The Influence of Wind Power on Rural Areas
Economic, Demographic, and Community Services Impacts

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by

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Economic, Demographic, and Community Services Impact

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DEDICATION

To my mother's soul

FAYEZAH SHEHATA

for the endless love and care throughout my life. I wish you were alive so I could share this moment with you – but I ask God every day to reward you and increase your ranks in Heaven, until you reach the highest level in Paradise.

To my encouraging father,

AHMED HAMED SHOEIB, for his prayers and thoughts

To my supportive husband,

OSAMA GABALLA BEHIGE, for being there for me.

And finally, to my lovely kids,

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ABSTRACT

THE INFLUENCE OF WIND POWER ON RURAL AREAS

ECONOMIC, DEMOGRAPHIC, AND COMMUNITY SERVICES IMPACTS

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Wind power development has rapidly expanded in the United States. Much of this growth occurred in rural areas because of the availability of land and wind resources required to power turbines. The economic promise of wind power projects is particularly appealing for rural areas whose traditional economic base (typically agricultural) no longer supports as many households as it once did. Numerous studies have found that wind power projects have positive economic impacts on rural areas. What is less well understood is the effect of these wind power farms on other indicators of development, such as municipal services, demographic change, and quality of life. This dissertation examined the effects of wind power development on the economy, society, and community services in rural counties in the United States. The dissertation utilizes a mixed-methods approach, including both statistical analyses of secondary data, as well as the analysis of primary data collected through interviews.

I use two longitudinal data analysis models, mixed effect model and fixed effect model with a quasi-experimental approach, to measure the net economic and demographic impacts of wind development on rural counties. The primary data addressed the effects of substantial wind development on eleven rural counties when they hosted substantial wind farms over 1000 MW.

The results of the statistical analysis show a small significant effect of wind development on rural economies in term of increasing per capita income, median household income, farm income, and per capita employment. It also has a significant effect on decreasing the poverty rate. Increasing the county wind power by one-megawatt capacity increases the county's per capita income by $17 dollars, median household income by approximately $7 dollars, and farm income by $88 dollars.

Results of the primary data analysis show that wind power development increased the tax revenue of the rural community without any required public services or increases in population size of the rural communities. I find that counties with larger populations benefit more from wind development, particularly during the construction phase. Substantial wind development leads to an increase in municipal finances of rural counties. This increase has been reflected in improvements on the community services without any negative social impacts. Wind development is a suitable economic source to diversify the rural economy.

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LIST OF ABBREVIATIONS

ATE	Average Treatment Effect
AWEA	American Wind Energy Association
BLS	Bureau of Labor Statistics
GW	Gigawatt
IV	Instrumental Variable estimation
JEDI	Jobs and Economic Development Impact model
Km	Kilometer
LCEDC	Lincoln County Economic Development Corp
MW	Megawatt
NAWSLIC	New Amsterdan Wind Source LIC
NREL	National Renewable Energy Laboratory
OLS	Ordinary Least Square model
PSM	Propensity Score Matching
RDD	Regression discontinuity designs
RUCCs	Rural-Urban Continuum Codes
UICs	Urban Influence Codes
USDA	United States Department of Agriculture

CHAPTER 1

INTRODUCTION OF THE DISSERTATION

1.1 Introduction

Wind power development has rapidly expanded in the United States (Wiser & Bollinger, 2010). The United States' cumulative installation capacity increased from 2.578 Gigawatts (GW) in 2000 to 74,472 GW by 2015. Much of this growth occurred in rural areas because of the availability of land for wind turbines. The research conducted on renewable energy technology in the European Union suggests that net economic impacts of specific terrestrial renewable energy projects, including net job creation, are likely to be positive, but not substantial at the national level (Ragwitz et al., 2009). In the United States, there have been several academic and non-academic studies measuring the economic impacts of wind power projects. Most have estimated the hypothetical economic impacts of wind projects using simulation models, generally finding modest positive impacts on income and small positive impacts on employment. These impacts come from a combination of sources: direct impacts such as the addition of jobs in the wind farm industry, new tax revenues, lease payments to landowners, as well as indirect impacts as new investment filters down through local retailers, restaurants, child care providers, and others that serve the needs of the local population (Brown, Pender, Wiser, Lantz, & Hoen, 2012; William, Acker, Goldberg, & Greve, 2008; Grover, 2002; Slattery, Lantz, & Richards, 2011; Reategui & Tegen, 2008; Tegen, 2006).

The economic promise of wind power projects is particularly appealing for rural areas. Many rural communities in the United States are economically distressed and struggle with identifying viable development opportunities because of the dual liabilities of size and physical isolation (GAO, 2004). Although rural communities may be isolated and small, they are often rich in potential for wind power development. Proponents argue that wind farms provide new jobs in rural communities where there is a high need for job retention and diversification amid an economic crisis resulting in high out-immigration (Reategui & Tegen, 2008; GAO, 2004). These arguments are based on specific case studies that may or may not apply to all rural areas.

This study measures the post-development impacts of wind power projects. It expands and provides an update to previous work by Brown et al. (2012), who measure the post-economic impacts of wind energy projects using an econometric approach. They estimate the economic impacts between 2000 and 2008 of the installed capacity of wind power on county income and employment in the Great Plains region. Notably, they find an average aggregate increase in annual personal income of approximately $11,000 over the sample period and an average aggregate net increase in county-level employment of 0.5 jobs per megawatt.

There is still much that we do not know about the impacts of wind power development on rural communities. Previous research has focused almost exclusively on measuring changes in jobs and income, but none, to my knowledge, has more broadly considered the impacts of wind power development on community change. For instance, Brown et al. (2012) consider employment and income, but ignore other impacts such as population, poverty, community services, and quality of life. In order to adequately understand these effects, it is important to understand the full scope of terrestrial wind farm development.

This research seeks to fill such gaps in the literature by taking a broader perspective on community change by examining the economic, demographic, and community services impacts of wind power projects in rural areas. By doing so, it sheds light on the question of whether or not there is a correlation between wind projects and rural development. I define development as "compositional or structural changes in economic profile and related transformations that affect the well-being of individuals and groups" and not just on account of new jobs and income increase (Summers & Selvik, 1979). This research utilises a mixed-methods approach, including both statistical analysis of secondary data as well as primary data collected through interviews research methods. The statistical analysis measures the tangible impacts of wind power on rural development such as changes in personal income, employment, as well as the changes in population growth, and poverty rate. The primary data measures wind development's impacts on community services. The primary data measured the impacts of substantial wind development on rural counties when they hosted substantial wind farms over 1000 MW. This approach consists of three components: descriptive analysis, semi-structured interviews, and documents analysis.

1.2 Research Questions

- Do wind farms have a net positive economic impact on rural counties, as measured by increases in personal income and employment, as well as by reductions in the poverty rate?
- Do wind farms have an impact on population growth and contribute to changes in the demographic composition of rural communities? For example, do the

potential jobs associated with wind power projects attract new residents that differ in terms of educational attainment compared to prior residents?

- What are the impacts of wind power projects on local governments' services? Do wind power expansions provide additional tax revenue or do they increase fiscal pressure on the public sector due to the increased strain on community services and infrastructure? Did the impacts of wind power projects on local government's services differ from county to county? If yes, why?

1.3 Research Hypotheses

Building upon a review of the literature review, I have developed three main research hypotheses to test for changes in local economic, demographic and level of public services.

- **H1:** There will be positive economic impacts of wind power projects on rural counties, conditional upon the size of the wind power project. Previous studies generally find a strong association between wind power projects and economic growth in rural counties measured by an increase in personal income and municipal finance (Brown et al., 2012; William et al., 2008; Grover, 2002; Khan, 2013; De Silva, McComb, & Schiller,, 2016; Leistritz & Coon, 2009; Castleberry & Greene, 2017). This study considers a broader array of economic outcomes, such as rising per capita income, declining unemployment rates, and lower poverty rates. I expect there to be varied changes, depending on the size of wind development. I expect that the changes in the poverty rate will appear only with large wind power projects.
- **H2:** I expect a positive association between wind development and population growth in rural areas. Counties with larger wind power projects may experience

changes on population growth rate relative to similar counties without. Wind power projects will provide more job opportunity that may prevent youth immigration from rural counties. New jobs will keep the young population in rural communities and result in population growth from increased births. The wind power's workers may make some demographic changes in rural communities, such as increasing the younger educated residents in the rural community. Furthermore, I expect the development of wind power to lead to a change in the educational composition of the local population, with new residents typically being more highly educated than current residents. Wind development jobs require a certain level education, such as technicians and engineers. The latter will be reflected by a positive shift in the educational attainment of the county.

- **H3:** Local spending on public services will increase in wind power counties due to additional local taxes. This will enhance the quality of the public services which may lead to a better standard of living for local residents. This hypothesis examines the consequences of the economic and demographic changes on public services. This hypothesis will be tested only on counties with substantial wind farm projects over 1000 MW, using interviews research methods with local officials of counties with substantial wind projects. I expect that wind farms will increase the property value of the agriculture land. Increasing the property value will spur an increase in the property tax revenue, which usually is dispersed to local schools and other public services. Public sector cost and revenues could be an indicator of improvement or decline of public services.

1.4 Conceptual Framework

Three separate bodies of theory shed light on growth scenarios and impacts of wind power projects in rural areas. They include: economic theories (Malizia & Feser, 1999; Paul, 1979; Brown et al., 2012); demographic theories (Edmiston, 2004; Murdock & Leistritz, 1978) and; theories about the changes in community services after the installation of energy facilities (Paul, 1979; Murdock & Leistritz, 1978; Jacquet, 2009). This section briefly discusses these theories and highlights the findings that are significant for this research.

1.4.1 Economic Theories

There are several economic theories that provide a framework about how wind power development can affect the economic growth on rural communities. Wind power development requires a substantial investment on the local economy. The Keynesian aggregate demand model states a clear relation between increasing the investment and economic growth, measured through local outcome, and the total volume of outputs goods and services in that county. If we consider that GDP(y) as annual gross local expenditure of the county, following the next equation: wind development investment in rural counties will increase the local investment (I), and increasing the export of the local produced wind energy(X). As a consequence, the local economy outcome will increase, causing economic growth on these counties (Ezeala-Harrison, 1996).

$$y = C + I + G + X - M \quad (1)$$

Where:

y= GDP annual gross national expenditure of the economy
C= Consumption

I= Investment
G= Governmental spending
X= Exports
M= Imports

Economic growth is usually measured by increases in real income sales, outputs, or job creation. Previous studies generally find a strong association between wind power projects and economic growth in rural counties measured by an increase in personal income and employment (Brown et al., 2012; William et al., 2008; Grover, 2002; Slattery & Richards, 2011; Reategui & Tegen, 2008; Tegen, 2006). This research aims to figure out if this economic growth could lead to rural economic development.

The difference between economic growth and economic development is an important distinction. For example, Meier (1976) mentions that, "economic development involves something more than economic growth. Economic development is usually measured by qualitative changes or structural transformations that can put a local economy on a path toward future growth or improvements in the quality of life and living standards and qualitative differences (Flammang, 1979). In the structural condition of an economy, economic growth happens first and that economic development may occur after economic growth (Malizi & Feser, 1999). However, economic growth does not always lead to economic development. Measurements of economic development are: equity in income distribution; level of literacy; employment structure and; nutrition and health occupational patterns (Ezeala-Harrison, 1996).

Paul R. Eberts (1979) finds that growth is necessary, although probably not sufficient for development toward a better quality of life. Growth usually appears as an increase in income, employment, and institutions. Eberts (1979) concludes that if the gains from income and employment growth are not directed to improve public services (e.g., additional educational facilities, public utilities and other subsidies), it could lead to lower quality of life. He also finds that changes in rural economic structure are often associated with an increase in crime, suicide, mortality, marital disruptions, and poor housing conditions. This research considers a broader set of economic indicators including unemployment rate and poverty rate as well as income and employment.

Wind power development is expected to provide new jobs through non-agricultural jobs, an increase in income of the local farmers and ranchers, and an increase in the local tax income of the rural communities. Following economic base theory, the expansion of wind power will generate not only direct jobs in the wind sector but also increase the demand for non-based services, leading to an overall increase in employment beyond those associated directly with the wind sector[1]. Wind power can be considered a basic industry in a county because, in most cases, large wind projects will be exporting wind power outside the county where it is produced and thus become a source of importing revenue. In terms of economic base theory, the change in total employment (E_T) is equal to basic employment in the wind energy sector (E_B) plus employment that comes from activities that serve the local market (E_{NB}). Local market serving is proportional to total employment.

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[1] Economic-base theory classifies the economy into two categories: basic and non–basic. Basic industries are those that produce goods for exporting and bringing in wealth from the outside, while non-basic (or service) industries are those that support basic industries, such as clothing, food, shelter, and public services. Export is an important factor in this model. Therefore, in order to achieve regional growth, the region must increase its exports to gain capital by producing and selling goods outside the region.

$$E_T = E_B + E_{NB} \tag{2}$$

This research examines counties with wind projects > 100 MW, where wind power maybe a substantial part of the local economic base. Authors who have studied the economic impacts on the county-level, using the JEDI model, tend to find that every MW of installed capacity creates approximately 0.045 to 0.58 jobs during the operations phase (Slattery et al., 2011; William et al., 2008; Costanti, 2004; Mongha, Staffor, & Harman, 2006). Following an ex-post econometric approach, Brown et al. (2012) found approximately 0.5 jobs per MW of wind power capacity installed at the county level. According to the Natural Renewable Energy Laboratory (NREL) database a typical 100 MW wind farm supports on average six to eight operation and maintenance workers. The population of this research is counties with large wind projects > 100 MW. According to the literature, 100 MW will provide at least five new jobs with a salary above the median. While wind power can be considered a basic industry in a county as long as the basic employment in the wind energy sector is large enough to make a change in the total employment structure and demands more employment services to serve the local market.

Changes in income can come from two sources: increasing farmers and ranchers' income from lease payments and providing new jobs or jobs that pay higher salaries. According to industry sources, wind technicians usually have starting salaries of between 35,000 and 40,000 United States dollars (USD), with wages and benefits varying by employer and geographic location. In contrast to the median agricultural worker's salary of 30,000 USD, wind engineers have starting salaries of between 70,000 to 80,000 USD

(Bureau of Labor Statistics [BLS], 2010). According to the BLS, earnings from wind-related jobs were considered to be above the median salary in 2015.

Rural residents in the United States who invest in wind power and own wind power projects also lease land to wind developers (Bolinger & Wiser, 2006). Farmers often use this leasing income to build up their farms (Ouderkirk & Pedden, 2004). Wind power projects can thus serve as a parallel source of income alongside agriculture. In contrast, landowners who do not invest or lease land to wind developers must deal with rising prices due to higher real estate values, which are not compensated for by wind-related revenue (Brannstrom & Persons, 2011).

1.4.2 The Demographic Theories

The literature on demographic theory, however, has a different set of focuses. The present study thus concentrated on population growth and demographic changes that are expected to be stimulated by wind farm jobs. Wind power projects have two phases: construction and operation. The construction phase is usually discrete and temporary, so workers come in to assemble the turbines but leave soon after their work is completed. This study focused instead on the potential long-term impacts of the operation phase. The proposed demographic impacts of wind power projects come from the local economy's diversification to include non-agriculture jobs, as well as job retention and decreased out-immigration. Non-agriculture jobs could potentially decrease youth out-immigration from rural areas or attract younger people to work on wind projects.

Population growth in the wake of wind power development is difficult to predict. New jobs in the wind sector could be taken by either in-migrants or existing residents.

While wind power provides a small number of jobs, these require specialized skills. Wind farm operation and maintenance require technicians and mechanical and electrical engineers (BLS, 2010). The new jobs are filled by workers with different skills than the incumbent workforce normally possesses.

However, while many wind jobs need specialized skills unique to the wind power sector, in most cases, these can be acquired in other industries. For the majority of positions, wind companies thus hire individuals with experience in other areas and give them wind-specific training (BLS, 2010, p. 8). Currently, a large proportion of these technicians learn on the job or through apprenticeship programs, which means local residents with relevant skills can easily learn to do the work of wind technicians. In such cases, wind development can encourage younger people in rural counties to acquire new skills in order to find jobs with a suitable salary and stay in their home community. Some jobs will, nonetheless, be filled by outsiders, thereby triggering related population growth and shifts in the region's demographic composition.

The next aspect to consider is where these new employees will reside. The members of the wind farm workforce may live in the same county in which wind projects are located or in adjacent areas. The residential allocation and gravity models posit that the location of immigration will depend on distances between work and populations and additional attraction factors (Murdock & Leistritz, 1978). Jobs from wind power projects in rural areas will likely result in increased population stability or growth in the relevant counties or nearby areas.

Researchers who have studied the energy boom's demographic impacts on the United States in the 1970s have found an association with rapid population growth (Gilmore & Duff 1975; Greider & Krannich 1985; Kohrs, 1974). Wind power, however, is less labor intensive than other energy-related industries such as coal and natural gas (Brown et al., 2013). However, the expected demographic impacts of wind power projects could be similar to those found by Edmiston (2004), who studied the net effects of large plant locations and expansions on county-level employment. The cited author found that the impact on population growth is positive for both new and expanding firms in broad areas that comprise host counties and their contiguous areas.

Wind workers are generally expected to be younger individuals, in contrast to older rural communities. These workers have at least a college-level degree. For instance, wind turbine technicians usually have a 9-month certificate or 2-year associate degree in wind energy (BLS, 2010). Thus, the new residents may contrast with local residents and represent demographic changes.

Murdock and Leistritz (1978) estimated demographic changes in North Dakota rural areas due to the energy boom in terms of age, gender, school enrollment, and housing requirements. Using descriptive data analysis, Jacquet (2009) examined changes in Sublette County, Southwestern Wyoming, from 2000 to 2007, after the opening of two massive natural gas fields that contained a minimum of 28 trillion cubic feet of natural gas. The cited author found an increase in the population and shifts in the age profile of this county after the natural gas projects started.

The relevant theories suggest that wind power projects will encourage younger people to learn new skills and stay in their rural communities, especially in counties with large wind projects. In smaller counties with large projects, the wind power workers may contribute significantly to demographic changes in rural communities, such as making the population younger and more educated. These demographic shifts will be depend on the wind projects and local population's size. For example, if a county with a population of 1,500 people has a total of 1,000 megawatt (MW) wind projects, according to the literature, each 100 MW will provide at least 5 new jobs with an above average salary, which means at least 50 new jobs in this county (Slattery et al., 2011; William et al., 2008; Costanti, 2004; Mongha et al. 2006). If these wind workers live in the host county, they will make a substantial change in the county's population size and its communities' profiles.

1.4.3 Theories about community services: Public services changes after energy facilities

The quality of community services is often considered to be indicative of the quality of life among an area's residents. For example, Eberts (1979) finds that if the gains from income and employment growth are not directed toward the improvement of public services (e.g., additional educational facilities, public utilities, and other subsidies), it could lead to a lower quality of life, as employment growth spurs population growth, which causes pressure on the existing public services. This happened in the decade between 1970 and 1980, after a massive increase in natural gas and coal production in rural communities. The new energy development doubled the population size in some counties without any expansion or improvement of public services, such as education and law enforcement. Although this development increased the population and its income, it led to a decline in the quality of municipal and other local services, such as an increasing deficit of roads, schoolrooms, and municipal water, electric, and sewerage facilities (Cummings & Mehr, 1977).

Along these lines, there are a wide variety of potential environmental effects from wind turbines, ranging from a reduction in climate change at the global level to the harming of birds and bats that could have a broad association to quality of life. However, these more indirect associations will not be explored in this study. Murdock and Leistritz (1978) used public sector costs and revenue as indicators of decline or improvement in the quality of public services. The quality of those services could be a good indicator of the quality of life but not alone. If wind projects increased the tax income without any increase in the population size, this new tax income could be used to improve public services or to add new amenities. I will test this by asking directly how wind projects affect the area's public services.

Research on the impact of wind power development on community services is rather limited. However, there is ample research about the effects of the energy boom on rural areas during the 1970s and early 1980s. The research on the effects of the increase in coal and natural gas production on rural areas found that rapid population growth and changes in the social structure often leads to changes in the quality of municipal services (Gilmore & Duff, 1975; Greider & Krannich, 1985; Kohrs, 1974). Boomtown research shows that economic effects can be mixed, with some sectors or communities benefiting more than others. Businesses or residents who are not directly tied to the energy industry may have to deal with employment or inflationary pressures while not seeing direct gains in revenue. From the experience of a boomtown resident, locating new industrial projects in small communities does not always manifest as improvements in local conditions (Ervin, 1978). For example, Cuba, New Mexico experienced an increase in coal-mining activity during 1970 to 1974, and the socio-economic impact seemed to benefit the entire community. By contrast, during that same period, Sweetwater County, Wyoming experienced the expansion of mining and the construction of the Jim Bridger Power Plant. Population and employment levels in the county doubled from 18,931 to 36,900 and 7,230 to 15,225, respectively. Yet, the quality of municipal and other local services declined markedly, such as an increasing deficit of roads, schoolrooms, and municipal water, electric, and sewerage facilities (Cummings and Mehr, 1977). The difference between the two scenarios reflects the ways in which the local governments faced the challenges of development.

The impact of wind power development on community services will depend on the degree to which it affects the population size as well as the local tax revenue. However, the likely economic and demographic effects of wind power are not necessarily comparable to those of natural gas or coal: Wind power production is less labor intensive than coal and natural gas production (Brown, Weber, & Wojan, 2013). Brown et al. (2013) found that natural gas development was associated with a 12 percent increase in total employment in counties in Colorado, Texas, and Wyoming that experienced a large increase in natural gas production, compared to a 0.6 percent increase for wind power development. Further, natural gas development requires more workers for different pre-production stages, such as drilling and extraction, and the construction of a natural gas infrastructure can take three years compared to one year for the infrastructure required for wind power development. The impact of wind projects on a community's services is related to the demanded services:

resident services and turbine-related services. It also related to the funding and maintenance of those services through the tax and income revenue of such wind projects.

Turbine-related services are considered to be immediate services as opposed to resident services, which are not. As it pertains to both kinds of services, one must ask: Who will pay for the services, and when? Interviewees will be asked direct questions about turbine-related services and who pays for the cost. For example, wind turbines incorporated and zoned as a part of new land use will, at the very least, need road access and fire protection. At the same time, the wind power development and production will provide tax revenue to the community. Problems arise when the growth in tax income is surpassed by an increase in service demands or from a mismatch in the timing of flows to services required.

The alternate scenarios in regards to how wind projects may affect rural communities, income, population, and public services will shape how wind power development affects the quality of life. One of the expected scenarios is that wind farms will create significant economic and demographic changes, which will be followed by physical and social changes in rural communities. The best-case scenario is the stabilization of population growth which is typically declining in rural counties; thiswill limit the demand on residents' services. Meanwhile, the wind power development will increase residents' income, and counties can use the tax revenue of wind power development to cover the turbine-related services and improve public services. In turn, this will improve the quality of life for entire communities.

1.5 Research Design

This dissertation has three main research questions, provided in Section 1.2, and uses a mixed-methods approach. I conduct a statistical analysis of secondary data to answer the first two questions, followed by the analysis of primary data collected through interview research methods to address the third question (Figure 1-1). Table 1-1 shows the research questions and the methods that have been used to answer these questions. A more detailed review of the methods and different chapters, each chapter has the detail method and data. The research purpose and questions seek to measure the impacts of wind power projects. Researchers generally judge the impact of development according to changes in income and employment rates. This research considers a broader set of developmental factors including economic, demographic, and community services impacts. Analyzing this broader set of development indicators requires a variety of approaches, both quantitative and qualitative. The economic and demographic impacts are measured using secondary data analyzed using two longitudinal regressions with covariate controls. The community services impacts are measured through case studies analysis, focusing on counties with large wind farms in excess of 1000 MW. The case studies use primary data, as well as published public data, to measure the impacts of wind power on public revenues and service costs. The case studies also include interviews with planners and local officials to better understand how wind power developments impact public services.

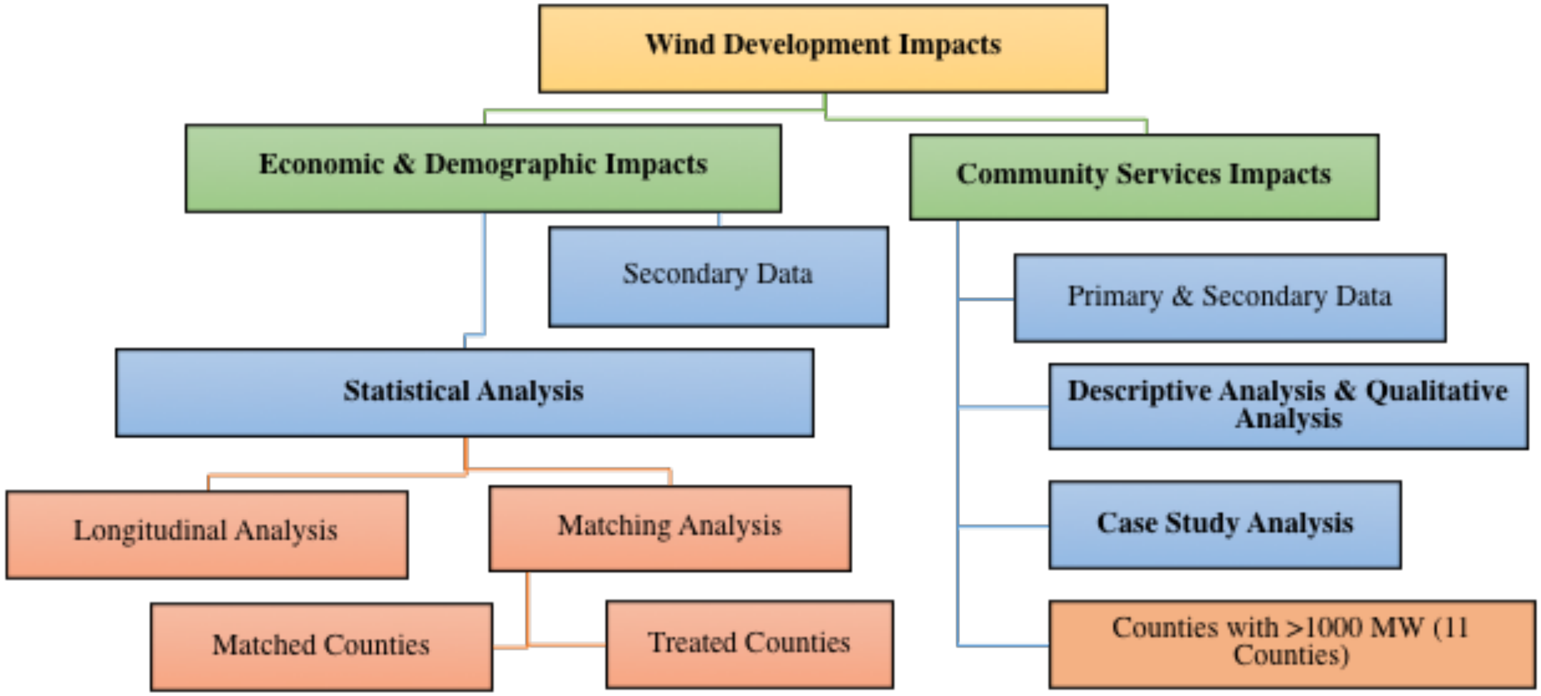

Figure 1-1: Research design of the dissertation

Table 1-1: Overview of the research question and method in this dissertation.

