employment effects of wind power remains limited and inconsistent. Some studies investigate only direct job creation, while others aim to capture broader indirect effects (Dvořák, 2017; Hondo, 2017). The definition and measurement of "employment" also vary among studies, leading to different conclusions (Aldieri et al., 2020). Moreover, the industry currently faces a growing challenge of skill gaps, where firms report difficulty hiring qualified high-skilled employees while workers struggle to acquire specialized training. Consequently, it is important to better understand how wind energy expansion influences local labor markets and which types of jobs are created, to inform the design of labor and education policies (IEA, 2019).

Answering these questions is important for both policymakers and industry stakeholders. First, credible evidence on the local economic impacts of renewable energy can help state and local governments design subsidy programs and development initiatives. Second, understanding the skills gap is important for aligning training and hiring strategies. In particular, a clear understanding of talent shortages could encourage firms to invest in targeted training and recruitment programs and to prepare for the foreseeable high demand for specialized labor. Finally, this information helps communities that consider wind energy development weigh the long-term economic and job-creation benefits against potential drawbacks, such as noise pollution and visual concerns.

This study contributes to the growing literature on the socioeconomic effects of renewable energy by analyzing how wind power development affects state-level employment and income in the U.S. Prior research in this area has produced mixed findings. Brown et al. (2012) examine how wind power development affects local economies using county-level panel data from 2000 to 2008. They use fixed effects regressions and find positive effects on income and employment. Loomis et al. (2016) employ an input–output model to examine 23 large wind farms in Illinois and report local economic gains. In contrast, Hartley et al. (2015) estimate job creation from wind power, shale oil, and gas using monthly county-level data from 2001 to 2011 for Texas and find no significant impact of wind power on either local employment or wages. Gibbons (2015) analyzes how the visual environmental impacts of wind farms reduce local house prices in England and Wales. By providing new evidence using state-level data for a more recent period, this study would help bridge this gap by focusing on the local economic implications of large-scale wind energy deployment in the United States.

The remainder of the paper is organized as follows. Section 2 describes the data used for the regression analysis and provides an overview of the U.S. wind energy market. Section 3 outlines the regression model used to examine the effect of wind energy expansion on local employment and income. Section 4 discusses the results of this econometric analysis, and Section 5 provides a conclusion.

Data

This study combines data from multiple publicly available sources to examine how wind power development affects state-level employment and income outcomes in the U.S. These data sources include the U.S. Wind Turbine Database (USWTDB), the Bureau of Economic Analysis (BEA) Regional Economic Accounts, and the BEA State Population Estimates.

1. U.S. Wind Turbine Database (USWTDB)

The U.S. Wind Turbine Database provides an inventory of land-based and offshore wind turbines in the United States starting from 1998. The database includes detailed information for each wind project, including project name, location (latitude and longitude), installation year, capacity, hub height, rotor diameter, and project identifier.

For this analysis, I aggregate the data to the state–year level to capture the evolution of wind power development across states over time. Particularly, for each state and year, I calculate the total number of installed turbines and total wind capacity (measured in megawatts). These variables serve as the main proxies for wind energy deployment, enabling this paper to track both the intensity and timing of wind power expansion from 1998 to 2021.

2. BEA Regional Economic Accounts

This paper collects economic outcomes from the Bureau of Economic Analysis (BEA) Regional Economic Accounts, which provide consistent annual measures of state and local economic activity dating back to 1969. From this dataset, we extract total employment (full- and part-time jobs), per capita income, and real gross domestic product (GDP) per capita. Employment and income serve as the primary outcome variables, representing the local labor market and income effects of wind power development. GDP is included as a control for each state's overall macroeconomic condition in a given year.

3. BEA State Population Estimates

Finally, I incorporate annual state-level population estimates from the BEA. These data provide a measure of state size and are used as a control variable to account for population-driven differences in economic scale and labor supply.

4. Descriptive Statistics

a. Summary Statistics

The final dataset is a balanced panel capturing both the growth of wind energy infrastructure and key indicators of economic performance for all 50 states and the District of Columbia over the period 1998-2021. Table 1 presents the summary statistics for the main variables used in the analysis.

During this time, roughly 68,800 wind turbines were installed on average, with substantial variation across states and years. The total wind capacity averaged about 75,900 megawatts (MW), ranging from zero in states without active projects to more than 3.4 million MW in leading wind-producing states. This large dispersion reflects the highly uneven geographic distribution of wind power development in the U.S.