Chapter	Research Questions	Empirical material	Method	Study Population
Chapter 2	**Q:** What are the actual social and economic impacts of large-scale wind power projects on rural communities? **Q:** Are these impacts significant enough to improve the quality of life in rural areas?	Literature review	A systematic review of the previous research about wind development in the United States. Theoretical analysis of previous findings to distinguish between if these findings are economic growth or economic development	Studies about the United States
Chapter 3	**Q1:** Do wind farms have a net positive economic impact on rural counties, as measured in terms of an increase in personal income and employment, as well as a reduction in the poverty rate? **Q2:** Do wind farms have an impact on population growth and contribute to changes in the demographic composition of rural communities? For example, do the potential jobs associated with wind power projects	Secondary data from a governmental institution	Longitudinal data analysis and mixed - effects model & Longitudinal data analysis- fixed -effects model with a quasi- experimental approach.	All counties in the continental U.S., excluding those in Alaska, Hawaii, Puerto Rico, and other U.S. territories. Counties with wind projects over 100 MW in

	attract new residents that differ in terms of educational attainment compared to prior residents?			2012 and their matched counties
Chapter 4	**Q3:** What are the impacts of wind power projects on local governments' services? Do wind power expansions provide additional tax revenue or do they increase fiscal pressure on the public sector due to the increased strain on community services and infrastructure? Did the impacts of wind power projects on local government's services differ from county to county? If yes, why?	Semi structured interviews, governmental documents, newspaper articles	Case studies analysis	Counties with substantial wind power farms over 1000 MW in the U.S. There are only eleven counties in the U.S have wind project over 1000 MW according to AWEA data in 2016.

CHAPTER 2
EXAMINING THE SOCIOECONOMIC IMPACTS OF WIND POWER DEVELOPMENT ON RURAL AREAS IN THE UNITED STATES

2.1 Abstract

Wind power development has rapidly expanded in the United States. Much of this growth has occurred in rural areas due to the availability of land and wind resources to power turbines. The economic promise of wind power projects is particularly appealing for rural areas whose traditional economic base (typically agricultural) no longer supports as many households as it once did. Numerous studies have found that wind power projects have positive economic impacts on rural areas (Brown et al., 2012; De Silva et al., 2016; Leistritz & Coon, 2009; Kahn, 2013; Castleberry & Greene, 2017; Slattery et al., 2011; William et al., 2008). What is less well understood is the effect these wind power farms have on other indicators of development, such as municipal services, demographic change, and quality of life. This article reviews the literature on the socioeconomic impacts of wind projects in the United States and the relationship between these impacts and rural development, broadly defined. Most studies have found a strong association between wind power projects and economic growth in rural counties. Such an association has been measured by an increase in personal income, employment, tax base, and local school revenue. Increasing the tax base and local school revenue, as well as decreasing the property tax rate, is a sign of boosting the public finances. However, the consequence of this economic growth has not been well investigated yet; more research is needed to determine how wind power benefits quality of life and other dimensions of development. I recommend using different measurements to find the consequences of the economic

growth in terms of per capita income, tax base, and school revenue on rural development in relation to poverty rate, population growth and education attainment. I also recommend using different methods such as longitudinal analysis to find the net impacts of wind power development on rural development.

2.2 Introduction

As shown in Figure 2-1, the United States' cumulative installation of wind power capacity increased from 2.578 Gigawatts (GW) in 2000 to 97,645 GW by 2018 (AWEA, 2019). Much of this growth occurred in rural areas because of the availability of land and wind speed for wind turbines. Although rural communities may be isolated and small, they are often rich in potential for wind power. Some studies argue that wind farms provide new jobs in rural communities where there is a need for job retention and diversification amid an economic crisis resulting in a high level of relocation outside of rural communities (Reategui & Tegen, 2008; GAO, 2004).

The trigger question of this paper is: can wind power development be a viable development opportunity for struggling rural communities to achieve rural development? The local consequences of the fast growth in wind power energy in rural areas are not well documented in previous studies. To help fill this void, this paper explores the influence of wind development in rural areas in the United States by reviewing the previous studies about the impacts of wind farms in rural counties, and by offering my own analysis and conclusions. Specifically, this research seeks to find what the measured impacts and the unmeasured impacts are of wind power projects on rural development. Are these measured impacts large enough to trigger rural development? Defining 'development' as the "compositional or structural changes in economic profile and related transformations that affect the well-being of individuals and groups" (Summers & Selvik, 1979).

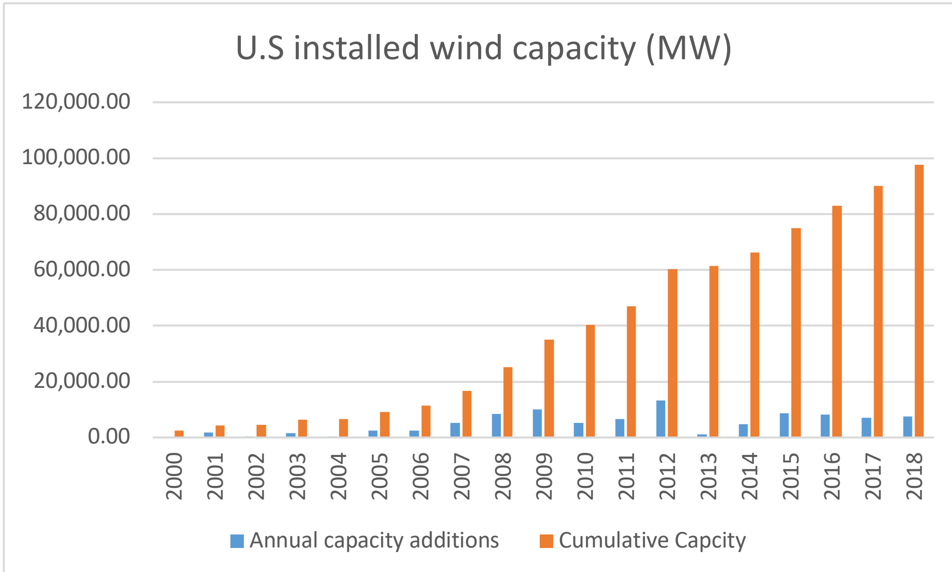

Figure 2-1: Wind power growth in the USA (AWEA, 2019)

Wind power development is a recent phenomenon in the United States which saw large-scale wind development starting in 20th century. Since the 2000s, the impacts of wind power development have been investigated widely in U.K and U.S. This paper focuses on the socioeconomic effects of wind development on rural areas in the United States. There are over 30 studies focused on the socioeconomic effects of wind power. Some measure residents' perception of the socioeconomic effects of wind power in different rural areas in the United States using mail surveys (Greene & Sawatzky, 2013; Leistritz, & Coon, 2009; Groth & Vogt, 2014a; Groth & Vogt, 2014b; Jacquet & Stedman, 2013; Slattery, Johnson, Swofford, & Pasqualetti, 2012). Many other estimate the hypothetical socioeconomic impacts of wind projects using simulation models (Grover, 2002; GAO, 2004; Slattery et al., 2011; William et al., 2008; Costanti, 2004; Mongha et al., 2006; Tegen, 2006; Greene & Geisken 2013; Lantz, 2009; Halvatzis, & Keyser, 2013; Costanti, 2004; Ouderkirk & Pedden, 2004; Clemmer, 2001; Reategui, & Tegen, 2008; Reategui & Hendrickson, 2011). A smaller number of authors measure the local socioeconomic benefits using an econometric models (Brown et al., 2012; De Silva et al., 2016; Leistritz & Coon, 2009; Kahn, 2013; Castleberry & Greene, 2017; Hoen, Wiser, Cappers, Thayer, & Sethi, 2009; Hoen Hoen, Wiser, Cappers, Thayer, & Sethi, 2011; Hoen, Brown, Jackson, Thayer, & Cappers, 2015; Lang, Opaluch, & Sfinarolakis, 2014; Hoen & Palombo, 2016).

The primary objective of this paper is to present a systematic review of socioeconomic impacts of wind power development on the rural areas in the United States. I do so by reviewing the different measured impacts of wind power on rural areas and comparing these impacts to distinguish which results can be generalized from the case specific, and to identify where more research is needed.

The paper proceeds as follows. Section two discusses the material and method used in this paper. Section three discusses the general background of wind power impacts. Section four details the impacts of wind power projects in the U.S and how these impacts can affect rural development. Section five discusses the results of the systematic review and relates these results to the research questions. Section six puts the paper in context, provides ideas for future research, and briefly offers a summation of the study.

2. 3 Materials and Methods

I conducted a literature search on the socioeconomic impacts of wind power resulting in a compilation of over 100 published and unpublished studies from the United

States. To minimize bias, I applied several inclusion criteria, such as excluding off-shore wind studies and only including studies with an explicit method. This resulted in the acceptance of over 30 relevant studies from which I extracted impacts and potential impacts of wind development on rural areas. Although I reviewed and screened studies from England and Canada, only studies from the United States met inclusion criteria for the analysis of wind power impacts on rural development, since American rural conditions differ from others in policy and environment. I, therefore, limited the scope of my conclusions about development impacts associated with wind power development in rural areas to the U.S.

2.4 Background

Wind power is an abundant, clean source of power. The continuous increase in energy demands, along with high fuel prices and concerns over environmental hazards, have accelerated the expansion of renewable energy on a global scale. Among other renewable sources, wind power is considered to be the most environmental and cost-efficient source of energy (Klick & Smith, 2010; Kempton, Firestone, Lilley, Rouleau, & Whitaker, 2005). This viewpoint holds true for the United States, where in recent years, wind power development has rapidly expanded. The United States has the potential on-land capacity to generate electricity from wind, particularly in the Great Plains states, such as North and South Dakota, Iowa, and Texas (Natural Renewable Energy Laboratory Database[NREL], 2016). This century has witnessed a significant influx of literature about wind power in the United States. Excluding the engineering side of wind turbines, the rest of the literature I reviewed focused on public perceptions of wind power; the socioeconomic impacts of wind development on rural areas; the environmental impacts of wind power; and the effect of the federal and local tax credit on wind power development in the U.S.

Many studies in the UK and the U.S have covered public perception of wind turbines. Public opposition of wind turbines has been explained as an expression of "Not In My Back Yard" sentiment (NMBYism), arising from the conflict between general support and local opposition to specific locations or projects (Wright, 2005). Research about public perception of wind turbines in the United States did not agree with (NMBYism) sentiment. In general, public support of wind development is high and local opposition to rural wind projects is rather minimal (Swofford & Slattery, 2010). Previous studies found that the percentage of those expressing opposition of wind farms in the United States was too small to indicate NMBY as a sentiment toward wind turbines (Jones & Eiser, 2009; Swofford & Slattery, 2010; Groth & Volt, 2014a; Groth & Volt, 2014b). Public engagement in the decision-making process to develop wind power projects, as well as an emphasis on the local economic benefits of wind projects, may reduce public opposition to the adoption of wind turbines (Ledec, Rapp, &, 2011). To those that strongly oppose wind power development, the dominating visual impact of wind turbines emerges as a primary concern. Visual concerns are especially true in more affluent areas and in popular recreation areas, where the economy may be dependent upon tourism (Lapoint & Haggard, 2011; Hoffer, 2002). The most famous case of public opposition to wind turbines in the United States is the Cape Cod wind farm proposal. Offshore wind is entirely different in a public perception that regards oceans as a natural view that should not be polluted by an industrial use such as wind turbines. Also, offshore wind has different environmental effects than on-land turbines.

This research concerns on-land (terrestrial) wind farms in rural areas in the United States. Most of on-land wind turbines are located in rural areas where, unlike in touristic areas, residents are accustomed to their land being an economic resource to use for financial purposes rather than just an aesthetic function (Hamin, 2002). With wind power development, rural residents stand to reap relatively more of the economic benefits of new energy projects, with less displacement of the agriculture land. Although wind turbines may disturb the traditional visual landscape, they generally do not have a significant negative impact on agricultural sources of income. Farmers can continue to farm and raise cattle in the areas around wind turbines, while earning additional revenue through leasing the land to energy companies (Bolinger &Wiser, 2006).

Wind power projects have three main impacts: direct, indirect, and induced impacts (Figure 2-2). Direct impacts include job creation, lease income, tax revenue and legal and administrate support services. Indirect impacts include acquiring materials for the wind farms such as turbine towers, hardware, and software material. The indirect economic impacts are usually contracted out to big companies like turbine and blades companies, which are outside of local rural counties. Finally, the induced impacts are a result of jobs and earning spending, including benefits to grocery stores and retail sales (Reategui & Hendrickson, 2011; Reategui & Tegen, 2008; Lantze, 2009). The induced impacts of wind power projects came from the local multiplier of the increased local income and jobs. For example, when the farmers earn more money from leasing their land to wind developers, they use this additional money to enhance their farms. Local impacts on the county scale come mainly from direct impacts, as well as the induced impacts of the domestic spending.

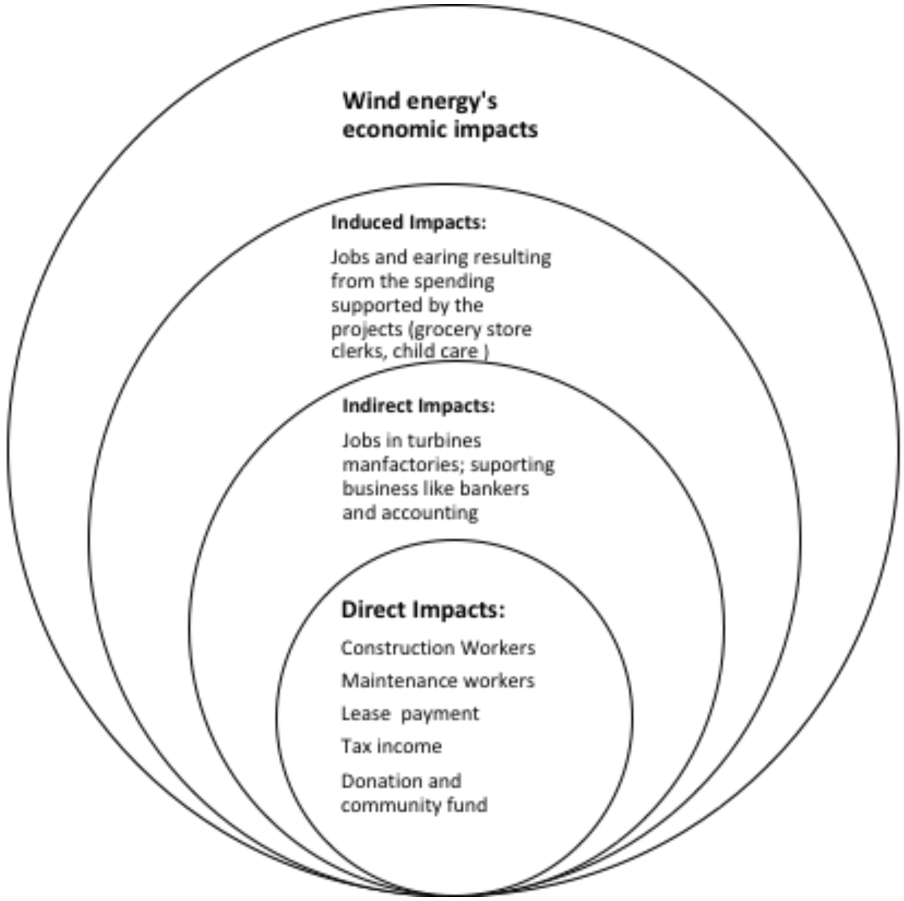

Figure 2-2: Ripple effect of wind power projects.

Socioeconomic impacts of wind power projects typically emerge in two phases: the construction phase and the operation phase. The construction phase requires a substantial financial investment over a short period of time. This phase usually takes one year, acting as a positive economic stimulus, especially for small communities. The construction of wind turbines creates an immediate and heavily localized demand for construction jobs and materials, although construction employment and their income gains are typically of a very short duration and are limited to a handful of skilled trade sectors (Lantz & Tegen, 2009). However, most construction expenditure is for capital equipment, predominately purchased outside of the local area. Figure 3-3 shows the component costs of the typical wind plant, where almost 50 percent of costs goes to the wind turbine purchase. At the state level, increasing wind turbine supply maximizes the economic benefits of the construction phase because more of the labor and materials can be procured from in-state sources. However, at the local level, more of the funds leak out of the county, in part because domestic construction workers generally lack the specific expertise required for the installation of such projects. Table 1-1 shows the expected potential economic benefits of the wind projects on the county level.

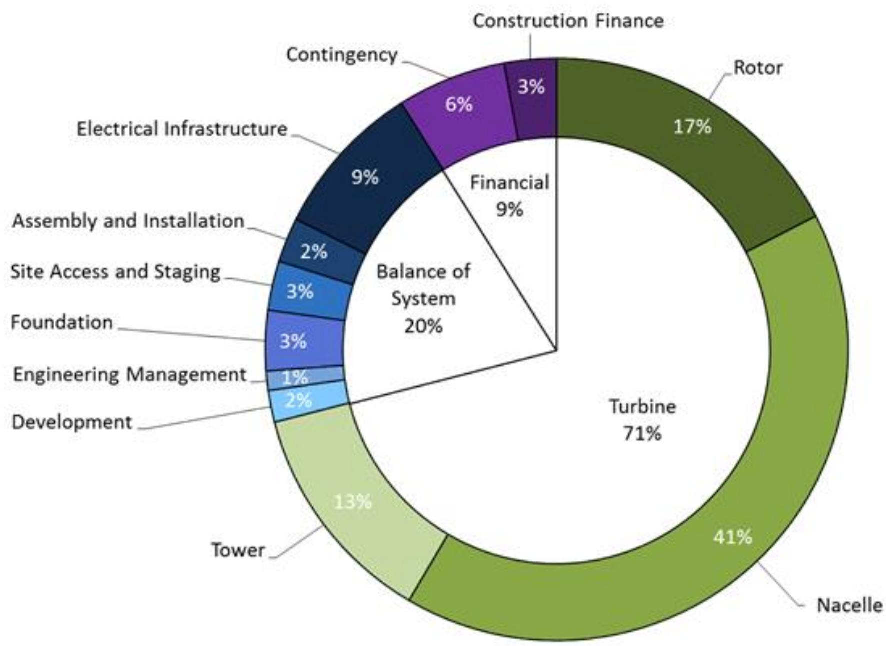

Figure 3-3: The component costs of a typical wind plant (Moné, Stehly, Ben Maples, & Edward, 2015)

Table 1-1: Local direct economic impacts of wind farms (the author).

	Local impacts							
	Construction phase				Operation and Maintenance			
	Labor		Material		Labor		Material	Lease Income
Economic Activity	Turbine labor	Non-turbines labor	Turbine	Non-turbines materials Sand gravel, etc.	Travel crews for more than one farm	Local crew or business	Operation materials	Lease agreement with Landowners

Scale of Benefits	Out of the county and the state level	**Local suppliers**	National or international suppliers	In-state suppliers	In-State	**Local County level**	In-state suppliers	**Local Landowners**

Even though the overall costs associated with the operation phase of wind farm development are less than the construction phase, operational expenditures are more likely to be spent on labor wages, lease payments, and taxes, which yields relatively more significant benefits to the local community. Furthermore, the operation phase yields gains sustained over the lifetime of the project, which is typically from 20 to 25 years.

The local socioeconomic impacts of wind development can vary considerably from one project to another. Ultimately, the impacts depend on project size, location, financing arrangements, and numerous site-specific factors that influence construction and operation costs (Goldberg, Sinclai, & Milligan, 2004). Williams et al. (2008) estimate the economic impacts of various scenarios of wind projects for two counties in Texas, using Monte Carlo simulation combined with an economic input/output analysis. Considering both construction and operations, they find that a county with a more rural and less developed economy typically receives fewer economic benefits than a highly developed economy, since relatively less of the labor and equipment, and fewer of the supplies, are purchased locally (Williams et al., 2008).

2.4.1 Environmental Impacts

Negative impacts of wind turbines are very low when compared to other power sources, since it provides clean and cheap power without increasing carbon dioxide in the atmosphere (Saidur, Rahim, Islam, & Solangi, 2011). The negative environmental impacts associated with wind power are: visual eyesores, noise, killing of birds, and disturbing wildlife (Saidur et al., 2011). Even excluding studies about the impacts of off-shore turbines on marine life, the environmental impacts of wind turbines have been covered by several pieces of research. Environmental research has focused on: positive environmental impacts of wind turbines and comparing the environmental impacts of wind turbines to others energy sources like fossil fuels, natural gas, or solar panels (Saidur et al., 2011; McCubbin & Sovacool, 2013); negative impacts like noise and visual eyesore (Palmer, 2015;); and impacts on bat mortality (Santos, Rodrigues, Jones, & Rebelo, 2013; Thompson, Beston, Etterson, Diffendorfer, & Loss, 2017). However, most agree that the negative impacts are highly localized, and can be mitigated by locating wind farms farther from dense areas, primarily to reduce the visual eyesore and the noise impacts, thus favoring rural settings (De Vries, Vuuren, & Hoogwijk, 2007; Mc Cubbin, & Sovacool, 2013; Saidur et al., 2011; Santos et al., 2013). Some studies consider visual disturbance as a negative impact of wind farms (Plamer, 2015). This research concerns itself with rural areas where, unlike in touristic areas, rural residents are accustomed to their land being an economic resource to use for financial purposes rather than just an aesthetic function (Hamin, 2002).

After reducing the noise and eyesore by locating wind turbines in rural areas, we must address the impacts of disturbing wildlife and killing bats. The federal government and the state governments have policies to protect natural resources and wildlife areas from development – even green development like wind farms. Fargione, Kiesecker, Slaats, & Olimb, (2012) identified low impacts areas of wildlife for wind development in the Northern Great Plains region; using these low impact areas as a guide, certain regions can achieve the goal of increasing wind energy without harming wildlife. The remaining negative environmental impact of wind turbines is killing bats. Generally, bat mortality has been increasing in recent years due to many anthropogenic threats and low productivity (Thompson et al., 2017), making bat mortality on account of wind farming a significant issue. According to Thompson et al. (2017), wind turbines killed hundreds of thousands of bats annually by colliding with wind turbines, in the United States. There is a variation in mortality across wind energy facilities. Increasing the percentage of grassland cover around wind turbines decreases the bat mortality per MW (Thompson et al., 2017). The bat mortality around wind turbines needs more research to know how to decrease bat mortality around wind turbines.

Finally, there are questions about air quality. Kahn (2013) claimed that using wind power enhanced the local air quality which improves the quality of life. Using data from the Environmental Protection Agency (EPA)[2] on ambient air pollution by county to study how electric utility production activity affects local air quality, Kahn used total nitrogen oxide emissions and total sulfur dioxide emissions from the electric utilities located within county borders. He found that local air pollution is higher in counties where fossil fuel plants are located, in contrast to counties with wind power and solar plant.

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[2] The U.S EPA creates EGRID data for over 5000 United States power plants. The EGRID data provides information on the exact location of the power plant and its size, emissions and primary fuel it uses. “Total NOX” represents a county's total nitrogen oxide emissions from the electric utilities located within its borders. “Total SO_2” represents the same object but based on total sulfur dioxide emissions

A concern for wind farms is whether they harm agricultural incomes. Each turbine typically removes less than an acre from agriculture production, leading to slightly reduced agricultural production. However, economic incomes tend not to be reduced. The income from hosting a turbine exceeds the amount of revenue lost from decreased crop production (Ouderkirk & Pedden, 2004). Rural residents believe that wind turbines can prevent developers from buying up agriculture land and allow farmers to continue actively farming because there is a strong belief that the underlying amount of income will be forthcoming (Mulvaney, Woodson, & Prokopy, 2013; Brannstrom & Persons, 2011).

It has been clear that wind turbines slightly reduced the size of agricultural land but did not reduce the farmer’s income. What is less known is the effects of wind turbines on crop production. To date, only one study tried to measure the impacts of wind turbines on crop production, particularly on corn and soybeans, for two summers in Iowa (Rajewski et al., 2013). Their experiment discovered that wind turbines create measurable changes in microclimate over crops. They suggested that these changes may actually enhance crop production, although their experiments did not provide any measurements of plant growth. The changes on the microclimate over crops include turbulence wakes forcing warmer air downward. The wakes cool the plants on hot days and warm them to prevent freezing during colder nights. Furthermore, the fanning breeze evaporates dew or other moisture, thus inhibiting the growth of damaging fungi and molds (Rajewski et al., 2013). One study is insufficient to judge the effect on wind turbines on plant productivity; this point needs further research.

The relationship between wind development and tourism is complicated. One perspective fears that wind farms may destroy the aesthetic appeal of tourist areas. The other posits that wind farms may bring a different kind of tourism to rural areas. In the end, local governments decide what is better for their local economy. If there is any chance for a conflict of interest with the local economy and wind power projects, the county does not agree to have wind farms. Examples include Stoneham County in Texas and the state of Vermont, both of which have refused wind projects over concerns about hurting the tourism economy (Lapoint & Haggard, 2011; Hoffer, 2002).

There is a common argument about the negative effect of wind turbines on property values. This argument has been studied widely in the United States and Europe, but with mixed results. Several recent studies in Europe found that wind farm visibility reduces local house prices (Gibbons, 2015; Jensen et al., 2018; Sunak & Madlener, 2016). In contrast, two studies did not find impacts on home prices surrounding wind facilities in Cornwall, United Kingdom (Sims & Dent 2007; Sims, Dent, & Oskrochi, 2008). Studies on the United States and Canada find that wind turbines have not significantly impacted nearby property values (Vyn & McCullough, 2014; Hoen et al., 2009; Hoen et al., 2011; Hoen et al., 2015; Lang et al., 2014; Hoen & Palombo, 2016).

2.5 Empirical analysis of studies that investigated socioeconomic impacts of wind power by approaches

Although rural wind development is a relatively recent phenomenon, there have been several studies that attempt to measure its impacts. These studies measured the impacts of wind power in terms of income, employment, tax income, lease payments, school revenue, property value, property tax rate, and pollution levels. Researchers generally follow three approaches to study the socioeconomic impacts of wind power: studies estimating the hypothetical impacts of wind projects using simulation models;

studies measured local impacts using statistical approaches, and others investigated the public perception of the impacts of wind power. In the next section, I discuss each approach alone, then build a picture of how these factors together can affect rural development.

2.5.1 Simulation Models

Many researchers have used input-output models to estimate indirect and induced benefits of wind power development. Predicted outcomes from input-output modeling are gross effects and determined by the model's parameters and input levels. The expected outcome of wind development has been covered by academic studies and governmental reports on two scales: state and county. Studies employed an application of input and output model, named Jobs and Economic Development Impact (JEDI), created by the National Renewable Energy Laboratory (NREL) to estimate the economic impacts of wind power projects on the state level. However, most of the authors modified the JEDI model, either by using local data instead of the model's defaults, or by mixing the model with another simulation method such as Monte Carlo simulation. The JEDI model was designed to overcome some of the typical limitations of an input/output model such as allowing the analyst to adjust local purchase coefficients. However, the models still produce estimates that are reasonably high (Brown et al., 2012). The research of Slattery et al., (2011), and Torgerson, Sorte, & Nam (2006) compare the JEDI default results with real local data results. Slattery et al., (2011) find that at the state level, the JEDI default model appears to overestimate economic impacts during construction and to slightly underestimate impacts during operations relative to models conducted with the project-specific data. Torgerson et al. (2006) find that JEDI default results are much higher than those using IMPLAN[3] model's impact modeling software.

The outcomes of the expected model were jobs, income, tax income, and property tax income. All the expected studies found positive impacts of wind power. The next table (Table 2-2) summarizes the predictable impacts of wind power development per MW.

Table 2-2: The expected impacts of wind powers on the county level

Expected Impacts	Impacts per county	Studies
The permanent jobs	0.045 - 0.58 jobs per MW	Grover, 2002; GAO, 2004; NEA, 2003; Slattery et al., 2011; William et al., 2008; Costanti, 2004; Mongha et al., 2006.
Tax Income	$4,000 to $12,000 for each MW.	Grover, (2002); NERL database
Lease payments	$2,000 to $10,000 annually, per utility-scale turbine.	Bolinger & Wiser, 2006; Tegen & Goldberg, 2006

Studies at the state level predict that every MW of installed capacity during the construction period creates approximately 1.7 to 2.9 jobs and from 0.23 to 0.3 jobs during the operations phase (Reategui & Tegen, 2008; Lantz, 2009; Reategui & Hendrickson, 2011; Halvatzis & Keyser, 2013). County-level studies tend to find higher impacts, with every MW of installed capacity expected to create approximately 0.12 to 2.5 jobs during the construction phase and from 0.045 to 0.58 jobs during the operations phase at the

3 IMPLAN is an economic impact assessment software system. The system was originally developed and is now maintained by the Minnesota IMPLAN Group (MIG).

county level (Grover, 2002; GAO, 2004; Slattery et al., 2011; William et al., 2008; Costanti, 2004; Mongha et al. 2006).

The job creation values are also dramatically different from one another at the same level (e.g., 0.05 jobs/MW for one study and 0.5 jobs/MW for the other), so one is tempted to discount the relative impact of job creation of wind farms. Also, the job creation values are different from the state and county-level studies. The state level studied tend to find high values of jobs than the county level studies.

Table 2-3: Literature summary of number of jobs created per MW

	Construction period	Operation period
State level (JEDI model)	0.5 – 2.9 jobs per MW	0.23 - 0.45 jobs per MW
County level (JEDI model)	0.12 - 2.5 jobs per MW	0.045 - 0.58 jobs per MW
County level (ex-post econometric model)	----	0.5 jobs per MW

2.5.1.1 Tax Revenue

According to the literature I have reviewed, wind projects increased local tax revenue. The NERL database states that wind power projects provide property tax payment to the local government in the order of \$4,000 to \$12,000 for each MW. Grover (2002) estimated the local tax revenue impacts of a proposed 390 MW wind power plant in Kittitas County, Washington. He predicted that tax revenues from the area would increase by 11% per year, 2% of the increases would be disbursed for immediate local services. According to Grover, (2002) each MW could provide approximately \$7,000 local tax annually. However, Grover failed to consider the tax abatements that are commonly offered to wind farm developers and may reduce the overall amount of direct tax revenue. For example, the State of Texas allows counties the authority to abate local property taxes on wind developers for up to ten years. After the ten years, wind developers pay the full property tax (Media agent, 2015 April 22). In the end, local tax revenues depend heavily on state and county law. Notably, other researchers do not estimate tax revenue impacts from wind power projects under the assumption that wind projects receive local sales and property tax abatements that negate the direct impacts on local revenues (Slattery et al., 2011).

2.5.1.2 Lease Payments

An additional source of economic benefits from wind energy are the lease payments made to landowners who are often rural farmers. The use of wind turbines is considered a new “cash crop” among landowners who may receive up to \$2,000 to \$10,000 per year in a lease or in royalty payments for every utility-scale turbine (Bolinger & Wiser, 2006). Similarly, Tegen and Goldberg (2006) found that landowners typically receive between \$3,000 to \$6,000 per turbine per year, depending on the size of the turbine and the contract agreement. Since each turbine typically removes less than an acre from agriculture production, and, in most cases, livestock can continue to graze right up to the base of the turbine tower, this extra income from hosting number of wind turbines is literally “a windfall” for farmers (Bolinger & Wiser, 2006).

Table 2-4: Summary of literature review estimated wind power impacts.

Study	Level	Method	Outcomes	Multiplier	Findings
William et al., 2008	County-level - two counties.	Monte Carlo Simulation with Economic Input/Output Analysis	JEDI outputs: Jobs, economic activities, tax income, and lease payments	Estimated the county multiplier, following the same method of IMPLAN.	For a 60 MW project increase economic activities in the rage of \$9.91 to \$12.51 and \$10.29 to \$12.43 million, during the construction phase During the operation phase, economic activity increased by \$0.74–\$1.00 million and \$1.24–\$1.67 million. Each MW expected to create 2.4 to 2.5 jobs during the construction, and 0.48 to 0.43 jobs for each MW during operations.
Grover, 2002	Kittitas County, Washington	Phone survey and interview with tax assessors of seven counties with recent wind projects as well as JEDI with local data	Property value, economic impacts, and tax revenue	JEDI Defaults	A proposed 390 MW estimated to increase the county tax revenue by \$2.8 million/y (11% increase), of which \$693,000/y would be disbursed for immediate local services (2% increase). Tax assessors of seven counties with recent wind projects reported that there is no effect on property value and two counties voluntary mentioned that wind projects increased the county tax base.
Slattery et al., 2011	Four counties in west Texas and the state level	JEDI	JEDI outputs	IMPLAN local multiplier, project-specific data obtained from interviews.	For job creation: In the construction period .48 jobs per MW at the county level and 2.9 jobs per MW at the state level. In the operation period, .045 at the county level and .25 at the state level. Although Texas has seen extensive wind energy development, the expected

					employment of wind power projects is not higher than other states' results.
Global Energy Concept (GEC), 2005	Lewis County New York	Previous projects' data to expect the outcomes	JEDI outputs	Not applicable	Wind facility 330 MW in Lewis County, New York. Job creation: For construction:1.4 job per MW and 0.08 job per MW in the operation. Approximately $8 million in annual PILOT payments to local towns, school districts and the county, plus licensing fees and other services revenues (due in part to the project's location in an Empire Zone). Approximately $1.5 million annually in landowner lease payments.
Greene & Geisken (2013)	City of Weatherford, OK - small city in a rural area	Economic model (IMPLAN + JEDI) In-depth interviews with local politicians, public officials, and business owners. Survey for the residents	Estimated economic impacts, perception of the residents, and local economic benefits according to local politicians.	IMPLAN	This study analyzes the impact of 147 MW wind farm. Expected economic impacts: estimated US$27 million in local spending. Job creation: For Construction: 1.3 job per MW and 0.08 job per MW in the operation phase. US$1.7 million continues to be spent annually in the local economy, with over US$600,000 in additional property tax revenue and almost US$400,000 in direct land lease payments to landowners. Using in-depth personal interviews: according to the mayor, the city receives

					US$25,000 a year from the developer for lost aesthetic beauty and community improvement. A variety of local business owners reported how their business was impacted during the construction phase. For example, local hotels said that they were at full capacity for three to four months at a time during the construction.
Reategui, & Tegen, 2008	State of Colorado for 1000 MW	JEDI	JEDI outputs	Adjustment to the model by using local information instead of the model default.	In the construction phase, \$34.9 million annual local activities. During the operation period: 4.6 million tax income, and 2.5 million lease income. In the construction phase, 1.7 jobs per MW and the operation phase, 0.3 jobs per MW
Lantz, 2009	State of Nebraska for 1000 MW	JEDI	JEDI outputs	Adjustment to the model by using local information instead of the model default.	In the construction phase, two jobs per MW and in the operation phase, 0.23 per MW
Reategui & Hendrickson, 2011	State of Texas for 1000 MW	JEDI	JEDI Outputs	Adjustment to the model by using local information instead of the model default.	In the construction phase, 2.1 jobs per MW and the operation phase, 0.24 jobs per MW
Halvatzis, & Keyser (2013).	State of Iowa for 1000 MW	JEDI	JEDI Outputs	Adjustment to the model by using local information instead of the model default.	In the construction phase, 2.3 jobs per MW and the operation phase, 0.27 jobs per MW.

Costanti, 2004	Six counties in Montana	JEDI	JEDI Outputs	Some of the JEDI inputs were the same as the default of JEDI, and the author changed some.	Job creation ranges from .12 to 1.58 during the construction phase. And .32 to .58 jobs during the operation phase.
Torgerson, et al., 2006	Umatilla County at Oregon	JEDI and input/output model editing by using IMPLAN data	JEDI outputs	using IMPLAN derived model regional purchase coefficients (RPC's) for Umatilla County	Using the county detailed multiplier result of 1.54 jobs per MW during the construction phase and .28 per MW jobs for the operation phase.
Mongha, & Harman (2006)	County at Utah state	JEDI	JEDI outputs	JEDI default	3.2 jobs for 1 MW in the construction phase and .4 for the operation phase. This number is very high compared to another study which reveals the bias of the study.
Ouderkirk & Pedden (2004)	Sherman County Organ State	Interviews and emails with local landowners, residents, businesses, technicians, county officials, the developer, and the owner	Construction workers, lease payments, and tax income	Estimated the local multiplier using other counties multiplier and compared to the population size. (1.1 to 1.3)	The construction of 24 MW used 32,000 labor hr, approximately .64 jobs per MW. Lease payments: $2,000 to $4,000 per turbine, per year In the first year of operations, property tax revenues totaled $321,206 from the wind turbines, or slightly over $20,000 per turbine, increasing tax revenues in the county by 10% over the previous year. Wind project increased the tax base in the county and the local school revenue.

Clemmer, 2001	State of Nebraska	Input-output model IMPLAN	JEDI outcomes	IMPLAN	Estimating the economic impacts if the state produce 10% of its electricity from wind. 800 MW wind farms would create 420 jobs in construction and 360 new jobs in operation. 0.5 jobs per MW in the construction and 0.45 per MW in the operation. In additional to $15 million in earnings and $26 million in GSP. Payment lease $2,000 per turbine. He concluded that wind power would produce more in-state economic benefits than imported natural gas and coal.

2.5.2 Measured the ongoing impacts using statistical approaches

Most of the studies that measured the real post-impacts of wind power projects used an econometric model that focused mostly on the property value, some on the school improvement and few on the income and employment. Table 2-5 shows the measured impacts of wind power in the U.S. at the county level. The measured impacts are in terms of income, employment, property tax rates, and school revenue. The impacts of wind power on income was positive in terms of per capita income. Following an ex-post econometric approach, Brown et al. (2012) found a 0.2% increase in the income per capita of the county over the time of 2000 to 2008 at the county level in the Great Plains region. Although De Silva et al. (2016) found a significificate increase in per capita income in rural counties in Texas State attributed to wind power development, they did not find any effect on the median household income in the county, which proves that wind power benefits the landowners who enjoy lease and royalty income and whose personal incomes are most likely above the county median income. This suggests that while wind power may spark local economic growth, this growth may not benefit everyone in the local economic to the same extent. I can test this hypothesis by measuring the impact of wind power development on the percentage of people on poverty.

Table 2-5: The measured impacts of wind power development on rural areas in the U.S.

Impacts	Wind power effect	Study area
Per capita income	0.2 % increase	Great Plains region counties (Brown et al., 2012) Texas State's rural counties (De Silva et al., 2016)
Median household income	No significant effect	Texas State's rural counties (De Silva et al., 2016)
Employment	No significant increase	Texas State's rural counties (De Silva et al., 2016)
	Significant increase	Great Plains region counties (Brown et al., 2012)
Localized industry employment	A significant but small increase in retail and west management employment	Texas State rural counties (De Silva et al., 2016)
Tax base	Positive increase	Texas State's rural counties (De Silva et al., 2016) Howard County in Texas and Umatilla County in Oregon (Grover, 2002) Sherman County Oregon (Ouderkirk & Pedden, 2004)
Tax rate	Decreased	Rural counties in Texas state (Kahn, 2013)
Per student expenditure	Significant increase No significant increase	Rural counties in Texas state (Kahn, 2013) Western Oklahoma (Castleberry & Greene, 2017)
Student teacher ratio	Significant decrease No significant decrease	Texas State's rural counties (Kahn, 2013) Western Oklahoma (Castleberry & Greene, 2017)
Local school revenue	Significant increase	Western Oklahoma (Castleberry & Greene, 2017); Rural counties in Texas state (Kahn, 2013); Sherman County Oregon (Ouderkirk & Pedden, 2004)

Property value	No significant effect	Studies have been on rural and urban areas in most states: Hoen et al., 2009; Hoen et al., 2011; Hoen et al., 2015; Lang et al., 2014; Hoen & Palombo, 2016

Wind power development is often sold to the local community as a job creation strategy. Different studies have measured the impacts of wind power on job creation and employment. Using personal interviews to obtain real data from the developers, Leistritz and Coon (2009) found that each MW creates 1.7 jobs in the construction phase, and 0.06 jobs in the operation phase on the town of Lomgdon in Northeastern North Dakota. Using an ex-post econometric approach, Brown et al. (2012) found positive impact of wind development on employment, with approximately 0.5 jobs per MW of additional wind power capacity. De Silva et al. (2016) did not find a significant effect on overall county employment, but they found a significant employment increase in the most directly associated industries. De Silva et al. (2016) also found a low significant positive impact of wind power on retail and waste management employment, presumably due to indirect and induced impacts. De Silva et al. (2016) assumed that the small proportional change in the overall county employment (0.05%) is difficult to discern significantly.

The impacts of wind development on the tax base, tax rate, and school revenue are related to each other. Several have found that wind power development decreases the property tax rate and increased the tax base (Kahn, 2013; De Silva et al., 2016). At the same time, wind power counties have a higher local school revenue than other counties (Kahn, 2013; Castleberry & Greene, 2017). Kahn (2013), and Castleberry and Greene (2017) studied the impacts of wind power projects on school revenues in some counties in

Texas and Oklahoma, respectively. The two studies found that the local school revenues increased in counties hosting wind projects in contrast with counties without. Kahn (2013) found that that rural counties with wind farms have a lower student-teacher ratio in Texas; while Castleberry and Greene (2017) found that there are no statistically significant differences in percentage change in student-teacher ratio and per-student expenditures between districts with wind turbines and districts without wind turbines in Oklahoma. However, Kahn's (2013) study only used data from two years after wind projects, and thus did not account for the history of the county before wind projects as did Castleberry and Greene (2017). Other contradictory evidence comes from De Silva et al. (2016) who found a significant increase in local school revenues in wind counties after hosting wind projects, but had no effect on employment in the education sector. This result suggests that any localized property taxes and school tax benefits from the increase in fixed wind plant did not result in measurable increases in school employment. This result suggests that these counties devoted some additional wind-related revenues to school programs, facilities and equipment, but not staff.

The relationship between wind power projects and schools' revenue is depending on school funding formulas, which differ by state and sometimes by local jurisdiction. Most commonly schools receive income from the state and county, based upon revenue generated from property taxes collected by counties. When wind turbines are installed on farmland, the assessed value of that property increases. Property taxes are generally paid by the wind developer, not the landowner (Loomis & Aldeman, 2011). At the same time, the state aid to school districts depends on the wealth rate that determined by property taxes. Increased property valuation will be offset, at least in part, by a decrease in funds provided to the district by the state. Although circumstances vary widely from county to county and district to district, the evidence overall supports the conclusion that wind farms benefit school districts financially (Loomis & Aldeman, 2011). The state fund will be reduced in most cases because of increased tax revenue, but the net revenue stream will be positive (Loomis & Aldeman, 2011). Leistritz (2009) stated that school district in the Town of Lomgdon in Northeastern North Dakota received $1,666 annually for each MW in the town. Finally, I conclude that school districts with wind projects benefit economically from the projects; this economic benefit may be cause for an academic improvement. The education attainment can be a suitable indictor to measure how the economic growth of local school revenue can contribute to community improvement (Florence, 2010; Hoffman, Wiggall, Dereshiwsky, & Emanuel., 2013).

The effect of wind power projects on home prices and property value has been studied extensively, mainly through hedonic econometric models. Many studies differentiate impact according to the specific stage of wind projects: announcement, construction, and operation. Although two studies found that the announcement of wind projects reduced the selling price of property, they found no effect on the property values near the wind farm after the wind farm entered the operational stage (Laposa & Mueller, 2010; Hinman, 2010). Laposa and Mueller (2010) explained the 2% decrease in the home sales as an insignificant and minimal impact and attributed the diminution in value more to the coincidence of the timing of the announcement and problems that were occurring in the national housing market. Otherwise, studies on the United States and Canada found that wind turbines have not significantly impacted nearby property values (Vyn & McCullough, 2014; Hoen et al., 2009; Hoen et al., 2011; Hoen et al., 2015; Lang et al., 2014; Hoen & Palombo, 2016). Most of the studies that measured the effect of wind turbines on home value found that no statistical evidence that home values near turbines were negatively affected in any stage of the projects (Hoen et al., 2009; Hoen et al., 2011; Hoen et al., 2015; Lang et al., 2014; Hoen & Palombo, 2016).

Table 2-6: Summary of the literature measuring wind power impacts.

Study	Study Level	Method	Outcomes/Questions	Findings
Brown et al., 2012	Counties of the Great Plain region	Ex-post econometric model	Per capita income and employment	An increase in total county personal income and employment of 0.2% and 0.4% for counties with installed wind power. 0.5 jobs per megawatt of wind power capacity installed.
Kahn (2013)	Case study of four counties in West Texas, using school districts as unit of analyses	A multivariate linear regression	Student-teacher ratio, expenditure per pupil, property tax rate per county, and air pollution levels	Rural counties with wind farms have lower property tax rates than neighboring counties. Wind farm counties have lower student–teacher ratios. Ambient air pollution levels are higher near fossil fuel fired power plants. He concluded that the lower property tax rate in wind power counties after wind projects and indicated that wind development had played a role in public financing. He hypothesized that wind projects will improve the school quality in the area which may attract some people to migrate to these areas. Wind farms can be an example of place-based investment that change the character or rural areas, but his analysis did not prove this hypothesis.
Castleberry & Greene (2017)	108 school districts in western Oklahoma from 1997 to 2015	Spatial and multivariate analysis. Longitudinal temporal analysis	Percentage of revenue from local county sources, student-teacher ratios, and per-student expenditures	Statistically significant differences in percentage change in local and county revenues between districts with and without turbines. An average increase in local and county revenues of approximately 55.8%, comparing to 26.1%. No statistically significant differences in percentage change in per-student expenditures and student-teacher ratio between districts with turbines and districts without

				turbines in 2010.
Leistritz & Coon (2009).	Town of Lomgdon in Northeastern North Dakota	An integrated impact assessment model.	Local economy, population, public service's needs, and the costs and revenues for local government.	1.7 jobs per MW in the Construction; and 0.06 job in the operation phase. In the construction period: The motels were full, and all rental housing was taken. The recreational trailer vehicles were parked in the city park. The wind facility made payments of $8,900 per MW including payment roll and land lease for turbines. The annually local property taxes are estimated to be $2,900 per MW. The developer had agreed to take responsible for any needed road work to cover the cost of the expected road damage. Using real data about the project's workers and annual expenditure and estimated the indirect impacts.
De Silva et al., 2016	Counties in Texas	Traditional econometric methods	Employment, personal income, property tax base, and key public-school expenditure levels.	Wind power development does not have a statistically significant effect on net overall employment and establishments at the county level, and they agreed that such a small proportional change (0.05%) is difficult to discern significantly. There are significant effects at the local industry level (establishment and employment per industry). Increasing on the mining and utilities establishments and decreased on the agriculture establishment, but there is no evidence of such change in employment in agriculture sector. Low statistical significance of increasing on employment in retail and waste management affected by wind development, suggesting indirect/induced effect in these two industries of about 40 jobs per 100 MW.

				A statistically significant effect on the per capita income and no impact on the county maiden income. An increase in the property tax base and the local school revenue.
Loomis & Aldeman, (2011)	Illinois State	Hypothetical model and Two case studies (two school districts in Illinois)	School	This report seeks to clarify and explain the financial impact that a wind farm has on the total revenue to a school district. They Estimated the impacts of wind farms using three different scenarios of state aid formula. They also discussed the impacts on two case studies. In the hypothetical examples, as well as the two case studies, they found a significate increase on the school revenue due to wind farms. In the hypothetical examples, the effect of a 100 MW wind farm is shown on a school district under the three different scenarios. In this example, the average net annual benefits to the district over the first three years of the wind farm's operation is: • \$456,173 - under the Foundation Calculation • \$607,848 - under the Alternative Calculation • \$605,082 - under the Flat Grant Formula (Loomis & Aldeman, 2011).

Table 2-7: Summary of the literature measured the real wind power impacts on property value using Hedonic price model.

Study	Study level	Method	Outcomes\Questions	Findings
Laposa & Mueller, 2010	2,910 residential real estate transactions in two rural census tracts in Northern Colorado	Hedonic price model	The effect of the announcement on the property value, the farm was never constructed (at least not by the time of publication)	The announcement reduced the selling price of property by approximately 2% (insignificant and minimal impacts), but the authors attributed the diminution in value more to the coincidence of the timing of the announcement and problems that were occurring in the national housing market, especially that the wind farm announcement was in the middle of 2006. The authors' claim their opinion is substantiated by a survey they conducted of local real estate brokers as part of their analysis (Carter, 2011, p. 7).
Hoen et al., 2009	7,459 real estate transactions from 10 different communities near wind farms.	Different variations of the hedonic price model, a sales volume model, and repeat sales model	Investigated the presence of area stigma, scenic vista stigma, and nuisance stigma on property value.	The authors found some indication of nuisance and scenic vista stigma in their analysis, but the stigmas did not appear consistently across their specifications. This led them to conclude that "home prices surrounding wind facilities are [not] consistently, measurably, and significantly affected by either the view of wind facilities or the distance of the home to those facilities" (Hoen et al., 2009, p. 75).
Hoen (2006)	280 real estate transactions in Madison County, New York, over ten years.	Hedonic price model	Investigated the presence of area stigma, scenic vista stigma, and nuisance stigma on property value	He found no statistically significant difference in sale prices for houses that were sold within the view shed of an existing wind farm.

Carter, 2011	1,298 real estate transactions from 1998 to 2010 in Lee County, Illinois	A hedonic price model	Residential property sales	Located near wind turbines in Lee County have not been affected by their presence. Uses data from before any wind farms were proposed, instead of only using data from the post-construction period. This allows for analysis on how property values have changed since the development occurred.
Hinman (2010)	3,851 residential property transactions from January, 2001 through December, 2009 from McLean and Ford Counties, Illinois.	Pooled hedonic regression analysis with difference-in-differences estimators	Pooled hedonic regression analysis with difference-in-differences estimators	When the wind farm was initially announced, property values near the proposed wind farm site sold for less than those located elsewhere. However, after the wind farm entered the operational stage, property values near the wind farm appreciated faster than those located elsewhere in the county (Carter, 2011, p. 7).
Lang et al., 2014	Rhode Island Data from 2000 and February 2013	Hedonic difference-in-differences models	Property value	Ten sites in Rhode Island that currently have turbines of 100 KW or above. These are single turbine sites. The turbines were built in 2006 to 2012. Wind turbines have no statistically significant negative impacts on house prices, in either the post-public announcement phase or post- construction phase.
Hoen & Palombo , 2016	Massachusetts State 122,000 home sales, between 1998 and 2012, that occurred near	A base hedonic model along with a large set of robustness models	The impacts of the announcement, after construction on property value.	The effects of planned or operating wind turbines on urban home values. No net effects due to turbines in these communities. They also found no unique impact on the rate of home sales near wind turbines. Wind facilities in Massachusetts have been located in areas where average home prices were lower than

	41 turbines in densely populated Massachusetts communities.			prices in surrounding areas.
Hoen, 2011	Ten communities in nine separate states, and total 1,286 MW, or roughly 13% of total U.S. wind power capacity installed as of the end of 2005.	OLS and spatial process difference indifference hedonic models	The home value impacts of the wind facilities	7,500 sales of single-family homes surrounding 24 existing U.S. wind facilities. Across four different hedonic models, and a variety of robustness tests, the results are consistent: neither the view of the wind facilities nor the distance of the home to those facilities is found to have a statistically significant effect on sales prices, yet further research is warranted.
Poletti, 2007	256 sales that occurred near wind facilities in Wisconsin (Kewaunee County) and Illinois (Lee and McLean County).	Property Sales - Statistic	Property value	He was unable to find statistical evidence that parcels near the facilities were impacted.
Hoen et al., 2015	50,000 home sales among 27 counties in nine states. These homes were within 10 miles of 67 different	Standard OLS model, and spatial process difference-in-differences hedonic models to estimate the	The effects of the distance of wind farm on the sale price, the effect of announcement, after construction of the wind farm on the sale	The study claimed using large data and controlling for potentially confounding home value factors, such as those affecting home values before wind facilities were announced. Using OLS and spatial process difference in- difference hedonic models, across all model specifications, they find no statistical evidence that home prices near wind turbines were affected in

	existing wind facilities. Using data from 2013.	home value impacts of the wind facilities.	prices in different distance.	either the post-construction or post-announcement/pre-construction periods.

2.5.3 Perception Impacts

Public perception of wind power has been the topic of many recent studies. Some focus on environmental impacts such as eyesore and noise (Klick, & Smith, 2010; Palmer, 2015); the willingness to install more wind turbines on their communities (Swofford & Slattery, 2010); and, the knowledge of wind power (Greene & Sawatzky, 2013). Few of the public perception papers investigate how the community perceives the socioeconomic impacts of wind power (Greene & Sawatzky, 2013; Leistritz & Coon, 2009; Groth & Vogt, 2014a; Groth & Vogt, 2014b; Jacquet & Stedman, 2013; Slattery et al., 2012).

The majority of the perception research used mail surveys, while some employed interviews with local business owners, local officials, and homeowners. The local business owners stated substantial positive impacts on their business during the construction period. For instance, during the construction period, the local motels were full, and all rental housing was taken; local establishments like construction, fence, and food business made a decent revenue in the construction period (Greene & Sawatzky, 2013; Leistritz & Coon, 2009). The same benefits occurred with the local officials. The mayor of Weatherford city said that:

> "to compensate the city and citizens of Weatherford, the wind farm developer agreed to pay the city $25,000 a year for lost aesthetic beauty and community improvement projects. This was a huge benefit to the city and was not part of the city's normal budget. The city has used some of the money to install a security and surveillance system on the city government complex, a new city building, gym, and playground" (Greene & Sawatzky, 2013, p. 7).