Total employment averaged around 3.5 million jobs, with considerable heterogeneity depending on state size and economic structure. State GDP per capita averaged \$300,000, while per capita personal income averaged roughly \$41,000, ranging from \$20,000 to nearly \$98,000. The average state population during this period was about 6 million, varying from fewer than 500,000 in small states to nearly 40 million in the largest.

Table 1. Summary Statistics

	Mean	Standard Deviation	Min	Max
Total turbines	68,807.81	212,769.2	0	1,807,134
Total capacity (MW)	75,896.61	244,471.4	0	3,414,784
Total jobs	3,519,553	3,872,881	310,043	2,422,4461
GDP per capita	300,439.8	392,150.1	14,833.2	3,423,958
Income per capita	41,188.31	11,735.35	20,173	97,764
Population	6,017,409	6,756,206	490,787	39,547,995
Year	-	-	1998	2021
State	-	-	1	52

b. Trends in Wind Power Development in the United States

Figure 1 shows the evolution of the number of wind turbines and total wind capacity in the U.S. during this time. The number of wind turbines increased rapidly from the early 2010s onward. Similarly, total capacity grew exponentially, possibly due to improvements in turbine efficiency and size over time. The acceleration after 2010 may be due to the growth of major federal and state renewable energy policies (e.g., Production Tax Credit and Renewable Portfolio Standards) and declining installation costs. By 2021, total capacity exceeded 10,000,000 MW, showing the rapid scale-up of wind power generation within just two decades.

Figure 1. Growth of Wind Turbines and Total Capacity in the US, 1998-2021

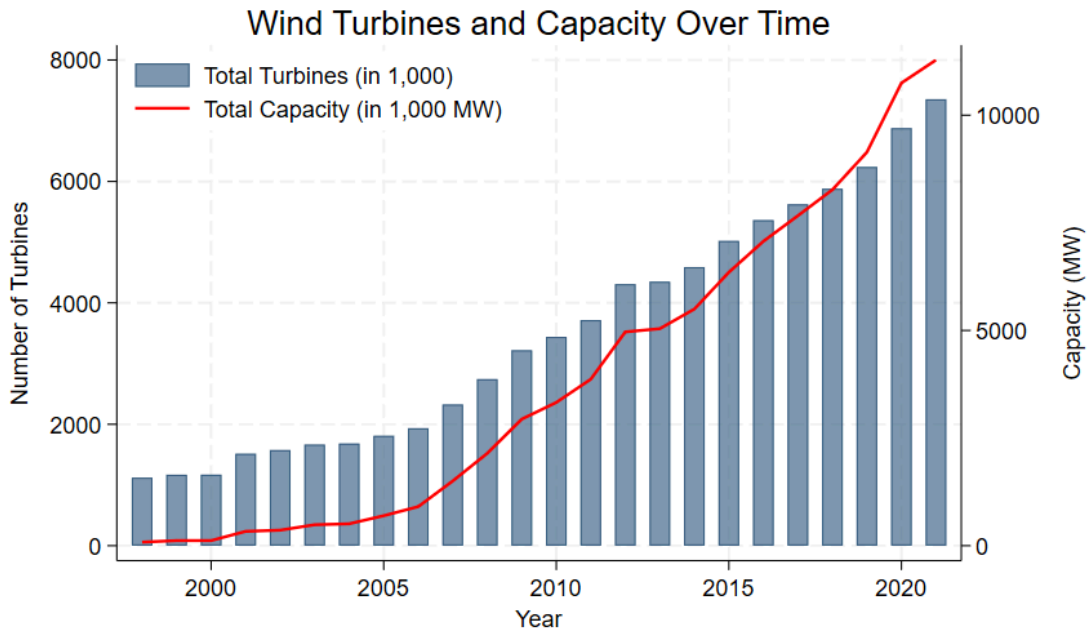


Figure 2 highlights the ten states with the largest shares of U.S. wind turbines as of 2021. Texas alone accounts for nearly 25 percent of all installed turbines, followed by California (17 percent) and Iowa (7 percent). The remaining top producers—Kansas, Oklahoma, Colorado, Illinois, New Mexico, Washington, and Oregon—each contribute between 3 and 6 percent. Together, these ten states account for over 75 percent of total turbine installations, showing the dominance of a few high-resource regions in shaping the overall U.S. wind market. Figure 3 maps the geographic distribution of wind turbines across the U.S. Wind energy deployment is highly uneven, with concentration in the southern and western regions. This spatial pattern underscores how geographic and policy factors jointly determine where large-scale wind power development occurs.