The question here is whether the increased municipal finances of the city of Weatherford are a unique case or a common impact for communities with wind power. The residents of Nolan County, Texas reported an increase in rental prices and cost of living prices due to wind projects, which hurts renters (Brannstrom & Persons, 2011). However, Nolan County is a peculiar case as a small rural county that has over 2000 MW of wind energy--the second highest wind capacity of any county in the United States after Kern County, California. If wind projects lead to an increase in rental prices and cost of living prices in rural communities, without an associated increase in income, wind energy will be hurting the rural communities more than benefiting them.

Researchers also asked the local officials about the physical impacts of wind power. The only concern of the local officials was the road conditions, and they reported that the developers agreed to take responsibility for any damage (Greene & Sawatzky, 2013). The local residents reported some traffic issues during the construction phase of wind projects (Jacquet & Stedman, 2013). However, this issue is temporary and is not specific to wind developments. A strange phenomenon is that the public believed that wind farms caused an increase in the energy prices in their community, found only in one study done by Groth and Volt (2014b).

Two studies found that local residents perceive positive economic and social impacts of wind power development (Slattery et al., 2012; Jacquet & Stedman, 2013). Slattery et al. (2012) examined the perception of the residents of rural counties in Iowa and Texas and found that more than two-thirds of the respondents indicated that their county had benefited economically from wind farms. The majority of respondents in both states felt that wind farms increased tax revenue, which benefited their community and schools. According to Slattery et al. (2012) and Jacquet & Stedman (2013) rural residents of Iowa, Texas, and Pennsylvania cited job creation as a benefit deriving from wind power development. Economic perception has the highest impact on the general attitude toward wind development, followed by environmental impacts and thirdly, social implications (Jacquet & Stedman, 2013; Slattery et al. 2012), although Groth and Volt (2014 a) did not support the hypothesis that economic beliefs were the driving force of perception and support of wind power. At the same time, Groth and Volt (2014 b) found that landowners felt the economic benefits more than others; landowners are more supportive of wind development than respondents who did not own any land. This result supports the hypothesis that wind power benefits are experienced by few people, not the whole community.

Table 2-8: The summary of the literature about the perceived socioeconomic impacts of wind power on rural areas.

Author	Study- level	Method	Outcomes/Questions	Result
Groth & Vogt, 2014a	Four townships in Huron County, Michigan. Two of the townships contained operating wind farms, and two without wind farms were used as comparison sites.	Interviews by implementing a small snowballing sample, of local stakeholders (n= 11), followed by a mail survey to homeowners. Respondents were almost exclusively homeowners without turbines (only 2 respondents out of 497 reported to have turbines on their property).	Questions developed to identify the social, economic and environmental characteristics that are linked to both positive and negative perceptions of wind energy development.	The findings from all four town-ships revealed that economic beliefs were not significant, but environmental (significant in two townships) and social (significant in three townships) beliefs were significant in predicting support for wind farms. The economic beliefs were not significant, in contrast with other studies, which may point to the nature of the questions. In the mail survey, the study used five statements to ask about the economic impacts of wind power, three positive impacts such as increases property value, brings money and other economic benefits to the communities; creates tourism (non-residents are interested in seeing. Two of them cannot be proved by other studies. The hypothesis that economic beliefs were the driving force of perception and support was not supported by the data. Social beliefs were the strongest predictor of support for wind development.
Groth & Vogt, 2014b	Two inland rural townships in Huron County. Both townships have wind farms.	A mail questionnaire	Questions were developed to identify the social, economic and environmental characteristics that are linked to both positive	The questionnaire included a “yes/no” questions on whether residents would support further wind energy development at any location within their township. The results were compared across the group as a whole and as two individual groups (those who opposed and those who supported wind

			and negative perceptions of wind energy development.	energy development). The top three most recurring attributes found in the qualitative analysis overall (including both of the groups who opposed and supported development) were the 'increase in electric rates,' 'uncertainty/unclarity' in general surrounding the turbines, and the concern regarding 'noise.' Overall, I found that respondents who owned land were more supportive than those respondents who did not own any land.
Slattery et al., 2012	Four counties in Texas and seven counties in Iowa State. They choose counties around the big wind projects in two of the leader states on wind power. They included small counties as well as densely populated counties to present both economically robust community and rural community. They	Mail Survey	Understanding public reactions to large-scale wind developments as a prerequisite of more widespread use of renewable energy resources.	The survey included 13 statements relating to socio-economic impacts. Most of the perceived impacts was positive; the only negative issue was the traffic associated with the construction time. Most of the respondents indicated that their county had benefited economically from the wind farms and they create jobs in the county. Residents also felt that wind farms increased tax revenue, which benefitted their community and schools. There were significant differences in attitudes between the Iowa and Texas respondents, explicitly relating to the socioeconomic impacts of the wind farms. Texas residents agreed more on the benefits of wind farms to their communities than Iowa. For example, only 52% of Iowans felt the wind farms had benefitted their counties; in Texas, 77% of respondents at both locations felt this was the case. The study found that the main reason behind the broad support for wind-

	included Nolan county which was the core of the study of Brannstrom and Persons (2011).			power development in west Texas and Iowa is the perceived increased employment and economic activity, two essential benefits in the eyes of key stakeholders. However, the degree of neutrality on whether tax revenues benefit schools and the community, and whether wind farm development results in increased property values, indicates concerns regarding two critical areas in attracting wind-power development.
Mulvaney & Prokopy, 2013	Three counties in Indiana. One county has the highest concentrated wind turbines in the state; one county in the processing of allowing of wind farms; the third county has a height ordinance that prevents the siting of wind turbines.	A mixed methods approach was used including mail surveys targeting residents, interviews with local officials and stakeholders and a document review of newspaper articles and published reports.	Reasons for support and oppositions of wind farms and how local government respond to wind development.	They found that the reasons of support are environmental and financial benefits; and causes of oppositions are changes to the landscape, the lights on the turbines at night, noise and health issues. The authors did not find any difference on the survey result among the three counties. But the interviews results and the local government respond shows different, especially between the Boon county that prevents the siting of wind turbines and Benton county with wind farms. The authors related this difference to two reasons: The first is the lower socio-economic status and rural nature of Benton County as the most influential reasons behind people's willingness to support wind turbine development. The nature of the residents of Boone County where they can live in a rural area and commute to work. A Boone County government official described Boone County's population as ''a large number of people who move here to be away from the city. And they're vocal. Once they get

				theirs, they want to protect it.'' County residents viewed the wind turbines as a way to prevent developers from buying up agriculture land or allowing for farmers to continue actively farming the land.
Brannstrom & Persons, 2011	Nolan County West Texas. Small county with over 3000 MW wind capacity	Semi- structured interview with landowners with wind turbines, elected and civil service government officials, and prominent local business and community leaders using snow ball sampling. Employed Q-method, which combines qualitative and quantitative techniques.	Social perspectives toward wind energy.	The social perspective of wind power projects as the development trigger was behind the advocacy of wind development. The perceived increased employment and economic activity, job creation and economic development are critical positive benefits in the eyes of key stakeholders. The poor socio-economic situation of the county is one of the importance reasons behind people's willingness to support wind turbine development. People believe that wind power will help ranchers and farmers keep ranching and farming because there is enough confidence that the underlying amount of income will be coming. The authors found indications of negative economic impacts involving housing and cost of living prices, which hurt Sweetwater's non landowning elites or boosters not directly engaged in renewable energy. For this, they recommend future research on the unequal distribution of benefits from wind-power development and to the debates surrounding the

				incentives that elites offer to wind energy firms.
Jacquet & Stedman, 2013	Two counties in Northern Pennsylvania	A mail survey for landowners between 3 km and 16 km from the nearest wind turbine.	Economic and social prespectives toward natural gas and wind power.	Although the study reveals that the types of perceived impact from wind and natural gas are similar overall, the perceived magnitude of positive and negative impacts is greater from natural gas drilling. They found that the perceived economic impacts were largely neutral for wind farm development (mean = 2.98), while they were quite positive for natural gas drilling (mean = 3.64). The most positive perceived impact was "area employment" from both wind and natural gas, while "effect on area scenic beauty" and "amount of traffic" were the most negatively affected variables for both energy sources, although the magnitude of impact was reported as more significant for gas drilling. The authors emphasized that the perceived impacts from energy development is an essential driver of overall attitudes toward the energy projects.

2.6 Discussions

The empirical results reported herein should be considered, in the light of the limitations of the literature, to cover the impacts of wind development on development indicators such as the percentage of people in poverty, educational attainment, public services, and other indicators. In this section, I discuss my results and how these results answer the main research question: can wind power development be a viable development opportunity for struggling rural communities to achieve better quality of life? The results answer the main research question by addressing these sub-questions first:

- **Question one:** What are the social and economic impacts of wind power projects on rural communities? From reviewing over 30 papers on the socioeconomic impacts of wind development on rural areas, the literature I studied found an increase in tax base, property tax, local school income, and the landowner income, without any effects on the property value in rural areas. The tax income of wind projects decreased or stabilized the tax rate in some communities. Wind projects provide a lot of short-term construction jobs comparing to very few long-term jobs.
- **Question two:** Are these impacts large enough to improve rural residents' life? Previous research has focused on the impacts of wind development on specified indicators and did not relate these effects to the quality of life or the rural development. Only Khan (2013) demonstrated that wind farm counties have lower property tax rates, higher school income, and less air pollution, to claim a better quality of life on counties with wind projects. Khan (2013) also

concluded that the improvement of the school quality in wind power counties may attract some people to migrate to these areas. I discussed each measured indicator of wind power development impacts to see whether it is an indicator of economic growth or economic development (Table 2-9). The impacts of wind power on rural areas appears on income, tax income, local school income, and employment. I find that rural development is more than simply employment and income, but also changes in the quality of life. It is difficult to see how the economic growth of wind projects in rural areas effectively alters rural development, especially given broader social trends of population and employment loss in rural areas. There is a limited research into whether and how economic growth leads to long-term rural development.

Table 2-9: The analysis of the wind development impacts indicators

Indicators	Economic Growth	Economic Development
Increased income	Yes	The equity of distributing this income only landowner benefit. landowners emphasized the economic benefits of wind power more than people who did not own land (Groth & Vogt, 2014b). Significant small increase on per capita income verses insignificant on medium household income.
Tax base	Yes	Has this influenced public services to improve the quality of life for the local residents?
School income	Yes	How has this improved the quality of education?
Municipal finance	Yes	How is the money spent? "The city has used some of the money to install a security and surveillance system on the city government complex, a new city building, gym, and playground" (Greene & Sawatzky, 2013, p. 7).

2.7 Conclusions

The belief that the development of wind power in rural areas affects rural economic development and quality of life has become one of the vital arguments for encouraging wind power projects in rural areas. This paper identified three approaches that have been covered in previous research to empirically address the socioeconomic impacts of wind power in the United States and has reviewed the empirical findings of these approaches. The three approaches are: estimating the gross impacts of wind power projects; measuring the net local post impacts, and testing the perceived impacts of wind power. Wind power projects have two phases: a short construction phase usually lasting a year, and long operation phase generally lasting for 20 to 25 years. Most of the researchers measured the impacts of both phases. Construction phase benefits may include construction jobs and massive local spending. The operation outcomes are job income, lease income, and tax income in addition to the induced economic activities of this income. Comparing the impacts of both phases, the construction phase creates huge impacts in the short-term, like an economic stimulus, while impacts during operations are more modest. While most of the research agreed on the overflow of the impacts of construction outside the local community, local business felt the positive benefits of the construction phase more than the operation phase. The benefits of the operation phase are small at the level of the whole community, but may be significant for landowners who receive land lease payments, as well as for municipal finance, and school districts.

When measuring the net post impacts of wind power, researchers found some evidence of increasing personal income, employment, local school revenue, and tax base on counties hosting wind power projects. It also found a decrease in the tax rate and no evidence of decreasing home prices or property value due to wind power projects. These impacts can be good indicators of improving the quality of life in rural areas if it reflects on other indicators like poverty rate, education attainment, population, and health conditions. I am unable to consider these impacts as a sign of rural development until more effects are measured. To date, according to the previous research, wind power projects cause a small economic growth in rural areas.

The research that measured the perceived impacts of wind power found that residents and local officials believed there were, or would be, positive economic and social impacts, in general. Local officials and landowners experienced the economic benefits of wind projects more than the broader category of all local residents. In the construction phase, local business and residents reported two effects of wind projects: positive financial revenue to local business, and traffic concerns from residents. For operation phase impacts, residents believe that wind projects created jobs in their communities and increased the tax revenue.

Taken together, the three methods of estimating the gross impacts of wind power, measuring the net local post impacts, and testing the perceived impacts of wind power all find and believe in the positive impacts of wind projects on rural communities. On one side, simulation studies expected substantial economic impacts of wind projects in terms of income and jobs. On the other hand, the real post studies found small positive impacts on income and employment.

Finally, to answer the question: Does wind power achieve the expected goal of promoting rural development? Virtually all the research (e.g., anticipating the impacts, measuring the ex-post impacts; or measuring the perceived impacts) found a strong association between wind power projects and economic growth in rural counties measured by an increase in personal income, employment rate, tax base, and school local revenue. Rural development, however, is not just income, but also how this income can affect the quality of life of rural residents. It is difficult to see how the economic growth of wind projects in rural areas effectively improve the quality of life in rural communities, especially given broader social trends of population and employment loss in rural areas. There is a significant limitation on the literature in covering the associated rural development with the economic growth of wind development. Does the increase in the tax base and municipal finances reflect on the public services and the whole community, or not?

More research needs to investigate how the benefits of wind power are reflected in the quality of life in rural areas, and what policies and plans can facilitate that. It may be that better local and state plans and strategies will enable wind farm projects to have more positive impacts on the quality of life of the whole rural community. For instance, if the jobs were filled by the local residents and the tax income is used to improve the quality of life of the rural community and educational attainment of residents, I can consider wind development as prompting rural development. If not, it will be only an economic growth goes to some people (e.g., landowners and developers) not the whole community. I agree that the positive known socioeconomic benefits of wind projects are not enough to decide how it affects rural development. I recommend using different measurements and methods to find the net impacts of wind power development on rural development.

CHAPTE 3
THE ECONOMIC AND DEMOGRAPHIC IMPACTS OF WIND POWER DEVELOPMENT ON RURAL COUNTIES IN THE UNITED STATES.

3.1 Abstract

This chapter employs two longitudinal data analytical models to measure the net economic and demographic impacts of wind power development on rural counties: a mixed-effects model, and a fixed-effect model with a quasi-experimental design approach. The mixed-effects model examines the impact of the accumulated wind power capacity in counties in the United States during the period of 1990 to 2015. It finds a small, but significant, effect of wind power development on rural economies. Increasing the accumulated wind power capacity leads to higher per capita income, median household income, per capita employment, and farm income. I likewise find that the introduction of large wind developments is associated with a slightly lower poverty rate. An incremental change in wind capacity does not significantly change the population of rural communities.

I also employ a quasi-experimental research design to compare nonmetropolitan counties with wind developments over 100 MW to a group of structurally similar counties lacking wind developments. I then use a fixed-effects longitudinal model to estimate the differences between the case and comparison groups. The model found that the economic impacts of wind power development on nonmetropolitan counties to be limited to an increase on income per capita only. For the demographic impacts, the fixed-effects results generally agree with those from the mixed-effects model. An incremental change in wind capacity does not significantly change the population of nonmetropolitan rural counties.

3.2 Introduction

Wind power development has rapidly expanded in the United States (Wiser & Bolinger, 2011). Much of this growth has occurred in rural areas because of the availability of land for wind turbines. In the United States, there have been several academic and non-academic studies measuring the economic impacts of wind power projects. However, none, to my knowledge, measures the demographic impacts of wind development on rural counties.

Most existing work estimates the hypothetical economic impacts of wind projects using simulation methods, most commonly input-output based economic impact models. These models generally report substantial positive effects on income and medium positive impacts on employment. The positive economic impacts stemming from wind projects come from a combination of sources: the addition of jobs in the wind farm industry, new tax revenues, lease payments to landowners, as well as indirect impacts, as new investment filters down through local retailers, restaurants, child care providers, and others that serve the needs of the local population (William et al., 2008; Grover, 2002; Slattery et al., 2011; Reategui & Tegen, 2008; Tegen, 2006).

A lesser number of studies measure the net direct impacts of wind development on the rural economies using empirical data, whether in terms of income, employment, school local income, tax base, or tax rate (Brown et al., 2012; De Silva et al., 2016; Leistritz & Coon, 2009; Kahn, 2013; Castleberry & Greene, 2017). They generally find that wind development increases per capita income, leading to growth in the tax base and higher spending on local schools. However, these studies disagree on the effects on employment and median household income.

To my knowledge, no prior study covers the impact of wind development on demographic indicators of community change in rural areas, such as population, poverty, and educational attainment. This study utilizes two longitudinal data analysis of secondary data to measure the net economic and demographic impacts of wind development on rural counties. The longitudinal analysis measures the tangible impacts of wind power on rural development, such as changes in personal income, employment, as well as the changes of population growth, education attainment, farm income, and poverty rate.

3.3 Literature Review

Wind power is an abundant, clean source of power. The continuous increase in energy demands, along with high fuel prices and concerns over environmental hazards, have accelerated the expansion of renewable energy on a global scale. Among the major renewable sources, wind power is considered to be the most environmentally-friendly and cost-efficient (Klick & Smith, 2010; Kempton et al., 2005).

The rapid expansion of wind power also holds true for the United States. The United States has a considerable on-land potential capacity to generate electricity from wind, particularly in the Great Plain's states such as North and South Dakota (NREL Database, 2016). Federal and state tax incentives promoted the growth of wind power development in the United States between 2008 to 2012 (Bird et al., 2005, Shrimali, Lynes, & Indvik, 2015). Technological improvement has also played a significant role in the rapid growth of wind development. Commercial utility-scale wind turbines have improved considerably, becoming larger, more efficient, and more durable. In fact, the energy produced by wind turbines has grown from just dozens of kilowatts in the late 1970s and early 1980s to a maximum of 6 megawatts in 2008 (Logan & Kaplan, 2008).

There are other reasons why the development of terrestrial wind power is seen as a viable development strategy for rural areas. To those that strongly oppose wind power development, the dominating visual impact of wind turbines is a primary concern. Wright (2005) explains public opposition of wind turbines as an expression of “Not In My Back Yard” sentiment (Nimbyism) arising from the conflict between general support and local opposition to specific locations or projects. Research about public perception of wind turbines in the United States disagrees that Nimbyist sentiment against wind development is widespread. In general, public support for wind development is high and local opposition to rural wind projects is rather minimal (Swofford & Slattery, 2010). Previous studies found that the percentage of those expressing opposition of wind farm was too small to indicate NIMBY as a behavior regarding wind turbines (Jones & Eiser, 2009; Swofford & Slattery, 2010; Groth & Volt, 2014a; Groth & Volt, 2014b). When it does arise, public engagement in the decision-making process to develop wind power, as well as an emphasis on the local economic benefits of wind projects, can also be used as effective strategies to reduce public opposition (Ledec et al., 2011).

Rural residents are generally more accustomed to using their land as an economic resource to use for financial purposes rather than just an aesthetic function, and proposed wind farms have generally met less local opposition in rural areas (Hamin, 2002). The visual eyesore concern is especially true in more affluent areas and in popular recreation areas, where the economy may be dependent upon tourism (Lapoint & Haggard, 2011; Hoffer, 2002). In some rural counties, they refused to have wind development due to conflict with other development like tourism and military bases. For example, both Stoneham County in Texas and the state of Vermont have blocked wind power development projects over concerns about hurting the tourism economy. A further concern is that wind turbines can interfere with military radar. For instance, the Stoneham County government has raised concerns that wind turbines might affect the radar signal of the military base in the county.

Due to the massive land requirements, many domestic wind power projects have been placed in rural areas. With wind power development, rural areas stand to reap relatively more of the economic benefits of new energy projects, with less displacement of the agriculture land. Although wind turbines may disturb the traditional visual landscape, they generally do not have any negative impact on agricultural sources of income. Farmers can continue to farm and raise cattle in the areas around wind turbines while earning additional revenue by leasing the land to energy companies (Bolinger & Wiser, 2006). Ouderkirk and Pedden (2004) show that income from hosting a turbine typically exceeds the amount of revenue lost from decreasing crop production. Rural residents believe that wind turbines can prevent developers from buying up agricultural land and allow farmers to continue actively farming because there is enough confidence that the underlying amount of income will be forthcoming (Mulvaney et al., 2013; Brannstrom & Persons, 2011).

3.3.1 Economic Impacts

Wind power projects have three economic impacts: direct, indirect, and induced impacts (Figure 3-1). Direct impacts include job creation, lease income, tax revenue and legal and administrate support services. Indirect impacts include acquiring materials for the wind farms such as turbine towers, hardware, and software programs. The indirect economic impacts are usually contracted out to big companies like turbine and blades companies, which are outside of local rural counties. Finally, the induced impacts are a result of jobs and earning spending, including benefits to grocery stores and retail sales (Reategui & Tegen, 2008; Lantze, 2009). The induced impacts of wind power projects came from the local multiplier of the increased local income and jobs. For example, when the farmers earn more money from leasing their land to wind developers, they use this additional money to enhance their farms. Local impacts on the county scale come mainly from direct impacts, as well as the induced impacts of the domestic spending.

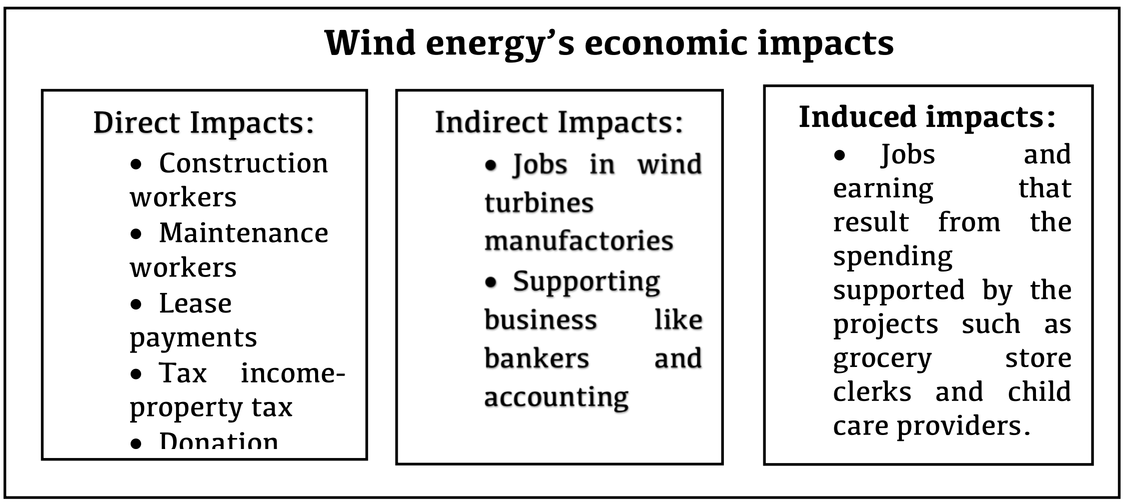

Figure 3-1: Ripple effect of wind power projects.

The economic impacts of wind power projects typically emerge in two phases: the construction phase and the operation phase. The construction phase requires a significant investment in money, labor and equipment for a short period of time - usually a year or two. The construction of wind turbines creates an immediate and heavily localized demand for construction jobs and materials, although employment and income gains are typically of a very short duration and are limited to a handful of skilled trade sectors (Lantz & Tegen, 2009). Even though the overall costs associated with the operation phase of wind farm development are less than the construction phase, operational expenditures are more likely to be spent on labor wages as well as lease payments and taxes, which yields relatively more significant benefits to the local community. Furthermore, the operation phase yields sustained gains over the lifetime of the project, which usually is 20 to 25 years.

The local economic impacts of wind development can vary considerably from one project to another. The ultimate impacts depend on project size, location, financing arrangements, and numerous site-specific factors that influence construction and operation costs (Goldberg et al., 2004). Williams et al. (2008) estimate the economic impacts of various scenarios of wind projects for two counties in Texas, using Monte Carlo simulation combined with an economic input/output analysis. Considering both construction and operations, they find that a county with a more rural and less developed economy typically receives fewer economic benefits than a highly developed economy, since relatively less of the labor and equipment, and fewer of the supplies, are purchased locally (Williams et al., 2008).

3.3.2 Estimating the gross impacts of wind development

Most studies consider only the gross impacts of wind development. For example, it considers the potential employment without considering the economic losses associated with the replacement of wind power to other energy sources. Research predicted wind power impacts employ input-output models to estimate indirect and induced benefits of wind power development. Predicted outcomes from input-output modeling are gross effects and determined by the model’s parameters and input levels. The expected outcome of wind power development has been covered by academic studies and governmental reports on two scales: state and county. Most of the estimating studies were for proposed projects as a tool to decide on adopting wind development. Approximately most of the studies employed an application of input and output model, named Jobs and Economic Development Impact (JEDI)[4], created by the National Renewable Energy Laboratory (NREL). However, most of the authors modified the JEDI model, either by using local data instead of the model's defaults or using the local multiplier provided by IMPLAN[5]. The JEDI model was designed to overcome some of the typical limitations of an input/output model such as allowing the analyst to adjust local purchase coefficients. However, JEDI still produces estimates that are high although within reason (Brown et al., 2012). Slattery et al., (2011) and Torgerson et al. (2006) both compared the JEDI results with the results real local data. Slattery and Richards (2011) found that at the state level, the JEDI default model appears to overestimate economic impacts during construction and to slightly underestimate impacts during operations relative to models conducted with the project-specific data. Torgerson et al. (2006) find that JEDI default results are much higher than those using IMPLAN models impact modeling software. Although economic impacts of wind power have been estimated using input/output model or its application JEDI model, both have some limitations. Limitations of input/output model and JEDI model include:

- Input-output models assume that all industrial inputs are elastic to increases in demand with no increase in prices or costs of production. The model accounts only

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[4] JEDI is an application of input and output model was created to estimate the economic impacts of wind power projects on the state level.

5 IMPLAN is an economic impact assessment software system. The system was originally developed and is now maintained by the Minnesota IMPLAN Group (MIG).

for the benefits of wind projects while ignoring the costs; generally, it predicts positive indirect and induced impacts of new development (i.e., they imply that economic multipliers are always higher than 1).

- The model coefficients are sometimes based on national input-output tables, adapted to the local economy based on local industrial composition. This limitation is addressed by most of the studies by using the local multiplier or local data (Brown et al., 2012).
- The model accounts only for inter-industry linkages but does not account for the interactions between firms and other principal actors in the economy. As such, it does not account for all flows of money within an economy. For example, investment income by local owners, lease payments by absentee owners, and property tax payments are essential contributors to the local economic impacts of wind power development, but these payments would not be incorporated into a traditional input-output model (Brown et al., 2012).

The outcomes of the simulation model were jobs, income, tax income, and property tax income. All the estimated studies found positive impacts of wind power. Table 3-1 summarizes the anticipated impacts of wind power development at the county level, as consistent with this studies focus on local impacts.

Table 3-1: The anticipated impacts of wind powers on the county level using simulation model

Impacts	Impacts per county	Studies
Long-term (permanent) jobs	0.045 - 0.58 jobs per MW	Grover, 2002; GAO, 2004; NEA, 2003; Slattery et al., 2011; William et al, 2008; Costanti, 2004; Mongha et al., 2006

Tax income	$4,000 to $12,000 for each MW	Grover, (2002); NERL database
Lease payments	$2,000 to $10,000 annually, per utility-scale turbine	Bolinger & Wiser, 2006; Tegen & Goldberg, 2006

3.3.3 Measuring the operational and on-going impacts of wind development

The post-construction influence of wind power development on the rural economy is usually measured at the county level (Brown et al., 2012; De Silva et al., 2016; Khan, 2013). Although some have studied school district data when considering the impacts on local fiscal conditions, some of the studies that measured the post impacts of wind power using econometric methods focusing on income and employment. Some examine school improvement. Table 3-2 summarizes the results of other studies examining the operational impacts of wind power in the U.S. at the county level. The impacts of wind power on income was positive in terms of per capita income. Following an ex-post econometric approach, Brown et al. (2012) found a 0.2% increase in the income over the time of 2000 to 2008 at the county level in the Great Plains region. Although De Silva et al. (2016) found a significate increase in per capita income in rural counties in Texas State was attributed to wind power development, they did not find any effect on the median household income.

There is some disagreement regarding the effect of wind development on employment. Following an ex-post econometric approach, Brown et al. (2012) found a positive impact of wind development on employment, with approximately 0.5 jobs per MW of additional wind power capacity. De Silva et al. (2016) did not find a significant effect on overall county employment, but they found a significant employment increase in directly associated industries. De Silva et al. (2016) also found a low significant positive impact of wind power on retail and waste management employment, presumably due to indirect and induced impacts.

Table 3-2: The operation and ongoing impacts of wind power development on rural areas in the U.S.

Impacts	**Wind power effect**	**Study area**
Per capita income	0.2 % increase	Great plains region counties (Brown et al., 2012) Texas State rural counties (De Silva et al., 2016)
Median county Income	No significant effect	Texas State rural counties (De Silva et al., 2016)
Employment	No significant increase Significant increase	Texas State rural counties (De Silva et al., 2016) Great plains region counties (Brown et al., 2012)
Localized Industry Employment	A significant but small increase in retail and waste management employment	Texas State rural counties (De Silva et al., 2016)
Tax Base	Positive increase	Texas State rural counties (De Silva et al., 2016) Howard County in Texas and Umatilla County in Oregon (Grover, 2002) Sherman County Oregon (Ouderkirk & Pedden, 2004)
Tax Rate	Decreased	Rural counties in Texas state (Kahn, 2013)
Per Student Expenditure	Significant increase No significant increase	Rural counties in Texas state (Kahn, 2013) Western Oklahoma (Castleberry & Greene, 2017)
Student-Teacher Ratio	Significant decrease No significant decrease	Texas State rural counties (Kahn, 2013) Western Oklahoma (Castleberry & Greene, 2017)

Local school revenue	Significant increase	Western Oklahoma (Castleberry & Greene, 2017); Rural counties in Texas state (Kahn, 2013); Sherman County Oregon (Ouderkirk & Pedden, 2004)
Property value	No significant effect	Studies have been in rural and urban areas in most states: (Hoen et al. , 2009; Hoen et al., 2011; Hoen et al., 2015; Lang et al., 2014; Hoen & Palombo, 2016)

The impacts of wind development on the tax base, tax rate, and school revenues are related to each other. Several studies found that wind power development decreased the property tax rate and increased the tax base (Kahn, 2013; De Silva et al., 2016). Wind power counties also have higher local school revenues than other counties (Kahn, 2013; Castleberry & Greene, 2017). Kahn (2013) and Castleberry and Greene (2017) studied the impacts of wind power projects on school improvement in several counties in Texas and Oklahoma, respectively. Both studies found that the local school revenues were higher counties hosting wind projects in contrast with counties without. Kahn (2013) found that rural counties with wind farms have a lower student-teacher ratio in Texas; while Castleberry and Greene (2017) found that there are no statistically significant differences in percentage change in student-teacher ratio and per-student expenditures between districts with turbines and districts without turbines in Oklahoma. However, Kahn's (2013) study only used data from two years after wind projects, and thus did not control for the history of the county before wind projects, as did Castleberry and Greene (2017). Other contradictory evidence comes from De Silva et al. (2016) who found a significant increase in local school revenue in wind counties after hosting wind projects, but no effect on employment in the education sector. This result suggests that these counties devoted some additional wind-related revenues to school programs, facilities and equipment, but not staff.

Concluding the measured net post impacts of wind development, researchers found some evidence of increasing personal income, employment, local school revenue, and tax base on counties hosting wind power projects. It also found a decrease in the tax rate and no evidence of decreasing home prices or property value due to wind power projects.

Taken together – the estimating of the gross impacts of wind power and the measuring of the net post impacts – all found and believed in the positive impacts of wind projects on rural communities. On one side, simulation studies expected substantial economic impacts of wind projects in term of income and employment. On the other side, the real post studies found small positive impacts on income and debated small impact on employment.

3.4 What are the methods that previous research utilized to measure wind power development post impacts?

Wind power projects can be considered an economic stimulus for rural communities. Researchers who measured the real net impacts of wind projects usually did so during the operating period of the projects. The fundamental problem in assessing the net effects of projects such as wind power development is how to measure against the counterfactual situation-of what would have happened to the economy of counties if they not developed wind farm projects.

Random assignment is the preferred way to estimate a statistically equivalent counterfactual, although completely unrealistic in this context as it is difficult to implement outside of controlled laboratory settings. More specifically, wind resources and other economic factors cannot be randomly assigned or denied to established equivalent treatments and controls.

In the absence of random assignment, researchers used different approaches to measure the extent to which the wind development causes a change in the economic characteristics of the community. The goal is to use a methodology that is as robust as circumstances will permit with respect to this type of evidence. It is particularly important to ensure that an observed association between wind development and the change on economic characteristics of the community is not the spurious result of unmeasured variables that may be causing the observed correlation between wind farms and economic outcomes.

This study measures the impacts of wind power development on both income and employment using a different method to that used in previous studies, as well as a larger sample. Testing the causal relationship requires a robust method to identify the relative extent of the actual influence of wind power development on rural communities. Over the past decade, the post influence of wind power development on the socioeconomic characteristics of rural communities has been widely studied in the United States (Brown et al., 2012; De Silva et al., 2016; Khan, 2013; Castleberry & Greene, 2017). In fact, five different methods have been used across prior research to empirically measure the socioeconomic impacts of wind power in the United States. The five utilized methods are ordinary least squares (OLS) regression, instrumental variables estimation, hedonic price models,[6] a multivariate analysis with a control group, and a longitudinal analysis with a control group. Reviewing the respective advantages and disadvantages of these methods will serve to indicate the most appropriate method for determining the causal relationship between wind power development and changes in rural communities.

The majority of previous studies relied on either the OLS method alone or the OLS method in comparison to other methods. OLS is an estimation technique that is widely used to estimate the parameters of a linear model. OLS estimators minimize the sum of the squared errors (the difference between the observed values and the predicted values) (Wooldridge, 2009). Given a random sample, the OLS method is used to estimate the slope and intercept parameters in the population model. A famous limitation of the OLS method concerns the omitted variable bias, which occurs whenever the researcher omits a variable that (i) affects the dependent variable, y, and (ii) is correlated with the independent variable, x. In that case, the estimated coefficient on x will partially pick up the effect of the omitted variable; hence, it will misrepresent the true effect of x on y.

$$Y = B(X) + u \tag{3}$$

The inconsistency seen in relation to the OLS method stems from the endogeneity of x, meaning that changes in y are associated not only with changes in x, but also with changes in the error, u. Thus, we need to include all the relevant x-independent variables,

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[6] The hedonic price model is the most commonly used model for measuring the effect of wind farms on property values in the United States. However, the property value is not one of the variables of interest in this study.

since otherwise we would violate the zero conditional mean assumption[7]. In reality, including all the relevant x- independent variables is impossible due to the limitations of the data. Finally, the choice of factors ($X_{1,\ 2,\ 3,\ 4,\ k}$) is determined by both theory and consideration of the available data. Some researchers believe in the likelihood of omitted variable bias, while others assume that they have been able to include all the relevant variables. Those who believe in the likelihood of omitted variable bias tend to use an additional method to solve the problem, such as the IV estimation method.

Brown et al. (2012) use an IV estimation model to measure the relationship between the wind power capacity and the observed changes in both income and employment from 2000 to 2008 in the Great Plains region of the United States. The IV estimation model is commonly used in the field of econometrics in an effort to identify causal relationships, as opposed to simple correlation. The model recognizes the presence of the omitted variable that correlates with the endogenous variable (X) so as to avoid any endogenous bias. The IV estimation model relies on a third variable, Z, to account for any unexpected behavior between the variables and to identify any unobserved correlation, which allows us to observe the true correlation between the explanatory variable and the response variable, Y.

Brown et al. (2012) hypothesized that the location of the wind power development may be endogenous to the socioeconomic variables of interest (income and employment). In such a case, performing an estimation using OLS can result in endogenously biased

[7] The zero conditional mean assumption means the error term *u* have zero mean given any value of the independent variable *x*

estimates. As a result, Brown et al. (2012) also used the IV estimation model to avoid this kind of bias. Although Brown et al. (2012) found IV to be a useful method, De Silva et al., (2016) found IV to be not helpful. De Silva et al. (2016) estimated the tax-related models using an instrumental variable (IV) technique. They used log levels of wind capacity for the IV, instead of changes in the installed capacity as a given increment to installed capacity, only appears in the year in which the new wind plant is commissioned. They do not report these results because the level of wind capacity as the instrument does not pass the Hausman test in all of the specifications (De Silva et al., 2016, p. 852).

According to Wooldridge (2009), an instrumental variable must have two key properties, namely "(1) it must be exogenous, that is, uncorrelated with the error term of the structural equation; [and] (2) it must be partially correlated with the endogenous explanatory variable. Finding a variable with these two properties is usually challenging" (p. 543). The IV estimation model has a number of additional limitations, including the need for a large sample. When only a small sample is used, the coefficients are biased in the same direction as the OLS coefficients, but estimated with less efficiency.

Recent studies use a multivariate analysis with a comparison group to overcome the endogenous bias of OLS and the limitation of IV (Kahan, 2013; De Silva et al., 2016; Castleberry & Greene, 2017). These studies attempt to define a comparison group that is as similar as possible to the treatment group in terms of baseline (before wind power development) characteristics. These studies used a comparison group without a real matching technique; instead, they compared two groups (wind power counties to neighboring counties), they divided the population to wind power group and comparison group (Khan, 2013; Castleberry & Greene, 2017). De Silva et al. (2016) used population size as the only matching factor. They excluded counties with populations less than 421 or greater than 200,347 in 2001 as the beginning year of their study period. Using unmatched groups creates some internal biases (i.e. history bias) and/or natural growth or decline over time (maturation bias) (Cook & Campbell, 1979).

A quasi-experimental comparison group design is the closest solution to test the effect of wind projects on rural communities. It tries to mimic the randomized experimental approach in selecting "treatment" and "comparison" groups that are similar on a variety of parameters and confounding features. The comparison group captures the counterfactual situation of what would have been the outcomes if the wind projects had not been implemented. The comparison group solves the omitted variable bias and endogenous bias that may be caused by OLS or IV. A quasi-experimental design with actual matching combined with longitudinal analysis model has been used to measure the impacts of wind projects on property value in Europe (Gibbons, 2015). Based on the literature, the quasi-experimental design is the best research design to measure the effect of wind power development on rural areas, combined with longitudinal data analysis to avoid bias such as omitted variable, internal bias (i.e., history bias) and/or natural growth or decline over time (maturation bias).

Longitudinal data analysis has been used for evaluating outcomes of treatments over different lengths of time. Longitudinal analysis employs continuous or repeated measures to follow particular communities over prolonged periods of time - often years or decades. Longitudinal data analysis is the preferred method of evaluating outcomes of treatments because it provides more efficient estimators than cross-sectional analysis and can distinguish the impacts of the timing (Caruana, Roman, Hernández-Sánchez, & Solli, 2015). Cross-sectional studies may not provide definite information about cause-and-effect relationships because they only provide a snapshot of a single moment in time and cannot evaluate what happened before or after the snapshot was taken. With longitudinal study, I can detect developments or changes in the characteristics of the target counties. I extend beyond a single moment in time. As a result, I can establish sequences of events. Longitudinal research used to collect data on rural counties going backwards in time where the outcome variable for both counties: treated counties (those already known to have wind power projects) and control counties (those already known to not have wind power projects) are repeatedly collected backwards in time (Caruana et al., 2015).

Castleberry and Greene (2017) collected data for 108 school districts in western Oklahoma from 1997 to 2015. They used 2010 as the year of treatment (adopting wind projects), to answer the question of how wind power development affects public school districts located in western Oklahoma. Their study measured the impacts of wind projects on the percentage of revenue from local county sources, student-teacher ratios, and per-student expenditures. Castleberry and Greene (2017) compared the result of the change before and after wind projects between wind project school districts and other school districts. Castleberry and Greene (2017) used simple longitudinal temporal analysis. They measured if the Average Treatment Effect ATE is a significant difference between treated and nontreated group. They used descriptive and inferential analysis, using independent-samples t-tests, and independent-samples Mann-Whitney U tests.

I use longitudinal methods as my main research method. Counties are the primary unit of the analysis. All variables were measured at the county and incorporated in the statistical models through multi-level methods. I focussed on the period from 1990 to 2015. Most wind energy development in the U.S. began after the year 2000 and starting the period ten years prior allows me to establish baseline trends. As an additional analysis, I used two kind of longitudinal analysis: mixed models and fixed models with a quasi-experimental design approach.

3.5 Measuring the impacts of wind power projects (economic and demographic) using longitudinal analysis – mixed-effects model

In this section, I measure the effect of wind energy projects on rural areas over different lengths of time. I test the effects of the accumulated wind power capacity on the economic and demographic attribute of the rural counties. In this section, I use a longitudinal data analysis only without comparison group to overcome the external validity that may cause by the elimination of the matching.

3.5.1 Study Population

This study only focuses on counties in the continental U.S., excluding those in Alaska, Hawaii, Puerto Rico and other U.S. territories to ensure some degree of homogeneity in economy and demographic characteristics. Alaska and Hawaii have some wind projects, but they are small. Only one county in Hawaii has almost 100 MW. In this section, I use all the counties in the continental U.S.. Of 3072 counties, 494 have wind power capacity in excess of zero. The remaining 2,578 counties do not have wind power development or have wind power capacity of zero. The number of observations per county is 26 years starting from 1990 to 2015. As the following table shows, the study population is 3072 counties with a mean population in 2015 of 91,833 people and mean adjusted income per capita is 33,810 dollars (adjusted to 2015 dollar value). The largest county with a population over ten million people, compared to a county with a population of 115. The highest county with wind power capacity has 3,239 MW. The overall standard deviation is high, showing the wide distribution and difference between counties.

Table 3-3: The descriptive data of the population of longitudinal analysis in 2015

Variable	Mean	Std. Dev.	Min	Max	Observations
Population	91,833				
Overall		298,521	55	10,170,292	N = 78,936
Between counties		297,206	87	9,555,680	n = 3,036
Within county		28,488	-1,011,532	1,024,166	T = 26
Per capita Income	33,810				
Overall		10,649	5082	195,632	N = 78,936
Between counties		6,324	14,101	101,919	n = 3,036
Within county		8,568.45	-39,681	127,094	T = 26
Unemployment Rate	6.3				
Overall		2.93	0.5	40.4	N = 78,936
Between counties		2.22	2.13	23.52	n = 3,036
Within county		1.91	-4.79	30.4	T = 26
Poverty Rate	%15.37				
Overall		6.30	1.7	62	N = 64,512
Between counties		5.91	2.82	46.12	n = 3,072
Within county		2.18	-0.75	32.29	T-bar = 21
Median Household Income	39,126				
Overall		11,466.4	10,510	125,900	N = 64,512
Between counties		9,681.14	18,541	97,368	n = 3,072
Within county		6146.74	1,450	80,022	T-bar = 21
Farm Income	20,846				
Overall		55,921.98	-55,406	2,136,803	N = 79,404
Between counties		50,409.46	-6,506	1,116,700	n = 3,054
Within county		24,227.14	-681,336	1,314,581	T = 26
% of adult with some college	%26.03				
Overall		6.56	6.8	47.8	N = 9,216
Between counties		5.20	11.33	43.27	n = 3,072
Within county		3.99	11.87	39.54	T = 3

% of adult with bachelor's degree or higher	%16.71				
Overall		8.25	1.9	78.8	N = 9,216
Between counties		7.57	3.93	65.1	n = 3,072
Within county		3.29	0.38	31.81	T = 3
Accumulated wind Capacity	5. 99				
Overall		55.32	0	3239	N = 79,928
Between counties		35.52	0	1079	n = 3,072
Within county		42.4	-747	2166	T-bar = 25.95

3.5.2 Outcome Variables

The analysis includes four groups of outcome variables: income, employment, poverty and demographic variables such as population, and educational attainment (Table 3-4). The analysis includes many independent variables that have been used on previous studies that measured the impacts on the outcome variable. The specific control variables (or covariates) differ according to the outcome variable. The study specifies a parametric statistical model to measure how wind energy development and other observed confounding factors affect the outcomes of interest. In short, it estimates the impact of wind energy development conditional upon the levels of those other factors. The presence of wind farm projects is measured in terms of a continuous variable that refers to accumulated wind power capacity per megawatt. The effect of accumulated wind power capacity is measured in the outcome variables. All the income variables are adjusted to the 2015 dollar value.

Table 3-4: Description of outcome variables.

Categories	**Variables**	**Descriptions**	**Unit**
Income variables	Per capita income	The average income earned per person in county, in a specified year. It is	2015 Dollar

		calculated by dividing the county's total income by its total population. I used income per capita instead of earning per worker because it includes unearned income including dividends, rent, interest, and transfer in this case, such as wind turbines lease. While earnings per worker take into account only the earned salary and focus on the quality of jobs in a region.	
	Median household income	The number that divided the average household income to two half one above this number and one blow. Household income is the income of the householder and all other individuals 15 years old and over in the household.	2015 Dollar
	Farm income	Total farm earning per county per year, sources Bureau of Economic Analysis.	2015 Dollar
Employment variables	Per capita employment per county	The employed divided by the total population of the county, calculated by the author using data from Bureau of Labor statistics.	Job/ person
	Unemployment rate	Percentage of the total labor force that is unemployed but actively seeking employment and willing to work. Sources: Bureau of Labor statistics.	Percentage
Poverty	Poverty rate	Percentage of population in poverty	Percentage
Demographic variables	Population size	The total number of the county's population	Person
	% of adults with completing some college or associate degree	The percentage of adult (25 years and older) with completing some college or associate degree.	Percentage
	% of adults with bachelor 's degree or higher	The percentage of adult (25 years and older) with four years of college or higher degree like master and PhD.	Percentage

3.5.3 Mixed-effects model

One of the significant problems of longitudinal data analysis is the correlation between repeated outcome measurements over the same observations. Ignoring this correlation violates the theoretical assumption of the independence of the outcomes and can lead to biased statistical tests (Edwards, 2000). Mixed-effects longitudinal models account for repeated measures by incorporating a random component for each unit. Mixed-model also has various advantages, such as it is robust to missing data, and can easily handle both time-invariant and time-varying covariates. The expected outcomes are modeled as a linear function of time and other covariates that contain both within and between-subject effects. A mixed model is a regression model is particularly well-suited for analyzing correlated outcomes which are continuous. The mixed effect model provides estimation and hypothesis testing for simultaneously modeling both population effects (fixed effects) and random effects (subject-specific effect) (Edward, 2000, p. 334). Although, I selected the mixed-effects model as the main model, I compare the results of mixed-effects model with the results of fixed-effects model to test for robustness. I included random slope for accumulated wind power capacity because I expected that the effect of wind power capacity might be different for different counties. According to Williams et al. (2008), a county with a more rural and less developed economy typically receives fewer economic benefits than a highly developed economy (Williams et al., 2008). The effect of the accumulated wind power capacity may differ from county to county, even after we account for the county's economic characteristics. Adding random slope allows the accumulated wind power capacity to have a different effect for each county. I test if adding random slope fits significantly than only using random intercept. Using likelihood ratio test, I find that adding random slop brought significant improvement to the model.

The next two equations represent the mixed model equation and the fixed model equation respectively.

$$y_{it} = \beta_0 + \sum_{k=1}^{p} \beta_k X_{itk} + V_{i0} + \sum_{k=1}^{q} \ldots V_{ik} Z_{itk} + +U_{it} \tag{4}$$

Where:

- for i ∈ {1,...,n} and t ∈ {1,...,mi} where yit ∈ R is response for t-th measurement of i-th county
- b0 ∈ R is fixed intercept for the regression model.
- bk ∈ R is fixed slope for the k-th predictor
- Xitk ∈ R is t-th measurement of k-th fixed predictor for i-th subject i id 2
- Vi0 $\sim^{iid} N(0,\sigma_0^2)$ is random intercept for the i-th county
- Vik $\sim N(0,\sigma_k^2)$is random slope for k-th predictor of i-th county (accumulted wind power capacity)
- Zitk ∈ R is j-th measurement of k-th random predictor for i-th subject.
- Uit $\sim^{iid} N(0, \sigma_u^2)$ is a Gaussian error term

$$y_{it} = \beta_0 + B_1 X_{1\,it} + \cdots + \beta_K\, ux_{k\,i} + \delta\, T_t + \gamma_2\, E_2 + \gamma_n\, E_n + U_{it} \tag{5}$$

Where:

- Y_{it} is the dependent variable (DV) where i = county and t = time.
- X_1…k,it represents independent variables (IV)
- $\beta_{1\ldots k}$ is the coefficient for the IVs,
- U_{it} is the error term
- E_n is the county n. Since they are binary (dummies) you have n-1 counties included in the model.
- γ_2 is the coefficient for the binary regressors (entities).
- T_t is time as a binary variable (dummy), so I have t-1 time periods.
- δ_t is the coefficient for the binary time regressors.

3.5.4 The economic Outcomes

The economic outcomes are measured in terms of the change on the economic dependent variables; income per capita, median household income, unemployment rates, per capita employment, poverty rates, and farm income. In order to measure the economic impacts, it is necessary to control for human capital. I control for human capital by including two terms representing different levels of educational attainment. I control economic resources through control for agriculture productivity by measuring the farm share of total acres, the trend of per capita income, and natural amenities. My dependent variable (y) is either the per capita income or median household income. My independent variables can be categorized into three groups: (1) the interested variable -county-level of wind capacity in MW units; (2) county characteristics that vary with time such as population, unemployment rate and educational attainment, (Z1…k); and (3) county characteristics that do not vary with time such as the percentage of farmland, wind speed class, census region, close to metropolitan areas[8] (X1…k).

Table 3-5: Models results for income (per capita income and median household income).

Variables	Per capita income ij		Median household income ij	
	Fixed model	Mixed model	Fixed model	Mixed model
Population	0.008***	0.002***	-0.007**	0.0004
Unemployment percent	-206.12 ***	-385.27***	-1,492.51***	-1,707.72***
% adults with completing some college or associate degree	-213.6***	-32.97*	120.15***	236.54***
% adult have bachelor's degree or higher	463.7***	604.7***	200.28***	522.86***
Accumulated wind capacity	**8.33*****	**16.73*** **	**4.64*****	**7.43*****
Fair wind speed		989.73***		-2,297.36***
High wind speed		374.94		-636.72
% Farm Share		3,857.45***		1,771.08**
Natural Amenity Rank		258.1***		-70.63
Midwest Region		- 2,258.9 ***		-2,513.85*

[8] I group the rural classification of rural urban classification 1993 to three dummy varaibles.1. "In_Metro" that includes 1 for counties located inside large metropolitan areas. 2 "Adj-Metro" that includes counties located adjusted to medium metropolitan areas. 3. "Far metro" includes counties are not in the zone of metropolitan areas.

South Region		-4,215.08 ***		-5,113.5***
West Region		-3,979.11***		-2,280.19**
In Metropolitan areas of at least 250,000		1,647.912***		8,318.58***
Adjust to Metropolitan areas of 2,500 to 20,000		-221.4792		2,371.74***
Years	412.99***	293.60***	-86.06***	-202.79***
Constant	-793,261.5***	-560,011.1***	222,759.6	449,099.3***
Number of observations, groups	(9,108-3,036)	(9,108-3,036)	(6,072-3,036)	(6,072-3,036)

*, **, *** *coefficient statistically significant at 10-percent, 5-percent, and 1-percent levels, respectively*

Table 3-5 shows the results of the mixed and fixed effects models for the two income varaibles: per capita income and median household income. The results of both models are significant. According to the mixed-effects model, each increased megawatt in the accumulated wind power capacity in the county raises income per capita on the county, on average, by approximately seventeen dollars (p>|z|=0.000); and increases median household income in the county, on average, by approximately seven dollars (p>|z|=0.000). Both studies found a significant positive impact of wind development on per capita income, but De Silva et al. (2016) fail to prove any significant impact of wind development on median household income, as my result proves. This may be due to the small sample that De Silva et al. (2016) used, as they used rural counties in Texas as their population.

There are no significant effects of accumulated wind power capacity on the unemployment rate, but there is a very small positive effect on per capita employment (Table 3-6). Each increased megawatt in the accumulated wind power capacity raises county per capita employment by 0.00005 jobs (p>|z|=0.000). This is consistent with previous studies. Brown et al. (2012) also found a small positive effect of increasing wind power capacity on the per capita employment. While De Silva et al., (2016) also failed to find any significant relationship between wind capacity and the unemployment rate.

Table 3-6: Models results for jobs (per capita job and unemployment rate).

Variables	Per capita employment ij		Unemployment rate ij	
	Fixed model	Mixed model	Fixed model	Mixed model
% adults with completing some college or associate degree	0.0025***	0.0022***	-0.095	-0.11***
% adults with a bachelor's degree or higher	0.0025***	0.0034***	-0.004**	-0.081***
Accumulated wind capacity	**0.000034*** **	**0.00005*** **	**0.0002**	**0.0002**
Fair wind speed		-0.012***		-0.76***
High wind speed		0.031***		-0.52**
% Farm Share		0.043***		-2.01***
Natural Amenity Rank		-0.0017***		0.01
Midwest Region		0.0014		0.33**
South Region		-0.018***		.099
West Region		-0.024***		1.45***
In Metropolitan areas of at least 250,000		0.0092***		0.04
Adjust to Metropolitan areas of 2,500 to 20,000		0.00045		0.22**
Years	-0.002***	.002***	0.016***	.04***
Constant	3.94***	4.31***	-24.23**	-76.76***
Number of observations, groups	(9,108-3,036)	(9,108-3,036)	(9,108-3,036)	(9,108-3,036)

*, **, *** *coefficient statistically significant at 10-percent, 5-percent, and 1-percent levels, respectively*

The analysis also finds a significant impact of wind power development on the poverty rate of rural counties (Table 3-7). Increasing the county's wind power capacity of one megawatt decreases on percentage of people in poverty in the county by a tiny percentage of 0.0007 (p>|z|=0.077). None of the previous studies that I reviewed measured the impacts of wind development on the poverty rate. Although this is small change, the decrease may be noticeable in the case of large wind power projects.