Figure 2. Top Ten States by Share of Wind Turbines in 2021

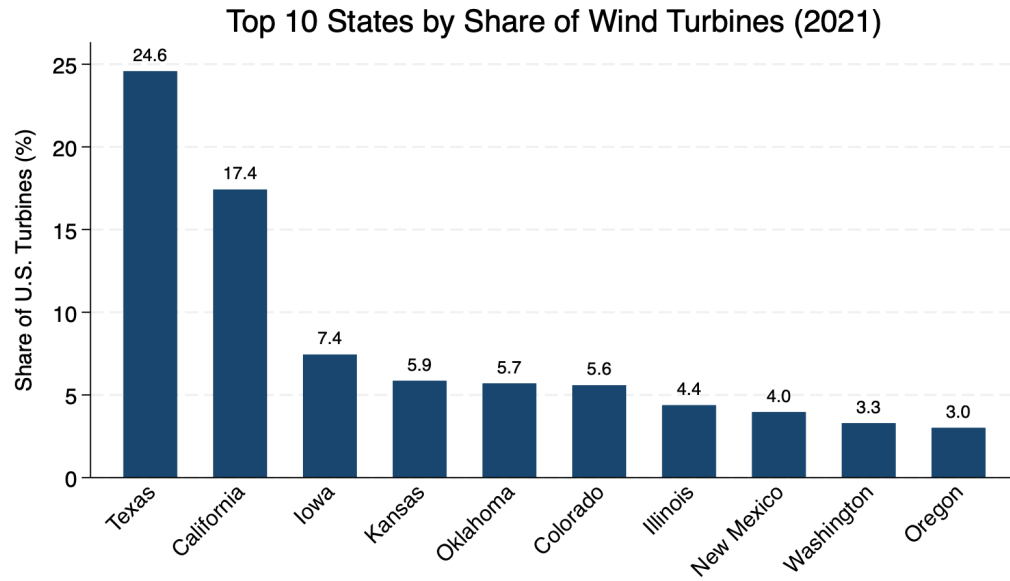
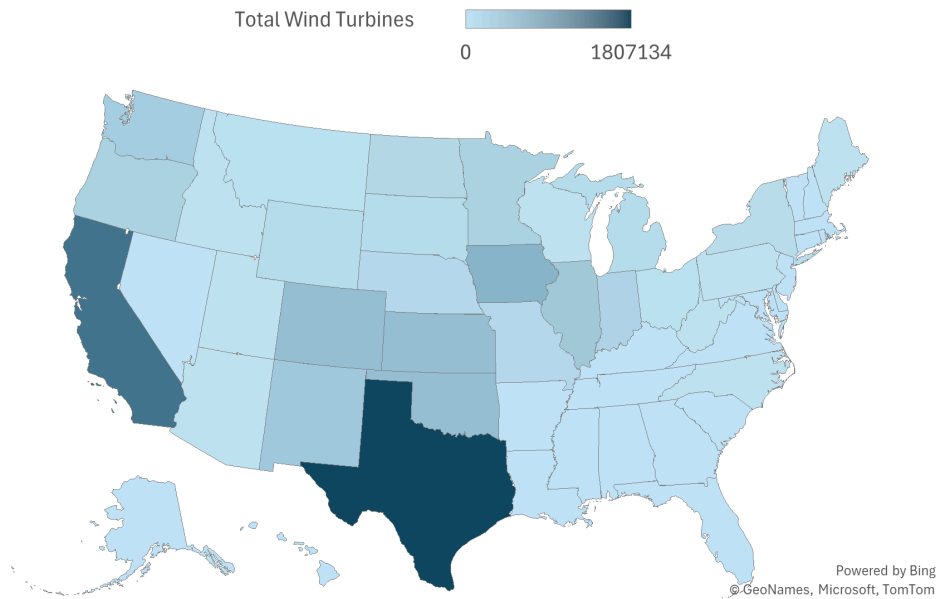


Figure 3. Geographic Distribution of Wind Turbines in the US (2021)



c. Employment and Income Trends in High- and Low-Wind Power Deployment States

To provide an initial illustration of how wind power expansion relates to local economic conditions, Figures 4 and 5 compare trends in employment and per capita income between Texas, the state with the largest share of U.S. wind turbines, and Kentucky, a state with virtually no wind farm development.