Table 3-7: Models results for poverty rate.

Variables	Poverty rate ij	
	Fixed model	Mixed model
Per capita income	-0.0001***	-0.0002***
Unemployment rate	0.64***	0.96***
% adults with completing some college or associate degree	-0.008	-0.12***
% adults with a bachelor's degree or higher	-0.091***	-0.057***
Accumulated wind capacity	**-0.0010*****	**-0.0007***
Fair wind speed		0.083
High Wind speed		-1.27**
% Farm Share		-0.13
Natural Amenity Rank		-0.16***
Midwest Region		-0.12
South Region		3.01***
West Region		1.1**
In Metropolitan areas of at least 250,000		-2.07***
Adjust to Metropolitan areas of 2,500 to 20,000		-1.05***
Years	0.25***	0.25***
Constant	-488.78***	-491.27***
Number of observations, groups	(6,072-3,036)	(6,072-3,036)

*, **, *** *coefficient statistically significant at 10-percent, 5-percent, and 1-percent levels, respectively*

I use total farm income as a more direct measure of the effect of wind turbine lease payments. Increasing the county's wind power capacity increases the average farm income of the county by 88 dollars per megawatt ($p>|z|=0.000$) (Table 3-8). This is a considerable effect. For example, if a county has a 1000 MW wind projects, it indicates the average farm income on the county increases by $88,000. Previous studies did not use farm income as an indicator of the economic benefits of wind development, but they emphasized the importance of lease payments of wind turbines to farmers.

Table 3-8: Models results for farm income.

Variables	Farm income ij	
	Fixed model	Mixed model
Population	0.06***	0.03***
Accumulated wind capacity	**75.75*****	**88.10*****

Fair wind speed		-6,103.31**
High wind speed		-37,101.48***
% Farm Share		91,616.58***
Natural Amenity Rank		8,557.04***
% Water area		-10.89
Midwest Region		-11,202.24**
South Region		-12,058.69**
West Region		17,999.36**
In Metropolitan areas of at least 250,000		26,113.04***
Adjust to Metropolitan areas of 2,500 to 20,000		5,146.34*
Years	251.12***	226.45***
Constant	-471,046.3 ***	-451,231.6***
Number of observations, groups	(78,936-3,036)	(78,936-3,036)

*, **, *** *coefficient statistically significant at 10-percent, 5-percent, and 1-percent levels, respectively*

3.5.5 Demographic Outcomes

I used a similar economic model for measuring changes in the population size and educational attainment. The model tests for the demographic level shift and trend slope effect, while controlling for a fixed location, wind speed, and natural amenity rank.

Table 3-9: Models results for population size.

Variables	Population ij	
	Fixed model	Mixed model
Per capita income	-0.72**	-0.57***
Unemployment rate	-802.08***	-812.77**
% adults with completing some college or associate degree	-5,088.56***	-4,853.27***
% adult with a bachelor's degree or higher	2,195.26***	2,761.66***
Accumulated wind capacity	**4.20**	**5.92**
Fair wind speed		-17,455.18
High wind speed		-100,480.7***
% Farm share		-51,780.56 *
Natural amenity rank		24,132.88***
Midwest region		-8,151.534
South region		-103,110.8***
West region		-44,179.63*
In metropolitan areas of at least 250,000		234,889.5***
Adjust to metropolitan areas of 2,500 to 20,000		21,435.52*

Years	2,342.08***	2,023.15***
Constant	-4,473,101***	-3,844,058 ***
Number of observations, groups	(9,108-3,036)	(9,108-3,036)

, **, * coefficient statistically significant at 10-percent, 5-percent, and 1-percent levels, respectively*

As is shown in detail in Table 3-9, there is no significant effect of accumulated wind capacity on the population size. This result was expected because wind power is less labor-intensive and demographic impacts may not appear at the county scale. As argued by Edmiston (2004), demographic changes may not be limited to the specific county but may spill over into neighboring counties as well. In this case, it may be better to measure the demographic impacts of large wind power projects on multi-county regions.

Table 3-10: Models results for educational attainment (percent adults with some college or associate degree and percent adults with a bachelor's degree or higher).

Variables	% adults with completing some college or associate degree ij		% adults with a bachelor's degree or higher ij	
	Fixed model	Mixed model	Fixed model	Mixed model
Population density	-0.0046***	-0.0002***	0.0034***	0.0005***
% people on poverty	0.048	-0.17***	-0.095	-0.16***
Per capita income	0.00002**	-0.00003***	0.000008***	-0.00009***
Accumulated wind capacity	**-0.0002****	**-0.0021****	**-0.0015*****	**-0.0033*****
Fair wind speed		2.27***		1.26***
High wind speed		1,26**		4.89***
% Farm Share		-0.065		-0.58
Natural Amenity Rank		0.13**		0.41***
Midwest Region		5.69***		-1.99***
South Region		2.18***		-3.91***
West Region		8.86***		-0.64
In Metropolitan areas of at least 250,000		2.09***		7.3***
Adjust to Metropolitan areas of 2,500 to 20,000		0.54**		0.93**
Years	0.30***	0.34***	0.29***	0.27***
Constant	-569.48 ***	-654.47***	-569.43***	-529.42***

Number of observations, groups	(9,108-3,036)	(9,108-3,036)	(9,108-3,036)	(9,108-3,036)

*, **, *** *coefficient statistically significant at 10-percent, 5-percent, and 1-percent levels, respectively*

Table 3-10 shows that there is a negative relationship between wind power development and educational attainment in the county. Increasing wind power capacity has a significant negative effect on the percentage of adults completing some college or associate degree and the percentage of adults with a bachelor's degree or higher. According to the mixed-effects model, each increased megawatt in the accumulated wind power capacity in the county decreases the percentage of the adults with some college by 0.0021 percent (p>|z|=0.001); and reduces the percentage of the adults with a bachelor's degree or higher in the county by 0.003 percent (p>|z|=0.000). The effect of wind power development in the educational attainment could be related to the nature of wind farm jobs. Most of the wind jobs are wind technicians which required some college degree or may be absorbed in the field during apprentices' programs. When I link the negative effect of wind development on the percentage of educated people and the neutral effect on the population size, the only suggestion is that local people filled the wind technicians jobs without obtaining any degree; they learn the skills through training programs and apprentices' programs.

3.6 Measuring the impacts of wind power projects (economic and demographic) using longitudinal analysis with a quasi-experimental design approach- matching analysis

I used a quasi-experimental matching approach to select rural counties in the continental U.S that had similar economic and demographic characteristics to wind power counties prior to implementation of the large-scale wind development and compare mean changes in outcomes between these groups of counties. A quasi-experimental control group design mimics the randomized experimental approach in selecting "treatment" and "comparison" groups that are similar to a variety of parameters and confounding features. I then use a fixed effect longitudinal model to identify the effects of the accumulated wind power capacity on the outcomes.

There are different techniques for creating a valid comparison group, to reduce the risk of bias. Two common approaches included regression discontinuity designs (RDD) and propensity score matching (PSM). Regression discontinuity is a quasi-experimental design that relies on a cut-off point on a continuous baseline variable to assign individuals to treatment. The individuals just to the right and left of the cut-off are assumed to be exchangeable – as in a randomized trial (Linden & Adams, 2012). However, use of the RDD design has been somewhat limited, due in part to challenges to the critical assumption that the treatment assignment variable alone ensures a balance of other baseline covariates (Linden & Adams, 2012).

Propensity Score Matching (PSM) approach is the most commonly employed method to estimate causal treatment effect from observational data. PSM uses the predicted probabilities from a statistical model to identify a set of "controls" that most closely match a treatment group based on observable characteristics (Caliendo & Kopeinig, 2008). A comparison of before-after differences between the treatment and control groups helps to reduce the bias of numerous confounding factors (Caliendo & Kopeinig, 2008). The propensity score matching process typically consists of three steps: (1) estimate the propensity score; (2) choose a matching algorithm that uses the estimated propensity scores to match untreated units to treated units; and (3) estimate the impact of the intervention with the matched sample and calculate standard errors. The exclusion and trimming of some counties from the analysis can limit external validity in some situations. However, this exclusion increases the robustness of the common support assumption. Common support assumption assumes that for each value for X, there is an equal probability of being both treated and untreated. Finding an appropriate region of common support often requires trimming or excluding cases that are difficult to match, potentially reducing the external validity of the sample, implying that the results of the analysis are strictly valid only for the region of common support.

3.6.1 Study Population

The population are counties in the continental U.S., excluding those in Alaska, Hawaii, Puerto Rico and other U.S. territories to ensure some degree of homogeneity in economy and demographic characteristic. For the sake of this study, I define the treatment as counties that had gained a new large-scale wind farm over the study period. Large-scale wind farms are those having at least 100 MW capacity per county in 2012, according to data from the American Wind Energy Association (AWEA, 2016). I did some exclusion steps before I did the real matching. The first exclusion I made was neighboring counties to those with significant wind projects from the pool of candidate comparison counties, in order to avoid possible spillover impacts from the wind farms. Using GIS, I created a five KM buffer zone around the wind farms and excluded the non-treated counties in this zone. The second exclusion was counties with small wind projects and recent wind projects, such as counties with small wind projects (greater than 20 MW and less than 100 MW), or those that have added wind capacity in excess of 100 MW after 2012 were excluded from both the treatment as well as the potential matching group. The third exclusion is metropolitan counties, in the matching analysis, I focused on nonmetropolitan counties[9] because I seek to understand the impacts of wind development on rural development. I consider a county as nonmetropolitan rural counties when it was not a part of, or adjacent to large metropolitan area of more than 20,000 person. I used rural influence codes to define nonmetropolitan rural counties.

The common measurement of rurality is metropolitan and non-metropolitan counties. The department of agriculture developed two methods to classify metropolitan and non-metropolitan counties according to degrees of rurality: the Urban Influence Codes (UICs) and the Rural-Urban Continuum Codes (RUCCs). The methods differ in how they measure a county's urban population for categorizing the county. The UICs work with the size of the largest town or city in a county, whereas the RUCCs sum the total population for all towns and cities of more than 2,500 in a county. Thus, the RUCCs would classify a

[9] "nonmetropolitan rural counties" are nonmetro counties that do not include any urban areas of 10,000. Because using only "nonmetropolitan" is not a perfect proxy for rural.

county with many small towns with populations totaling 20,000, but without a city of at least 10,000 people, as more economically centralized than the UICs would classify that county (Hall, Kaufman, & Ricketts, 2006).

Table 3-11 reports the distribution of the treated and untreated counties according to rural classification code 1993. Before excluding metropolitan counties, there are 2,518 counties. Of those 171 counties have wind project over 100 MW and 2,347 potential matching counties. I excluded 39 counties with urban codes 0 through 4 – those existing in metropolitan areas from the treatment group. I also excluded the metropolitan counties from the potential comparison counties. After the primary exclusion, the matching population and units of observation include nonmetropolitan wind power counties (over 100 MW in 2012) and other nonmetropolitan counties in continental U.S. In total, there are 132 counties that have exceeded 100 MW of wind power capacity by the year 2012 (Figure 3-2). These are matched with nonmetropolitan counties that had no, or relatively insignificant, wind power capacity.

Table 3-11: Urban classification

Code	Rural influence code	Treated		un-treated		Total
		Number	%	Number	%	
0	Central counties of metropolitan areas of 1 million population or more	4	2.34	121	5.16	125
1	Fringe counties of metropolitan areas of 1 million population or more	2	1.17	106	4.52	108
2	Counties in metropolitan areas of 250,000 to 1 million population	8	4.68	251	10.69	259
3	Counties in metropolitan areas of fewer than 250,000 population	14	8.19	130	5.54	144

4	Adjacent to a metropolitan area, urban population of 20,000 or more	11	6.43	98	4.18	109
5	Not adjacent to a metropolitan area, urban population of 20,000 or more	10	5.85	78	3.32	88
6	Adjacent to a metropolitan area, urban population of 2,500 to 19,999	27	15.79	488	20.79	515
7	Not adjacent to a metropolitan area, urban population of 2,500 to 19,999	47	27.49	488	20.79	535
8	Adjacent to a metropolitan area, less than 2,500 urban population	19	11.11	187	7.97	206
9	Not adjacent to a metropolitan area, less than 2,500 urban population	29	16.96	400	17.04	429
	Total	171	100.00	2,347	100.00	2,518

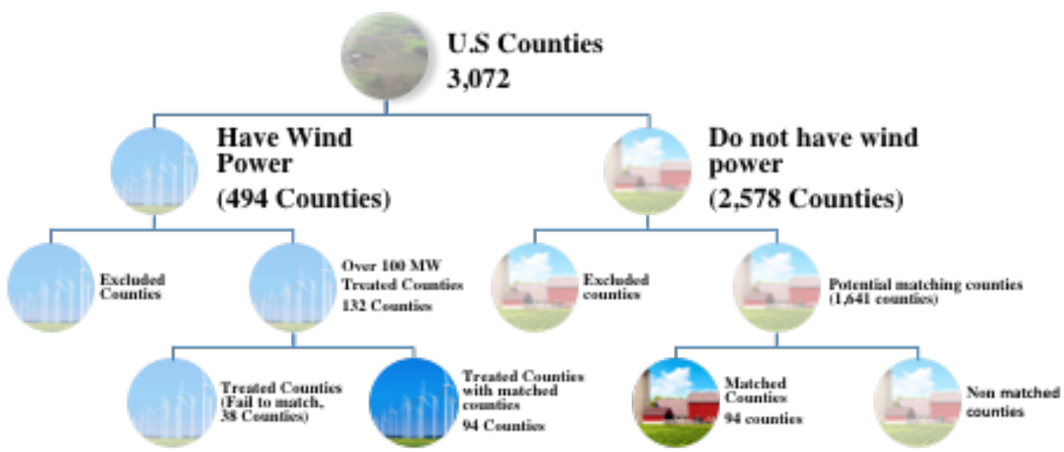

Figure 3-2: Study population

3.6.2 Descriptive Analysis

Table 3-12 shows the economic and demographic characteristics of the treated counties versus the non-treated counties and the total population of the study. The total population of counties that qualify in the matching analysis are 1,773 counties. From this population, 132 have significant wind capacity and thus serve as treated counties, leaving

1,641 as potential comparison counties. The mean wind capacity on the treated counties is approximately 260 MW, and the maximum wind capacity is 2,055 MW. Without matching, there is no equivalence between the treated and untreated counties. The treated counties have a lower mean in population size, unemployment rate, and the percentage of people in poverty, compared to potential matching counties. The treated counties also have a higher mean in per capita income, median household income, acres of farmland, and educational attainment level, compared to potential matching counties.

Table 3-12: Descriptive statistics.

Variable	Sample	Observations	Mean	Standard Deviation	Min	Max
Population 1990	Treated	131	17,696	15,978.43	454	86,160
	Non-treated	1,641	19,314	15,988.92	105	119,746
	Total	1,773	19,194	15,989.28	105	119,746
Per capita income 1990	Treated	131	15,777	2,257.17	7,930	26,031
	Non-treated	1,641	14,245	2,755.74	7,224	35,419
	Total	1,773	14,121	2,702.91	7,224	35,419
Medium House Hold income 1990	Treated	131	23,771	3,665.17	14,122	36,659
	Non-treated	1,641	21,325	4,218.94	9,500	44,142
	Total	1,773	21,129	4,199.94	9,500	44,142
Poverty rate 1989	Treated	131	13.9	6.02	6.1	45.9
	Non-treated	1,641	18.12	8.23	3.9	60.4
	Total	1,773	17.81	8.16	3.9	60.4
Unemployment rate 1990	Treated	131	5.15	2.7	1.1	16.7
	Non-treated	1,641	6.55	3.07	0.5	30.02
	Total	1,773	6.66	3.07	0.5	30.02
	Treated	131	24.2	4.71	10	36.7

% of adult with some college 1990	Non-treated	1,641	20.13	6.07	6.8	43.3
	Total	1,773	20.44	6.08	6.8	43.3
% of adult with bachelor's degree or higher 1990	Treated	131	12.87	4.77	6.7	42.6
	Non-treated	1,641	11.19	4.67	3.7	49.8
	Total	1,773	11.31	4.7	3.7	49.8
% Farm land share 1992	Treated	131	47.57	0.31	0	99.69
	Non-treated	1,641	29.02	0.25	0	98.12
	Total	1,773	30.4	0.26	0	99.69
Farm income 1990 ($000s)	Treated	131	20,234.75	16,373.42	-1,296	83,666
	Non-treated	1,641	10,409.51	13,002.85	-1,296	135,957
	Total	1,773	11,141	13,526.07	-3,100	135,957
Accumulated Wind power capacity 2012	Treated	131	297.341	263.27	100	2,055.78

There were differences in prior (and continuing) trends in outcomes between the nonmetropolitan wind counties and potential matched non-wind counties. These differences could indicate bias in the results of our analysis. Figures 3-3 to 3-8 show the change on the indicators of the treated counties and non-treated counties without matching. As the figures show, there is a difference between counties with wind power and counties without, over time.

The treated counties have a higher mean of annual income per capita compared to potential comparison counties. This difference started to increase in the last five years. This increase may relate to wind development or other factors (Figure 3-3).

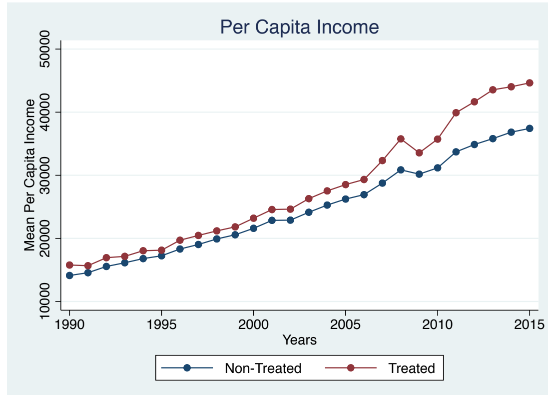

Figure3-3: The change in the mean annual income per capita of treated rural counties and potential matching counties without matching

Figure 3-4 shows the annual mean of the median household income of the treated counties is significantly higher than the annual mean of the potential comparison counties.

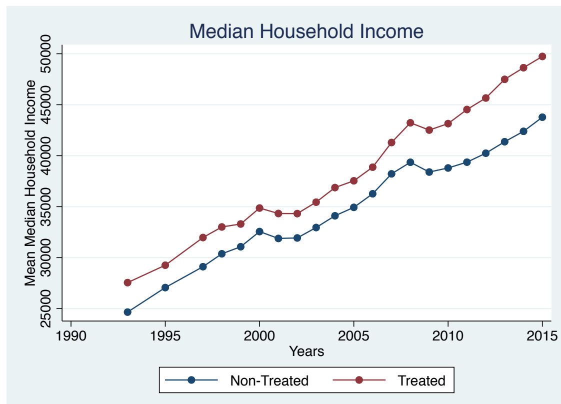

Figure 3-4: The change in the mean annual median household income of treated rural counties and potential matching counties without matching

Figure 3-5 shows the small difference between the mean farm income of the treated counties compared with the mean of non-treated counties in 1990. This difference increased in 2015.

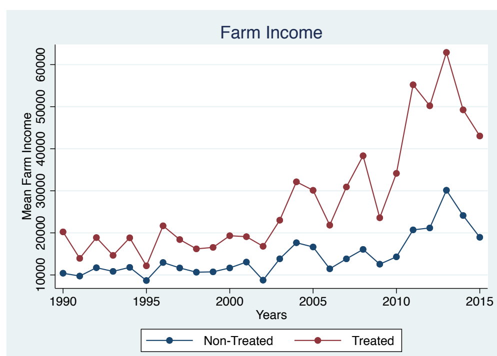

Figure 3-5: The change in the annual mean farm income of treated rural counties and potential matching counties without matching

Despite of the clear difference between the annual mean of the unemployment rate of the treated counties and the ones of non-treated counties, the difference is stable over the study period 1990 to 2015 (Figure 3-6).

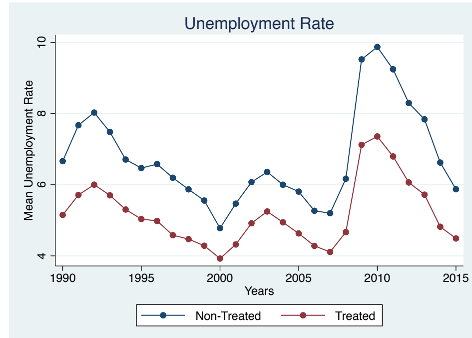

Figure 3-6: The change in the annual mean unemployment rate of treated rural counties and potential matching counties without matching

Figure 3-7 shows that wind power counties have a lower poverty rate than nonwind counties. The difference between the mean poverty rate of wind counties and non-wind counties is significant and stable over the study period from 1990 to 2015.

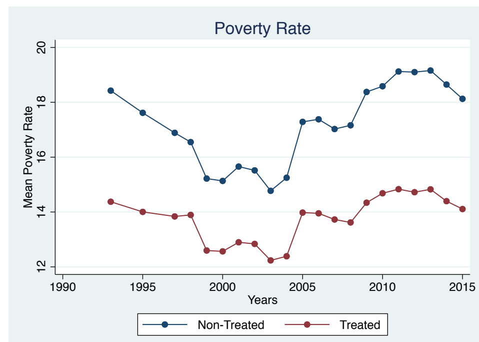

Figure 3-7: The change in the annual mean poverty rate of treated rural counties and potential matching counties without matching

As Figure 3-8 shows, wind counties have a lower population mean than non-wind counties in 1990. This difference increased in 2015. Wind power counties have a higher mean of the percentage of adults with completing some college or associate degree and the percentage of adults with a bachelor's degree or higher than the mean of the potential comparison counties.

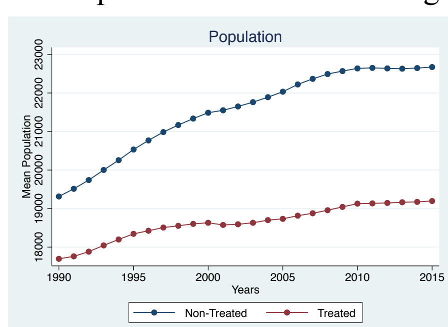

Figure 3-8: The change in the annual mean population size of treated rural counties and potential matching counties without matching

3.6.3 Estimating Propensity Scores

The study uses a PSM approach to match treated counties with comparison counties that have similar socioeconomic conditions, but do not have wind power projects. The PSM approach typically uses the predicted probabilities from a logistic regression, where the dependent variable is the existence or non-existence of the treatment (i.e. large wind farms >100 MW in 2012), which is regressed on a set of pre-treatment demographic and socioeconomic characteristics. The predicted probabilities from this model are used to identify a set of controls that most closely match the treatment group, before any changes resulting from the wind farm.

I use a logit model to measure the propensity score.[10] It is critical in a propensity score model to include all relevant factors that explain how the treated counties might systematically differ from the comparison group, and thus serve as a source of selection bias if left uncontrolled. However, it is also essential to favor a parsimonious model, as too many covariates may inflate the variance.

3.6.4 The matching variables

All the matching variables are measured in 1990, several years before the growth of large-scale wind projects in the United States. For data that was not available in 1990, such as farmland share, I used the nearest available data. For example, to measure the rural share by measuring the percentage of farmland in 1990, I divide the farmland in the county by the total area of the county. Farmland data is measured in the following years 1992,

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[10] In the case of the estimation of the probability of receiving the treatment, logit and probit models usually yield similar results. However, logistic regression is the most commonly used technique.

1997, 2002, and 2007. Farmland is measured by acres, and land area is a fixed variable and measured by square miles. I converted the square miles land area to acres by dividing it by 640. I created a new variable named "FarmLandShare_1992". I used this variable as a proxy of farm share in 1990. Also, the Urban Influence code was measured in the following years 1993, 2003, and 2013. I used 1993 as a proxy of 1990.

Some of the matching variables are given, and some were calculated using the given data (Table 3-13). Population density measures persons per square mile and is calculated using the population size and land area of each county as provided by the U.S Census Bureau. I used three measures to capture similarities in the rural nature of the county: population density, the USDA rural code to reflect the connection between each and nearby cities or metropolitan areas, and farmland share.

I estimated the propensity score by applying logistic regression to my population of 1,773 rural counties, including 132 treatment counties and 1,641 potential comparison counties. The results are provided in Table 3-14. The logistic regression produced a generalized R2 value of 20.9, which represents a significant likelihood ratio statistic, generally a good fit for this type of aggregate model. The logistic regression found that counties with wind farms tended to have high wind speeds, a higher percentage of farmland, favorable topography (e.g., counties with mountains are less likely to have wind projects), are further from metropolitan areas, and smaller population density.

Table 3-13: A preliminary set of possible matching variables includes

Source	Measurement	Match for
U.S Census 1990	Population Density	Rurality

Bureau of Economic Analysis U.S. department of Commerce	Per Capita Income	Income- Economy
Economic research services	Water percentage of the land	Environment
U.S Census, 1990	Percentage of adults with some college degree or associate degree Percentage of adults with a bachelor's degree or higher	The availability of human capital
Economic Research Service	Rural Influence Codes measured by four dummy variables: RIC 6: Adjacent to a metropolitan area, urban population of 2,500 to 19,999 RIC 7: Not adjacent to a metropolitan area, urban population of 2,500 to 19,999 RIC 8: Adjacent to a metropolitan area, less than 2,500 urban population RIC 9: Not adjacent to a metropolitan area, less than 2,500 urban population	Degree of Rurality/Remoteness
Census Bureau, U.S. Counties	Rural share measured as farmland share of total acres.	Extent of the agriculture economy
Bureau of Economic Analysis	Four dummy variables to control for broad regional difference: C_Region1: Northeast C_Region2: Midwest C_Region3: South C_Region4: West	
National Renewable Energy Laboratory (NREL)	Using GIS to calculate the average wind speed class per county in a county (where 3 is towards fair wind resources and 7 represents areas with the highest wind speeds). It represented by three dummy variables: Poor wind speed class: class 1 and 2. Faire wind speed class: 3 and 4. High wind speed class: over 4	Potential wind development

Table 3-14: Logistic regression to estimate the propensity score analysis.

Treatment	Coefficient	Standard errors	Z	P>|Z|

Diff income 2015 - income 1990	0.000015	0.0000000956	1.53	0.127
Per capita income 1990	2.55e-06	0.0000438	0.06	0.954
Fair wind speed class	1.1	0. 27	4.09	0.000 ***
High wind speed class	1.26	0.50	2.53	0.011**
Population density 1990	-0.022	0.008	-3.12	0.002**
Midwest Region	-2.62	0.644	-4.07	0.000 ***
South Region	-1.59	0.60	-2.65	0.008***
West Region	-1.43	0.67	-2.09	0.036**
Natural Amenity Rank	0.15	0.157	0.98	0.328
% Water surface percentage of the county	0.013	0.013	1.01	0.315
Mountains	-1.71	0.54	-3.17	0.000***
%Farm land share 1992	3.46	0.60	5.82	0.000***
% adults have some college degree or associate degree	0.06	0.027	2.23	0.026**
% adults have bachelor's degree or higher	-0.016	.028	-0.58	0.564
Adjacent to a metropolitan area, urban population of 2,500 to 19,999	1.38	0.50	2.77	0.006***
Not adjacent to a metropolitan area, urban population of 2,500 to 19,999	0.66	0.33	1.97	0.049**
Adjacent to a metropolitan area, less than 2,500 urban population	0.70	0.2844	2.46	0.014**
Not adjacent to a metropolitan area, less than 2,500 urban population	0.89	0.34	2.59	0.010**
Constant	-4.55	1.01	-4.51	0.000 ***

*, **, *** *coefficient statistically significant at 10-percent, 5-percent, and 1-percent levels, respectively.*

Once I estimated the propensity scores, the next step uses a matching algorithm to select the optimal control group from the full set of untreated counties. There are four different matching algorithms: nearest neighbor matching, caliper and radius matching, stratification and interval matching, and kernel and local linear matching. Nearest neighbor matching is the most straightforward matching estimator and is the easiest to implement and understand. I used nearest neighbor matching with a caliper of 0.2 to test the robustness of my results. I used one-to-one matching without replacement, which limited the matched counties, as some treated counties do not have matched counties, but it reduces bias from inappropriate matching. The final dataset included 94 counties as treated, and 94 control, counties. There are 38 treated counties could not be matched.

Table 3-15 illustrates the value of the propensity method in addressing selectivity bias by comparing economic and demographic attributes of counties with wind development and counties without wind development, with and without propensity score matching. Without matching, counties that eventually gained large wind farms had smaller populations, lower poverty rates, lower unemployment rates, higher per capita and median household incomes, higher farm income, and higher farmland share than the typical non-wind development counties. After matching there were no remaining significant differences pre-treatment differences between the treatment and comparison counties

Table 3-15: The difference between the treated and control counties before matching.

Variable	**Sample**	**Mean**		**Difference**	**p>|t|**
		Treated	**Control**		
Population 1990	Unmatched	17,696	19,314	-1618	0.2633
	Matched	16,884	14,026	2,858	0.1457
Per capita income 1990	Unmatched	15,777	14,121	1,656	0.00***
	Matched	15,594	15,659	-66	0.8703
Medium House Hold income 1989	Unmatched	23,771	21,129	2,642	0.000***
	Matched	23,655	22,251	1,404	0.0176*
Poverty rate 1989	Unmatched	13.90	18.12	4.22	0.000***
	Matched	14.17	16.41	2.23	0.05*
Unemployment rate 1990	Unmatched	5.15	6.66	-1.51	0.000***
	Matched	5.33	5.09	0.24	0.5657
% of adult with some college 1990	Unmatched	24.2	20.13	4.07	0.000***
	Matched	23.69	23.35	0.34	0.6506
% of adult with bachelor's degree or higher 1990	Unmatched	12.87	11.19	1.68	0.0001**
	Matched	12.6	12.96	0.36	0.6617
% Farm land share 1992	Unmatched	47.57	29	18.57	0.000***
	Matched	44.38	51.73	-7.35	0.0806*

Farm income 1990 per thousand dollars	Unmatched	20,235	10,410	9,825	0.000***
	Matched	18,882	17,100	1,758	0.49

*, **, *** *Difference statistically significant at 10-percent, 5-percent, and 1-percent levels, respectively.*

The data in Table 3-15 shows that there is a significant difference between the treated counties and non-treated counties in 1990, without matching. This difference is eliminated after the matching. As Figure 3-9 shows, the mean income per capita of treated counties and matched counties almost overlap. Although there is a clear difference in the population and poverty rate as Table 3-15 and *3-16* shows, this difference is not significant.

Table 3-16: The difference between the treated and control counties after matching.

Variable	**Sample**	**Mean**		**Difference**	**p>|t|**
		Treated	**Control**		
Population 2015	Unmatched	19,196	22,673	3,477	0.0671*
	Matched	18,112	15,208	2,904	0.2345
Per capita income 2015	Unmatched	44,646	37,428	7,218	0.000***
	Matched	42,964	43,020	-56	0.9714
Medium House Hold income 2015	Unmatched	49,734	43,776	5,958	0.000***
	Matched	49,312	47,614	1,698	0.16275
Poverty rate 2015	Unmatched	14.11	18.13	-4.02	0.000***
	Matched	14.42	15.22	.70	0.3628
Unemployment rate 2015	Unmatched	5.15	6.66	-1.51	0.000***
	Matched	4.68	4.65	-0.03	0.9072
% of adult with some college 2015	Unmatched	32.19	29.94	2.25	0.000***
	Matched	31.93	32.46	-0.53	0.4912
% of adult with bachelor's degree or higher 2015	Unmatched	18.79	17.08	1.71	0.0044**
	Matched	18.45	19.96	-1.51	0.1339
Farm income 2015 per thousand dollars	Unmatched	43,039	18,952	24,087	0.000***
	Matched	34,703	32,523	2,180	0.7664
Propensity score	Unmatched	0.26	0.059	0.201	0.000***
	Matched	0.17	0.17	00	0.98
Observation number	Unmatched	132	1641		
	Matched	94	94		

, **, * Difference statistically significant at 10-percent, 5-percent, and 1-percent levels, respectively.*
1 Using propensity score nearest neighbor without replacement

There is no significant difference between the mean income per capita of treated counties and the ones of matched counties over the study period from 1990 to 2015. The time curve of the mean per capita income of the treated counties and the matched counties almost overlap (Figure 3-9).

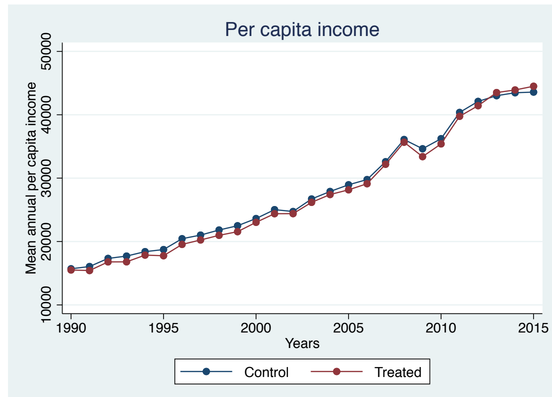

Figure 3-9: The change in the annual mean income per capita of treated rural counties and control counties with matching

As shown in Figure 3-10, the treated counties have a higher annual mean of the median household income over the study period from 1990 to 2015. This small difference is occurred before and after wind development, and is considered not significant, as shown in Figure 3-10.

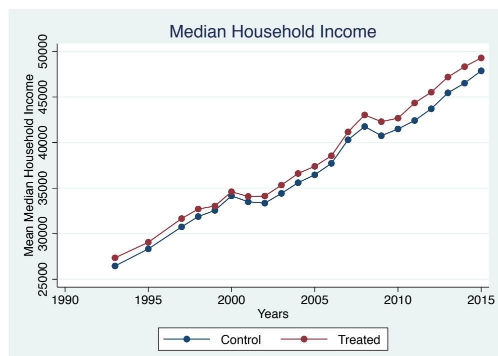

Figure 3-10: The change in the annual mean median household income of treated rural counties and control counties with matching

The annual mean farm income of the treated counties and the matched counties was almost the same until 2003. The treated counties started to have a higher mean of farm income. The increase of the farm income in the later years is too small to be significant (Figure 3-11).

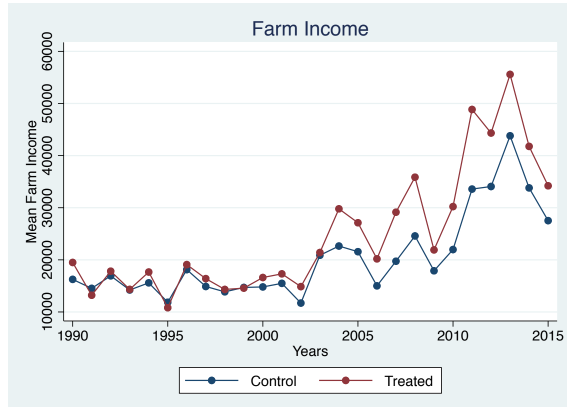

Figure 3-11: The change in the annual mean farm income of treated rural counties and control counties with matching

As Figure 3-12 shows, the matching counties have a lower unemployment rate than the treated counties until 2000; the unemployment rate of the treated counties started to decrease to be in line with the matched counties.

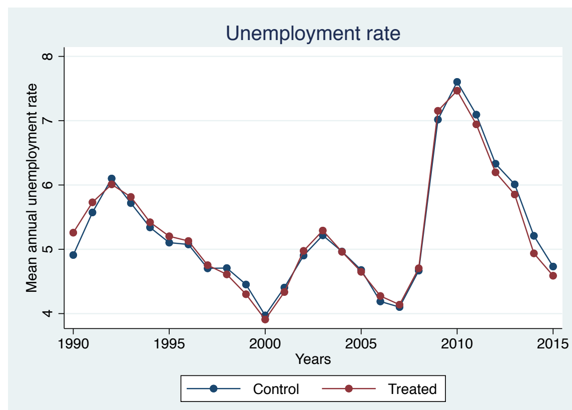

Figure 3-12: The change on the annual mean unemployment rate of treated rural counties and control counties with matching

Although there is a real difference between the annual mean of the poverty rate of treated counties and matching counties over the study period from 1990 to 2015, this difference is not significant (Figure 3-13).

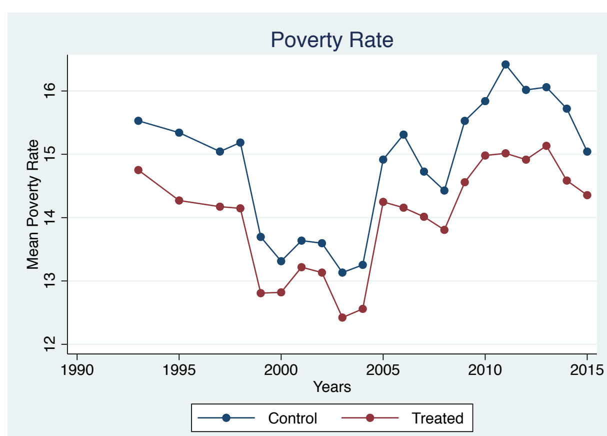

Figure 3-13: The change in the annual mean poverty rate of treated rural counties and control counties with matching

As Figure 3-14 shows, the treated counties have a higher mean of population size than the matching counties. Wind development does not have any relation to this difference as it occurred before wind development and continues to 2015.

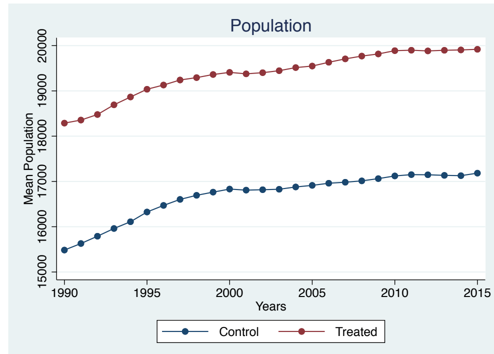

Figure 3-14: The change in the annual mean population size of treated rural counties and control counties with matching

The mean of treated counties educational attainment (percentage of adults with some college and percentage of adults with a bachelor's degree or higher) is almost the same as the mean of matched counties. The treated counties' mean was higher in 1990 than the educational attainment of the matched continued increasing to be very close to treated counties.

3.6.5 Longitudinal analysis – fixed-effects model for nonmetropolitan wind counties and their matched counties

After defining the treated and control counties, I compare the change on the matched rural counties that have wind development (94 counties) to a group of similar counties, control counties (94 counties). I used fixed -effects model analysis on the matched groups of counties to identify the effects of the accumulated wind power capacity on the outcome variables. The next equation presents the fixed effect model equation.

$$y_{it} = \beta_0 + B_1 X_{1\,it} + \cdots + \beta_K u x_{k\,i} + \delta\, T_t + \gamma_2 E_2 + \gamma_n E_n + U_{\,it} \qquad (6)$$

Where:

- Y_{it} is the dependent variable (DV) where i = county and t = time.
- X_{1}…k,it represents independent variables (IV)
- $\beta_{1\ldots k}$ is the coefficient for the IVs,
- U_{it} is the error term
- E_n is the county n. Since they are binary (dummies) you have n-1 counties included in the model.
- γ_2 is the coefficient for the binary regressors (entities).
- T_t is time as a binary variable (dummy), so I have t-1 time periods.
- δ_t is the coefficient for the binary time regressors.

The fixed-effects model measured the effect of the accumulated wind power capacity in the region of support (nonmetropolitan wind power counties and their matched counties). The model results indicate a significant effect of the accumulated wind power capacity on per capita income. On average, increasing the accumulated wind capacity by one MW increases the income per capita by 6.59 dollars (P > |t|0.000) (Table 3-17). At the same time, the model found no statistically significant effect of the accumulated wind power capacity on median household income, farm income, unemployment rate, per capita employment, poverty rate, and population size. There is only a small negative effect of increasing the accumulated wind power capacity among wind power counties on the educational attainment. Table 3-18 shows that increasing the accumulated wind power capacity by one megawatt decreases the percentage of adults with some college in wind power counties by 0.0019 (P>|t|0.01) and reduced the percentage of adults with a bachelor's degree or higher by 0.0027 (P>|t|0.000).

Table 3-17: Fixed -effects results of the per capita income and median household income on the matched counties.

	Per capita income $_{ij}$	Median household income $_{ij}$
population	-0.22**	-0.139
Accumulated wind power capacity	**6.59*** **	**2.18**

% adults have bachelor's degree or higher	355.51**	270.073**
Unemployment rate	101.62	-1,215.43**
Years	447.24***	31.46
Constant	-863,752.4***	-12,663,89
Sigma_u	6,144.996	6,968.34
Sigma_e	5,326.86	3,810.01
rho	0.57	0.77

*, **, *** *coefficient statistically significant at 10-percent, 5-percent, and 1-percent levels, respectively*

The results of fixed effect model focus on the effect of the accumulated wind power capacity on the nonmetropolitan rural counties. These results partially conflict with the results of Brown et al. (2012) who measured the post impacts of wind power development on the counties in the Great Plains region and found an increase in per capita income and per capita employment. The results of the fixed-effects are close to the results of De Silva et al. (2016) as they conclude a significant effect on the income per capita only and fail to find a substantial impact on the employment and median household income. However, De Silva et al. (2016) did not measure any effects on demographic attributes. My fixed-effects model's results are close to De Silva et al. (2016) results because we both have small population.

Table 3-18: Fixed effects models results for educational attainment (% adults with some college & % adults with a bachelor's degree or higher).

Variables	(% adults with some college ij	% adults with a bachelor's degree or higher ij
	Fixed model	Fixed model
population	-0.0002***	-0.00009*
Per capita income	-0.00005*	0.00006**
Accumulated wind capacity	**-0.0019****	**-0.0027*****
years	0.389***	0.25***
Constant	-757.63***	-498.86***
Sigma_u	5.38	5.47
Sigma_e	2.46	2.22
rho	0.83	0.86

Number of observations, groups	(564 - 188)	(568 - 188)

*, **, *** *coefficient statistically significant at 10-percent, 5-percent, and 1-percent levels, respectively*

3.7 Discussions

The longitudinal analysis, for the all counties in the continental United States, concludes a significant positive effect of wind power capacity on the economic attributes of rural counties in terms of increasing per capita income, median household income, per capita employment and farm income. At the same time, it concludes a significant small adverse effect on the poverty rate. For the demographic attributes, although there is no significant effect on the population size, it concludes a significant small adverse effect on the percentage of adults with some college, and the percentage of adults with a bachelor's degree or higher.

In addition to the longitudinal analysis for the whole study population, I conducted another longitudinal analysis with a comparison group, focusing on nonmetropolitan wind power counties. I define the nonmetropolitan wind power counties as counties with wind power project over 100 MW by 2012 and was not a part, or adjacent to, a large metropolitan area of more than 20,000 people. I use a restricted matching technique, nearest neighbor matching without replacement, that ends with 94 counties as treated counties and 94 counties as control counties. Using longitudinal analysis for the nonmetropolitan wind counties and their matched counties, fixed-effects model, I find a significant positive effect on the economic attributes represented on increasing in per capita income. For the demographic attributes, there is no significant effect on the population size, but it concludes a significant small adverse effect on the percentage of adults with some college and the percentage of adults with a bachelor's degree or higher.

The results of the fixed-effects model with matching analysis agree with the results of the mixed-effects model for the whole study population on the demographic attributes and partially agree on the economic attributes. Longitudinal analysis with a comparison group failed to find any significant impact of accumulated wind power capacity on median household income, farm income, per capita employment and poverty rate. In contrast, the longitudinal analysis for the whole population did.

The difference between the longitudinal analysis with a comparison group results and the longitudinal analysis' outcomes was related to the different population. The results of the fixed-effects model with quasi-experimental design are strictly valid only for the matching population, the common support region (94 treated counties and 94 control counties) compared with the longitudinal analysis's population (3072 counties).

3.8 Conclusion

Rural communities have faced a recent increase in wind power development, which many see as a chance to help increase economic diversity in rural areas. While previous simulation-based studies often estimate large impacts of wind power development on income and employment, recent empirical studies are more likely to find small positive effects.

This chapter measures the impact of wind power development on both economic as well as demographic attributes of rural counties in the continental U.S. I used two longitudinal analysis methods: mixed-effects model and fixed-effects model with a quasi-experimental approach that matches counties with large wind farms with structurally similar counties without. Both models controlled for unmeasured variation across 26 years starting from 1990 to 2015.

The mixed-effects model tests the effect of the accumulated wind power capacity on the economic and demographic characteristics of rural development. The model concludes that each increasing megawatt of wind power capacity related to a statistically significant increase in per capita income, median household income, per capita employment and farm income. It also decreases the percentage of people in poverty. An incremental change in wind capacity does not significantly change the population of rural communities, although I do find a significant adverse effect on the percentage of adults with some college and the percentage of adults with a bachelor's degree or higher.

I used a Propensity Score (PSM) approach with nearest neighbor matching to match nonmetropolitan counties with large wind farms with structurally similar counties without. I defined the treatment group as rural counties with wind power development over 100 MW in 2012, resulting in a sample of 94 treated counties and 94 control counties. Fixed-effects model is used to measure the impact of the accumulated wind power capacity on the outcome variables of nonmetropolitan wind counties and their comparison counties. I find that as the accumulated wind capacity increases by one megawatt, the income per capita of nonmetropolitan wind power counties increases by 6.59 dollars (P>|t|0.000).

There is an agreement of both longitudinal analysis on the neutral effect of wind development on the population size and unemployment rate. Wind power is less labor intensive to make any effects on the population size and unemployment rate of rural counties. The economic impacts of wind power development are limited in the nonmetropolitan rural counties, as it appears only as an increase on per capita income versus the economic impacts on the whole population. The mixed-effects model population includes metropolitan and nonmetropolitan rural counties that showed an increase on per capita income, median household income, and per capita employment as well as a reduction on the poverty rate.

Finally, according to both models' results, there is a small significant effect of wind development on the economic side of rural development. Increasing the accumulated wind power capacity leads to economic growth in terms of raising the per capita income, median household income, farm income, and per capita employment. It also affects economic development through a small reduction in poverty rate.

CHAPTE 4
CASE STUDY ANALYSIS: MEASURING THE IMPACTS OF SUBSTANTIAL WIND POWER PROJECTS ON RURAL AREA'S PLANNING AND COMMUNITY SERVICES.

4.1 Abstract

Wind power development has rapidly expanded in rural areas in the United States. Numerous studies addressing the impacts of wind development on rural communities focusing on economic, environmental, and social effects. This research addresses the impacts of substantial wind development on community services and the standard of living. It uses a mixed-methods approach to investigate the effect of wind power development on the eleven rural counties which hosted substantial wind farms over 1000 MW. This approach consists of three components: descriptive analysis, semi-structured interviews, and government documents and newspapers analysis. The descriptive analysis is performed to document changes in the population size, employment, and poverty rate of eleven rural counties before and after hosting substantial wind projects. The interviews and documents are analysed to identify the effect of wind development on public services and standard of living, based both on empirical outcomes and respondents' experiences. The results show that wind development increased the tax revenue of the rural community without any noticeable increases in required public services or increases in the population size of the rural communities. Counties received substantial tax revenues and showed an improvement on public services. Wind development provides an additional source of income to rural communities without any changes to the rural nature. This research suggests that wind development is a suitable economic source for rural economy's diversification

4.2 Introduction

Many rural communities in the United States are economically depressed and struggle with identifying viable development opportunities because of the dual liabilities of small population size and physical isolation (GAO, 2004). As a response, wind power development has rapidly expanded in rural areas in the United States (Wiser & Bolinger, 2011). Most of the significant wind power projects over 1000 MW are located in rural counties with a population less than 25,000 people, where communities are looking to generate income and population growth. The economic promise of wind power projects is particularly appealing for rural areas. Previous studies have generally found a strong association between wind power projects and economic growth in rural counties, measured by an increase in personal income and municipal finance, suggesting that wind projects could be an impetus for rural development (Brown et al., 2012; William et al., 2008; Grover, 2002; Khan, 2013; De Silva et al., 2016).

Previous studies have focused on the economic impacts of wind power projects, while none, to my knowledge, have studied the effects of large wind power projects on community services in rural areas. Although not perfectly analogous, past research on the effect of coal and natural gas on rural communities suggests that only massive energy projects affect the community services in immediately noticeable ways. Therefore, this study focuses solely on counties with substantial wind farms over 1000 MW. I use a mixed methods approach to answer the question: “What are the impacts of substantial wind power projects on local government services?"[11] To answer this question, I examine eleven counties with substantial wind farms. The strength of studying these cases is the ability to deal with a full variety of evidence documents, artifacts, interviews, and observations – beyond what might be available in a conventional historical study (Yin, 2014, p.12).

4.3 Literature Review

Research on the impacts of wind power development on community services is rather limited. However, there is ample research about the effects of the energy boom on rural areas during the 1970s and early 1980s. When the United States started relying more heavily on its coal and natural gas resources after the petroleum crisis in the 1970s, many huge energy projects were sited in small rural areas. Considered as a form of rural industrialization; the energy boom led to rapid population growth and changes in the social structure and quality of municipal services in rural communities—otherwise known as the boomtown effect (Jacquet & Stedman, 2013).[12]

4.3.1 Boomtown

Researchers studied the impact of energy boom on rural areas from different aspects such as economic, social, infrastructure, and local fiscal effects. From the experience of a boomtown resident, locating new industrial projects in small communities does not always

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[11] Local governmental services or community services are the services the municipality provides to the residents and business such as road services, police, fire, school, recreation areas, and water and sewer. In the case of wind projects, these services have two sides: turbine-related services like road access and fire protection, and resident services for the expected increased population, if there is any.

[12] The term boomtown is generally used to describe relatively small communities which are undergoing rapid and substantial changes in population growth and general levels of economic activity.

manifest as improvements in local conditions (Ervin, 1978). For example, Cuba, New Mexico experienced an increase in coal-mining activity during 1970 to 1074, and the socio-economical impact seemed to benefit entire community. By contrast, during that same period, Sweetwater County, Wyoming experienced the expansion of mining and the construction of the Jim Bridger Power Plant. Population and employment levels in the county doubled from 18,931 to 36,900 and 7,230 to 15,225, respectively. Yet, the quality of municipal and other local services declined markedly, such as an increasing deficit of roads, schoolrooms, and municipal water, electric, and sewerage facilities (Cummings & Mehr, 1977).

The difference between the two scenarios reflects the ways in which the local governments faced the challenges of development.Cummings and Mehr (1977) found the main challenge stemmed from difficulty anticipating and the uncertaintly associated with population growth. With rapid development, towns that previously had little need for highly educated and experienced planning staff now faced a shortage of professional expertise (Jacquet, 2009). Cummings and Mehr (1977) found that the positive effects on the town of Cuba were due to having substantial excess capacity regarding municipal facilities before energy projects.

More recently, Jacquet (2009) studied the impacts of natural gas development on Sublette County, in Southwestern Wyoming. He found that the local governments of Sublette County achieved significant increases in both revenues and expenditures due to royalties from natural gas development and the mitigation of impacts from the development (Jacquet, 2009). Jacquet stated that the development of natural gas caused some changes in the local economy and housing, as well as contributing to changes in the demographic composition of the community. The economic changes included a rapid increase in the job opportunities and growth in wages and family incomes. Demographically, Jacquet also found an increase in the population size, and the county's population became younger than before. The natural gas development also caused a dramatic increase in the number of permanent housing units in Sublette county, which increased 22% between 2000 and 2007, although this lagged the overall population growth rate of 33.9% during this same period. Home and rental prices rose as well, with an increase in the rent prices of over 128%. Although several studies have emphasized the massive negative social impacts associated with the energy boom in the 1970s in rural areas, these studies have been criticized on methodological grounds (Jacquet & Stedman, 2013). Most of the studies focused on the boom period; only a few have compared pre-boom and boom condition (Smith, Krannich, & Hunter, 2001).

The impact of wind power development on community services will depend on the degree to which it affects the population size as well as the local tax revenue. However, the likely economic and demographic effects of wind power are not necessarily comparable to those of natural gas or coal. The impact on community services from the new development mainly stem from population growth – which is likely to be more limited for wind farms. The natural gas boom has doubled the population in some areas due to the massive job creation and long construction period. Brown et al. (2013) found that natural gas development was associated with a 12 percent increase in total employment in counties in Colorado, Texas, and Wyoming that experienced a large increase in natural gas production, compared to a 0.6 percent increase for wind power development. Further, natural gas development requires more workers for different pre-production stages, such as drilling and extraction, and the construction of a natural gas infrastructure can take three years compared to one year for the infrastructure required for wind power development. The impact of wind projects on a community's services is related to the demanded services: resident services and turbine-related services. It also related to the funding and maintenance of those services through the tax and income revenue of such wind projects.

4.3.2 Wind Energy

Numerous studies have found that wind power projects have positive economic impacts on rural areas. What is less well understood is the impact of wind projects on the community services. Recent studies measured the impacts of wind energy projects on municipal finance in terms of the tax base, tax rate, and school local revenue. They found that wind power development decreased the property tax rate and increased the tax base (Khan, 2013; De Silva et al., 2016). At the same time, wind power counties have higher local school revenues than other counties (Khan, 2013; Castleberry & Greene, 2017). In addition to the expected tax income from wind projects, many developers also allocate funds for the community to compensate for the project impacts, as well as to build trust with the community. For example, a study in Wales, U.K reviewed 30 wind projects and found that two-thirds of the wind projects provided a benefit fund for community improvement projects (Bristow & Mundy, 2012). Most of the funds were around 1,000 Euro/per MW annually and usually allocated toward a particular project, such as restoration of wildlife enhancement, energy projects, mountain and bike community trials, or local road improvement.