Figure 4 shows that total employment in both states has risen steadily since the late 1990s, but growth in Texas has been significantly stronger. While some of this difference reflects the size and economic structure of the two states, the sustained rise in employment during the period of rapid wind power expansion suggests that large-scale renewable investment may contribute to broader job creation.

Figure 5 compares per capita income in the two states. The per capita income of both states follows consistent upward trends. However, income levels in Texas have grown slightly faster over time, particularly after 2010, which coincides with the state's surge in wind energy capacity. On the other hand, Kentucky has a more gradual increase. Although these figures cannot by themselves establish causality, they provide suggestive evidence that states with substantial wind energy development experienced stronger economic performance during the study period. These descriptive figures motivate a more formal econometric analysis to identify the effect of wind power expansion on employment and income outcomes across states over time.

Figure 4. Employment Trends in Texas and Kentucky (1998-2021)

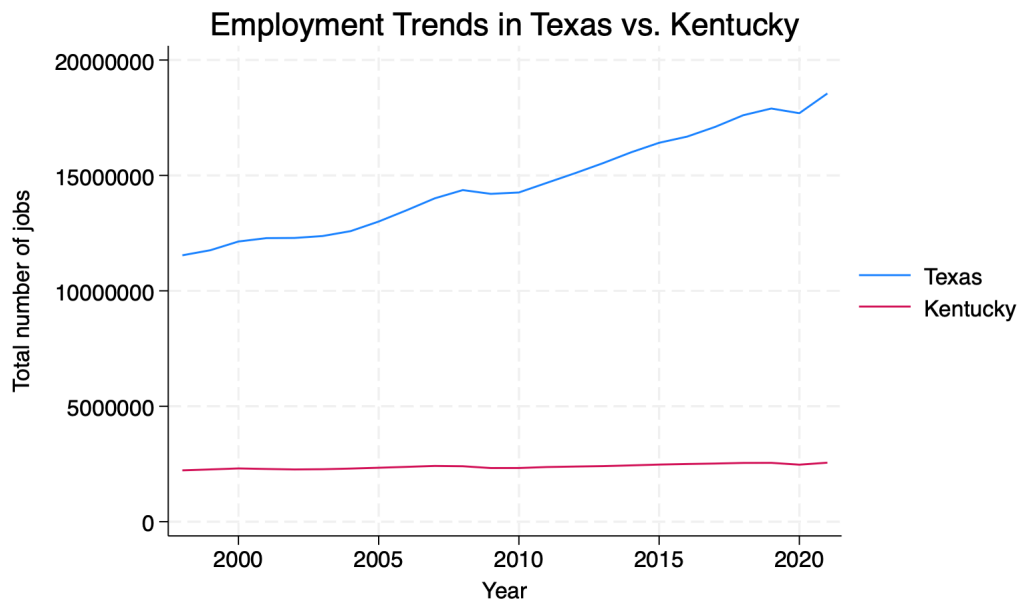
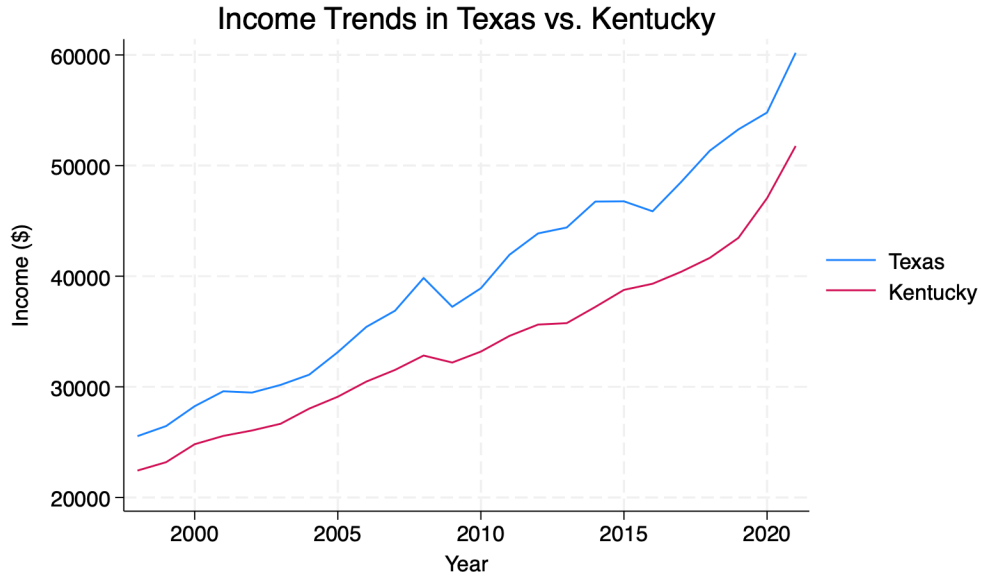


Figure 5. Per Capita Income Trends in Texas and Kentucky (1998-2021)



Methodology

To examine the effect of wind power deployment on employment and income, this paper uses the following econometric model:

$$Economic\ Outcome_{st} = \beta_0 + \beta_1 Wind\ Power_{st} + \beta_2 Pop_{st} + \beta_3 GDP_{st} + \delta_s + \gamma_t + \varepsilon_{st}$$

where $Economic\ Outcome_{st}$ represents the economic outcomes of interest, either total employment or per capita personal income, in state s and year t . The key independent variable, $Wind\ Power_{st}$, captures the scale of wind power development, measured alternatively by the total number of installed turbines or by total installed capacity (in megawatts). Both measures serve as proxies for the intensity of renewable energy investment within each state in a given year.

The model also includes two control variables. Pop_{st} is the total state population in year t , accounting for different state sizes and labor force. GDP_{st} controls for broader macroeconomic conditions that may influence employment and income. In addition, the model includes state and year fixed effects, δ_s and γ_t , respectively, to address omitted variable bias. State fixed effects absorb time-invariant differences across states, such as average wind potential, public perception of green energy, or the policy landscape. Year fixed effects control for nationwide shocks and

trends common across all states, such as federal policy changes, business cycles, or energy price fluctuations.

The coefficient of interest, β_1 , measures the effect of changes in wind power development on local economic outcomes, holding state-specific characteristics and national economic trends constant. ε_{st} is the error term, which captures unobserved factors that vary across states and years.

Empirical Results

1. Employment & Income Effects Across the U.S.

Table 2 reports the estimated effects of wind power development on employment and per capita income. Columns (1) and (2) present results for total employment, while Columns (3) and (4) show results for per capita income. Across all specifications, state and year fixed effects are included to control for time-invariant state characteristics and common national shocks.

The coefficient on Total turbines in column (1) is positive and statistically significant at the 1% level. This indicates that increases in the number of installed wind turbines are associated with higher employment within states over time. Specifically, a one-unit increase in the number of turbines corresponds to an average increase of 0.223 units in total employment, holding GDP and population constant.

Column (2) replaces the number of turbines with installed capacity (MW) as a proxy for wind power development. The coefficient on capacity (0.136) is also positive and significant at the 1% level, suggesting that states with higher wind power capacity see higher employment. In both columns, the coefficients on GDP and population remain positive and significant. This is consistent with the fact that larger and more economically active states naturally employ more workers. This finding suggests that wind farm construction and maintenance contribute meaningfully to local labor markets. Furthermore, this result suggests that the scale of renewable energy investment, rather than simply the count of projects, matters for employment growth.

In Column (3), the dependent variable shifts to per capita income, and the main explanatory variable returns to total turbines. The coefficient on turbines is positive but statistically insignificant. This result suggests that, despite an increase in employment, wind power deployment does not lead to significant gains in per capita income. In column (4), the model uses total capacity (MW) as a measurement for wind power deployment to test whether larger-scale wind projects affect income differently. The coefficient on capacity remains statistically insignificant, implying that an increase in wind power capacity does not meaningfully increase per capita income. These findings suggest that the economic benefits of wind energy development are primarily job creation rather than higher income. In other words, the growth of the wind sector tends to expand employment opportunities but may not substantially raise income.

Table 2. Estimated Effects of Wind Turbines and Capacity on Employment and Income

	(1) Total Jobs	(2) Total Jobs	(3) Income	(4) Income
Total turbines	0.223*** (0.048)	—	0.001 (0.001)	—
Capacity (MW)	—	0.136*** (0.025)	—	0.001 (0.000)
Population	0.459*** (0.011)	0.456*** (0.011)	-0.002*** (0.000)	-0.002*** (0.000)
GDP	1.533*** (0.050)	1.534*** (0.050)	0.012*** (0.001)	0.012*** (0.001)
Constant	148,000*** (54,401)	158,000*** (53,738)	26,478*** (975)	26,333*** (966)
State fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	1,224	1,224	1,224	1,224
R-squared	0.999	0.999	0.970	0.970

*Standard error in parentheses. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$*

2. Employment & Income Effects in Top Five Wind-Producing States

Table 3 shows the estimated relationships between wind power development and employment and income for the five states that account for the majority of the U.S. wind energy capacity. These states include Texas, California, Iowa, Kansas and Oklahoma. Columns (1) and (2) show results for total employment, while Columns (3) and (4) focus on per capita income.

In columns (1) and (2), the coefficients on both Total turbines and Capacity (MW) are positive and statistically significant at the 1% level, with larger magnitudes compared to those observed in the full-sample regressions. Particularly, a one-unit increase in the number of turbines corresponds to an average increase of 1.924 units in total employment (compared to 0.223 in full-sample regression). Similarly, if wind capacity increases by one megawatt, total employment increases by 0.946 units (compared to 0.136 in full-sample regression).

Unlike the nationwide results, the regression for income using the top five wind-producing states reports statistically significant and positive effects of wind power development. Column (3) shows that for each unit increase in the number of wind turbines, income increases by \$0.004 (significant at the 1% level). Similarly, according to column (4), for each unit increase in wind capacity (MW), income increases by \$0.002.

This result suggests that in states with a substantial wind industry presence, the economic benefits extend beyond job creation to higher average incomes. The findings imply that once wind power development reaches a sufficient scale, it can raise income significantly.

Table 3. Estimated Effects of Wind Turbines and Capacity on Employment and Income in the Top 5 Wind-Producing States

	(1) Total Jobs	(2) Total Jobs	(3) Income	(4) Income
Total turbines	1.924*** (0.293)	—	0.004*** (0.001)	—
Capacity (MW)	—	0.946*** (0.151)	—	0.002*** (0.001)
Population	0.061 (0.077)	0.104*** (0.074)	-0.002*** (0.000)	-0.002*** (0.000)
GDP	2.905*** (0.288)	2.782*** (0.282)	0.014*** (0.001)	0.013*** (0.001)
Constant	1.09e+07*** (1.98e+06)	1.15e+07*** (2.16e+06)	86434.07*** (8664.27)	85359.67*** (9437.88)
State fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	120	120	120	120
R-squared	0.999	0.999	0.993	0.993

*Standard error in parentheses. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$*

Taken together, the results indicate that the economic returns to wind power development are highly heterogeneous across states. In the full U.S. sample (Table 2), wind energy expansion

significantly increases employment but shows little impact on income. However, in the top five wind-producing states (Table 3), both employment and income respond positively and significantly to increases in wind capacity and turbine installations. These results underscore the importance of scale and concentration in a renewable energy market such as wind power.

Conclusion

This paper examines the impact of wind power development on the local economy in the U.S. between 1998 and 2021. Using state-level panel data and a fixed-effects regression model, I examine how the expansion of wind power, measured by the number of wind turbines and capacity (MW), affects employment and per capita income.

The results show that wind energy development has a significant positive effect on employment but a limited effect on income in the full U.S. sample. More wind turbines and higher wind capacity lead to higher total employment, suggesting that renewable energy investment creates direct job opportunities. However, these jobs do not translate into a substantial increase in per capita income, possibly because many are temporary, low-paying positions.

When restricting the sample to the top five wind-producing states, the results show stronger and statistically significant impacts on both employment and per capita income. These results imply that once renewable energy development reaches sufficient scale, it can generate broader economic effects, possibly through long-term, high-skilled, and highly paid employment.

In conclusion, this paper finds that renewable energy can deliver measurable local economic benefits, particularly when investment reaches sufficient scale. Policymakers seeking to balance environmental and economic goals should consider not only the adoption of green technologies but also the conditions that enable these industries to mature and deliver long-term economic growth in local communities.

Future research could extend this work by using more granular, micro-level labor data to explore heterogeneity across sectors and occupations. In addition, further research examining spillover effects on neighboring regions using county-level data could be beneficial to policymakers as they consider wind power expansion. These analyses would deepen our understanding of how renewable energy transitions reshape local economies beyond environmental gains.

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