Wind power development can affect the standard of living positively or negatively. The positive effect could be the increase in municipal finance, and using this increase to enhance municipal services. In the United States, the mayor of Weatherford City said that wind farm developers in the city agreed to pay the city $25,000 a year for lost aesthetic beauty, as well as to help fund community improvement projects. This was a huge benefit to the city that provided resources beyond the city's normal budget. Weatherford has used some of this fund to install a security and surveillance system on the city government complex, and to build a new city building, gym, and playground (Greene & Sawatzky, 2013, p.7).

The negative impacts of wind farm development are often realized through an increase in the cost of living. For example, the residents of Nolan County, Texas reported a rise in housing rental prices and cost of living prices due to wind projects, which hurt non-landowning residents (Brannstrom & Persons, 2011). Researchers also asked local officials about the possible physical impacts of wind power projects. The only concern of the local officials was the road conditions during the construction phase, and they reported that the developers agreed to take responsibility for any damage (Greene & Sawatzky, 2013). The residents also reported some traffic issues during the construction phase of wind projects (Jacquet & Stedman, 2013). However, this issue is temporary and can happen with any development.

This chapter focuses on measuring Wind impacts on community or local governmental services. These are the services a municipality provides to the residents and businesses such as road services, police, fire, school, recreation areas, and water and sewer. In the case of wind projects, these services have two sides: direct turbine-related services such as road access and fire protection, and; improvements to resident services that might be necessary due to population growth or just improving the quality of service for existing residents.

4.4 Theoretical Framework

Large-scale energy projects offer small isolated rural areas the promise for increasing income for residents and merchants, and deepening and diversifying the tax base that may contribute to better government services. At the same time, introducing sizeable new development on small rural communities creates some challenges for local governments and planners. Such challenges of the new development have two sides: political/management and community service. The political side came from how to deal with newcomers and developers. For example, jurisdictional unevenness can happen as the community bearing the cost of the development cannot control the growth and may not receive any benefits because the owners are elsewhere. There are other political challenges that arise from conflicts between newcomers and incumbent residents; insufficient land-use controls; the severity of growth; violation of growth pattern; monopoly of information; and risk of taking the decision with uncertainty surrounding the future of many energy activities (Markussen,1978; Jacquect, 2009).

New land uses generally provide more tax revenue, but also increase demands on related services from the local government. Figure 4-1 explains the cycle of the related services demand and the revenue of any new land use. For example, wind turbines as a new land use will need road access and fire protection, in the very least. Turbines will also provide new tax revenue to the community. Problems arise when the growth in tax income is surpassed by increased service demands. Sometimes, the revenue comes quite late. For example, the impacts of oil shale on the local government of three counties region in Colorado was negative for seven years before producing a positive financial return (Ervin, 1978). This is particularly problematic when communities offer multi-year tax abatements—such as those in Texas where wind farms are granted tax-abatements for ten-year period (Media agent, 2015 April, 22).

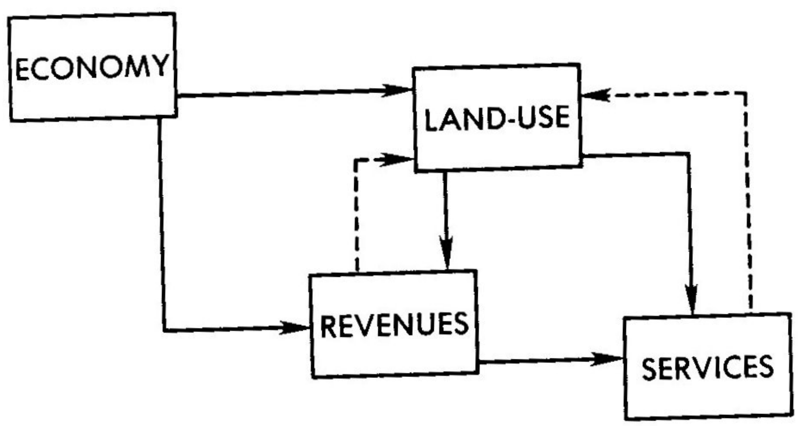


Figure 4-1: Economy services and revenues cycle (Ervin,1978)

There are two general kinds of local service: turbine-related and resident services. Turbine-related services are considered to be immediate services as opposed to resident services, which are not. As it pertains to both kinds of services, one must ask: Who will pay for the services, and when? Interviewees will be asked direct questions about turbine-related services and who pays for the cost. For example, wind turbines incorporated and zoned as a part of new land use will, at the very least, need road access and fire protection.

At the same time, the wind power development and production will provide tax revenue to the community. Problems arise when the growth in tax income is surpassed by an increase in service demands. Sometimes, the revenue comes too late.

To predict the residents' services demands from wind power projects, requires an accurate prediction of population growth stemming from the new development. Figure 4-2 shows the hypothetical change in the population over time due to the new wind power development. In all case scenarios, the county population increases during the construction period, although much of the employment is temporary and may not reflect on the county's permanent population size. Construction laborers tend to live in non-traditional housing units such as employer-supplied dormitories (i.e. "man-camps"), motels, and R.V. parks. Such temporary housing units typically do not affect building permits or driver's license trends that form the basic state and some U.S. Census Bureau population estimates (Jaquet, 2009). The local officials and local business owners state that in the construction period, the motels were full, and all rental housing was taken. The recreational trailer vehicles were parked in the city park (Greene & Sawatzky, 2013; Leistritz & Coon, 2009).

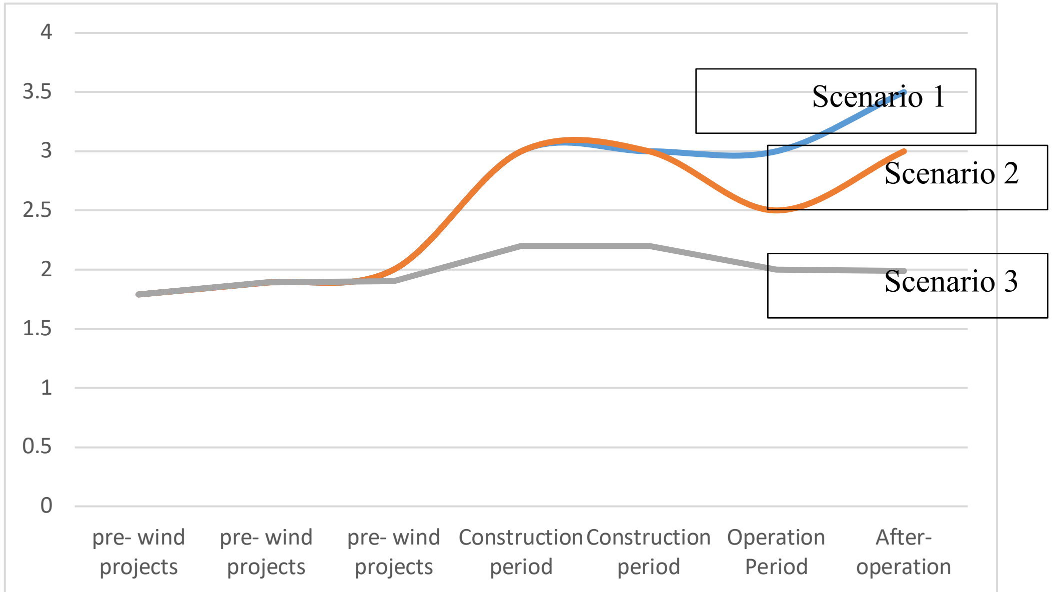


Figure 4-2: Hypothesized population growth projection after generic wind development

There are three possible scenarios for population change in the operations phase. Scenario one is a small increase on the population due to the new jobs. Scenario two is a stable population, as the new jobs are filled by the residents who were looking for jobs. Scenario three suggests the population will continue to decline, as the wind jobs are insufficient to stop the population declining. The expected impacts on the residents' services will be related to the implications of the new development on the population size and the current situation of the community services. If there is an increase in the population size, there will be a demand on residents' services. If this demand is financed by wind power projects' tax revenue, there will not be any problem with public services. If this demand is not filled by the new development's revenue, it would create a shortage of the community services or a pressure on the local finance.

The impacts on the community services will depend on the size of the population growth and whether there is excess capacity in relevant municipal infrastructure systems or excess supply in housing and other local markets. While small population growth can often be easily handled, substantial growth can generate pressure on the community services. Gilmore (1976) notes that towns can typically handle rates of 5% of population growth annually without much problem. However, if the increase rate is more than 15%, it will lead to institutional breakdowns in the labor market, the housing market, and the system for maintaining local public facilities.

Figure 4-3 shows how wind development can affect the standard of living of rural communities. The figure shows alternate scenarios in regards to how wind projects may affect rural communities, income, population, and public services will shape how wind power development affects the quality of life. The best-case scenario is the stabilization of population growth, which will balance the demand on residents' services. Meanwhile, the wind power development will increase residents' income, and counties tax revenue of wind power development exceeds the turbine-related services and is able to improve public services. In turn, this will improve the quality of life for entire communities.

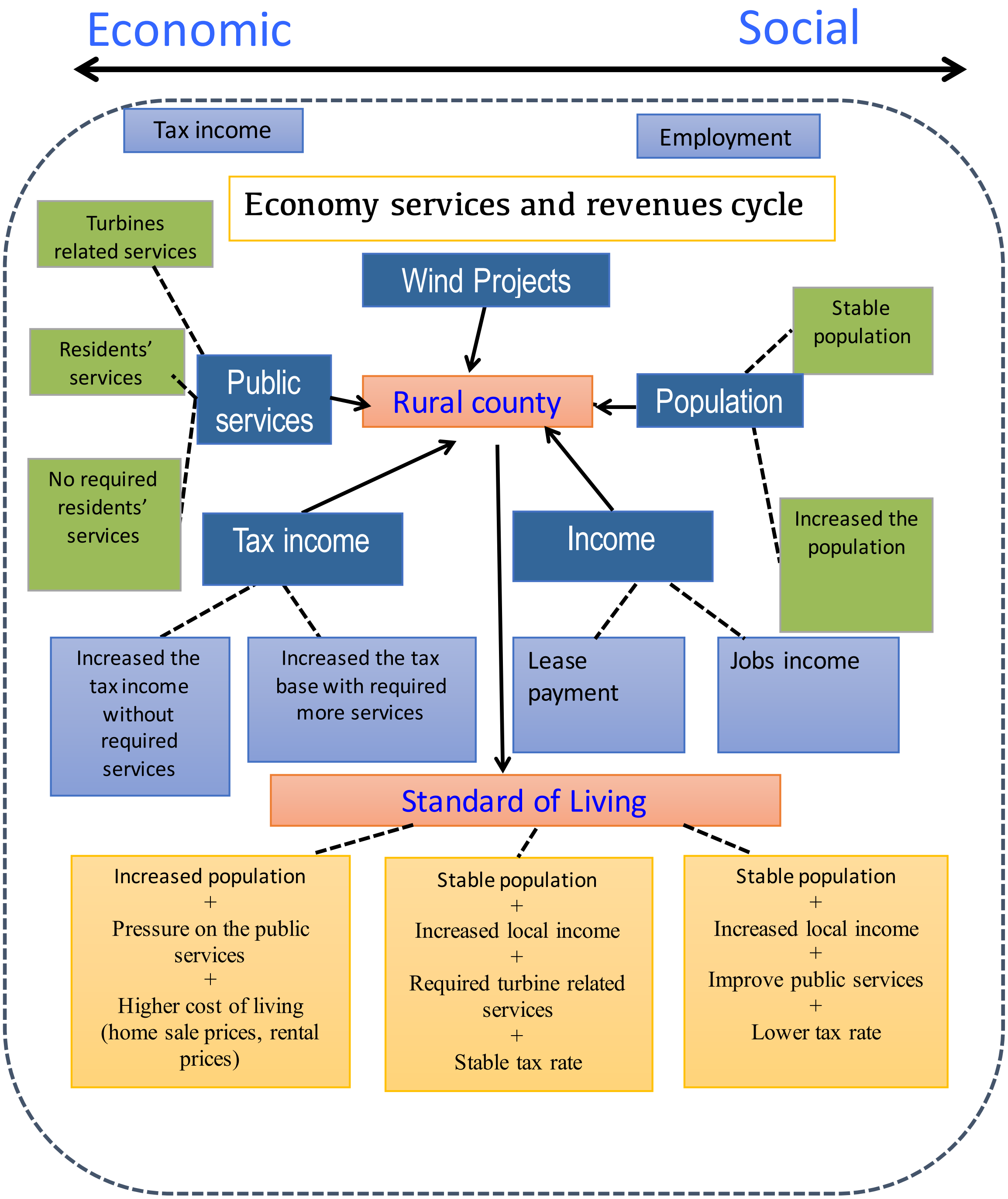


Figure 4-3: The conceptual framework of the effect of wind power development on community services.

4.5 Research Question

The main research question is: What are the impacts of substantial wind power projects on local government services? Do wind power expansions increase the local tax revenue? Do wind power projects required any additional public services and how are the cost of these services is covered? How have the counties used the additional tax income? Was the additional tax income used to improve the public services in the county? Did wind power projects increase the population and did this increase require more residents services in additional to turbine-related services?

These questions are answered by a comparative case studies analysis involving both descriptive quantitative analysis and qualitative analysis of data gleaned from interviews and public documents. I first use descriptive data analysis to document changes in the population size, employment, and poverty rate of several rural counties before and after hosting substantial wind projects. Second, I conduct a qualitative analysis of interviews and documents to measure the impacts of wind projects on tax revenues as well as public and turbine-related services.

4.6 The Study Area

The target population are counties with substantial wind farms in the United States and the county is the primary unit of the analysis. Among counties in the United States, over four hundred counties with wind power projects ranging from one MW to over 3000 MW. This paper is focuses on counties with substantial wind projects, defined here as those with capacity in excess of 1000 MW. According to American Wind Energy Association's (AWEA) 2016 second quarter wind capacity data, only eleven counties from five different states with wind farms over 1000 MW in the United States. I use these eleven as my cases.

Five of these counties are located in Texas, two in California, two in Oregon, finally one in Colorado and one in Washington State (Figure 4-4). Some of these counties are adjacent and neighboring counties, such as Sherman County and Gilliam County in Oregon, as well as Klickitat County, Washington. Although Texas State has five counties, none of them are neighbors. Some counties have a long history with wind power since the 1980s like Kern County California, and some are new to wind power development such as Floyd County, Texas which introduced wind power in 2014.

I classified the eleven counties to three groups: (i) large rural counties with an urban portion (ii) Medium rural counties with small towns, and (iii) small rural counties with tiny towns. The eleven counties all have high wind potential and are close to major transmission lines. For example, Kenedy County Texas has the highest wind speeds during high demand hours for electricity rates; and Floyd County, Texas has the top wind speeds in the country.

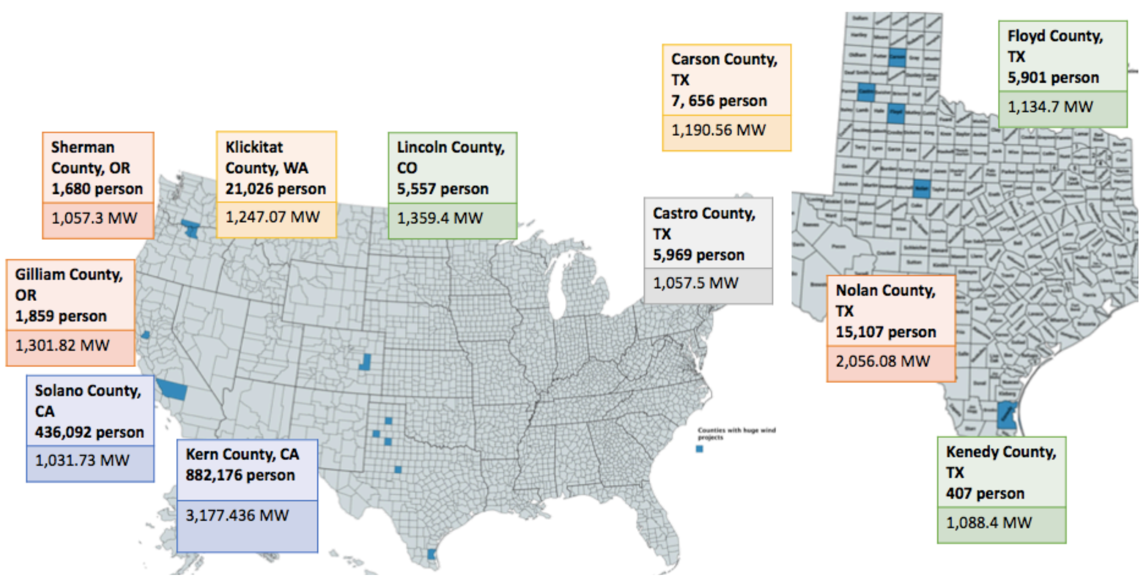


Figure 4-4: Case Studies of counties with wind projects over 1000 MW

4.7 Method

This research uses a mixed-methods approach to investigate the impact on rural counties' community services when substantial wind projects are built. This approach consists of two components: descriptive statistical analysis and qualitative analysis. The descriptive analysis includes data about each county for 26 years, starting from 1990 to 2015. The descriptive data consists of economic and demographic data, as shown in the next table.

Table 4-1: Descriptive data

Data	Variables 1980 to 2015	Sources
Demographic	Population	Available online on the county's website
Economic	Per capita income Unemployment rate Poverty rate	Available online on the county's website
Wind Capacity data	Added capacity per year Accumulated wind capacity	These data available online AWEA

I collected my qualitative data through semi-structured interviews, collection documents and editorial articles. I conducted a dozen interviews with local officials and public representatives of the eleven counties. Each county was contacted by emails and phone calls to identify the best person to talk about the wind projects on the county. Some counties had their wind projects for more than ten years. I targeted people who witnessed wind power development projects within their county and contributed to wind development's processing. Due to geographical constraints and resource limitations, the interviews were conducted online via phone interviews rather than face-to-face. All research procedures were approved by the IRB(Institution Review Board) at the University of Massachusetts Amherst. The interviews were only voice-recorded for identity protection. Most of the interviews last for around forty-five minutes to one hour.

The interview included nine main questions which were categorized into nine groups. Under each main question, there were some sub-questions (see list of interview questions in Appendix A). The interview started with some descriptive question about the county and its experience with wind development, and then progressed to casual and relationship questions to understand the relationship of hosting wind development and the changes on the tax revenue, income, housing, and energy prices. The interview also covered some opinion questions to know the local official opinion based on their experience. For example, the question about the effect of wind development on County's future: How do you expect that wind power project will affect the county's future?

I also searched for official documents, plans, and editorial articles about wind projects in each county. This research started with the county website, Google search, and asking the counties' representatives about any official plans. Some of the governmental plans and documents were available on the counties' website, and some were provided to me by the counties' representative after I asked them about any plans in the interview, especially any recent plans that were not yet be available online. The rest of the documents were obtained from Google searches. I excluded some of the documents and editorial articles that were not relevant to understanding relevant community impacts. For example, I excluded some regional plans for multi-counties in Texas because they focused more on legislative plans and did not have detailed information about each county. I also excluded environmental hazard plans, such as mitigation action plans, soil survey reports, and flood plans. The exclusion of these documents and articles was dependent on their context and mainly because it does not include any related information to my research. I analyzed over twenty legislative reports included: comprehensive plans, economic strategies, strategic plans, economic policies, renewable energy policies, economic diversification studies, and energy cluster studies. For the newspaper articles, I focused on the ones about the socioeconomic side of wind projects within the counties studied. I analyzed twenty-six newspaper articles about the impacts of wind projects on the eleven rural communities.

The qualitative data of each county is analyzed by coding the interview's transcripts, reports, and newspapers. Most of the coding themes were taken from the literature and the theoretical framework. The main themes were related to the main questions group. Table 4-2 shows the main questions and the main coding themes. All the main coding themes were expected and shaped before the analysis. Only a few branching coding ideas came from the data itself. For example, the literature shows that rural communities may face some problems when they host substantial energy projects. The interview included a question about the challenges that the county met with wind power projects. I came out with different themes of pertaining to the challenges such as road access, environmental protection, conflict with other developments (like a military base), and law code.

Table 4-2: The main interview questions and coding themes

	Main questions topic	Main coding themes
Q1	**Describe the county** How would you describe the county?	**Local economy** Lack of amenity (gas station, food store) Economic crisis (closing plant, oil field)
Q2	**Experience with wind development** Did you witness the wind projects planning process? What is the role that you have taken as part of the county's wind power planning process? Did the county's planning team face any challenges during wind power development? What are the challenges the planning team face?	**Challenges faced the county** Road access Protected species Conflict with other developments Transmission lines Housing the construction crew Agriculture law code
Q3	**The impacts on population** Do you think the wind projects brought more population to the area or helped people to stay here? What do you think about wind project workers? Where do they live? From, where are they?	**Population** Attracting the new employment Where wind employment lives?
Q4	**The impacts on employment** Do you think wind power projects brought new employment to the county?	**Employment** Construction employment Permanent employment Training programs Recommended to hire local people.
Q5	**The impacts on tax revenue** How the county spends the tax income from wind development? Did wind developers ask for tax abatement? What is the county's plan to use the wind power project tax revenue?	**Tax** Tax revenue from wind development Tax abatement Tax relief Tax rate Compensation programs
Q6	**Donation** Did the county receive any donation from wind developers? Did the county or the community receive any fund from wind developers other than the tax income? Maybe under donation, or community trust fund?	**Donation** Donation to improve public services like school, fire station, and emergency Community fund Involvement with the community

		Inviting the developers to community events
Q7	**Public services** Did the county have a public services demand related to wind power development? Did the wind developers ask for any services to help set their projects? Who pay for these services? Residents services. Impacts on school. Did the county have a public services deficit before wind power projects? Did the county plan to add more public services due to wind power projects?	**Public services** The required turbine-related services: • Road access • Fire training, special fire protection material • Safety • who pay the cost of the road?
Q8	**Housing** Depend on the county numbers there are (increase, or decrees) on the housing numbers? Do you think that this increase related to jobs provided by wind projects?	**Housing** The effect on rental prices The effect on the median house sales Housing the construction crews.
Q9	**Future plans of the county & Community changes** How did wind development affect the county's future plans?	**Future & Community changes** Community changes County benefits Looking for more wind development What will happen after wind projects?

All the documents including interviews transcripts, plans and reports, and editorial articles were coded using NVivo, and followed the same coding themes. The triangulation analysis of different material increased the validity of the results. I found a confirmation of the facts from the interview in the governmental documents and vice versa. Looking for the answers of the same questions in different sources, and in different places, increased the validity of the results. For example, the numbers of the descriptive analysis confirmed the results of the interviews. Also, the numbers of the tax income in the governmental document confirmed the result of the interviews.

4.7.1 Summary of the descriptive data analysis

The following table shows the case studies counties' population, income, and wind power capacity in 1990 and 2015. The case studies include a variety of small and large counties. For example, Kenedy County is a small county with approximately four hundred people, while Kern County has 882,176 people. Most of the counties have a wind capacity around 1000 MW except Kern county, which has wind capacity over 3000 MW and Nolan County which has wind capacity over 2000 MW. As shown in Table 4-3, the per capita income is increasing fast in the eleven counties, even after adjusting the income to the 2015 dollar value. Population growth is less consistent, increasing in counties like Kern, Solano and Lincoln while declining in others such as Sherman, Carson, Castro, and Floyd County.

Table 4-3: The summary of the changes in counties with huge wind project

County	Year	Population person	Per capita Income Dollar	Accumulated wind power capacity MW
Kern County, CA	1990	549,535	30,334	406
	2015	882,176	37,355	3,177
Solano County, CA	1990	343,463	36,404	49
	2015	436,092	44,504	1,032
Lincoln County, CO	1990	4,552	29,585	0
	2015	5,557	33,968	1,359
Gilliam County, OR	1990	1,719	28,310	0
	2015	1,859	43,694	1,302
Sherman County, OR	1990	1,924	33,229	0
	2015	1,680	57,526	1,057
Carson County, TX	1990	6,553	31,243	0
	2015	5,969	45,244	1,191
Castro County, TX	1990	9,007	37,232	0
	2015	7,656	63,583	1,058
Floyd County, TX	1990	8,460	35,000	0
	2015	5,901	45,346	1,135

4.8 Results and Discussion

The results here are based on a deductive research approach of the theoretical framework and the confirmation of the descriptive data analysis and coding analysis of the counties' plans and the interviews. The results are presented following the main topics of the theoretical framework: population, economy, public services, and living cost.

4.8.1 Population

The effect of wind power development on the population size has two sides: the temporary population and the permanent population. For the temporary population, I found that wind projects brought more people to live in the rural communities during the construction phase of wind projects. However, in the long term, there was no noticeable effect of the wind projects on the permanent population size of the rural communities. Most of the counties' representatives did not think that there was any tangible effect of wind power development on their population. One exception is Nolan County Texas, where representatives believed that there was a slight increase in population. Nolan county's population was declining before wind projects and continued to decline after wind projects, but the rate of decline was less. Although most of the counties agree on the fact of zero net effect of wind power development on the population, they also agree that wind development helped some residents to stay in the community (Klickitat, Nolan, Sherman, and Carson County). For example, Klickitat County's representative said: "There are people in the local community, and they were saying, their children were able to stay in the county because of the jobs that wind projects provide."

The interview results agreed with the descriptive analysis of the minimum impact of wind power projects on the population size of the rural counties. For example, small counties' populations were declining before wind power development and still declining after wind projects such as Sherman, Nolan, Castro and Carson County. Larger counties' populations, such as Kern and Solano County were growing before wind projects and continued growing after wind projects.

The impacts of wind development on population size is a result of employment growth in the county. From the literature and the economic calculation, a 1000 MW wind project will create at least 100 to 500 permanent jobs. For a small rural community of less than 10,000, this number is significant if wind projects employees live in the county. I asked a direct question about who were employed in these jobs and where they lived. The answer was different depending on the county size. For isolated counties like Kenedy and Gilliam, which did not have a grocery store, gas station or any available rental units, the spillover is almost a hundred percent; outsiders took most of the jobs. For the counties with urban centers and populations over 250,000, such as Solano County and Kern County, the spillover was very small, and most of the wind technicians live in the county. For medium counties, the spillover is around the medium, and some of the wind workers live in the county and some commute. Lincoln County representative states that:

> "It brought permanent wind technician jobs in the county, with probably up to 35 to 40 of those wind technician jobs that are working here. So it brought people here working in the county. However, we do not have all of those technicians living in Lincoln County. Many of them are commuting back into Denver for the weekend or back to their home in Colorado Springs."

Wind development had zero or minimum impact on the population growth even with large projects because of the small number of permanent jobs, the spillover of the jobs, and the choice of the workers where to live.

4.8.2 Rural Economy

Rural governments considered renewable energy like wind development and solar as a suitable way to diversify their economic base. Many rural plans aim to diversify the local economy through renewable energy projects. Lincoln County, Kern County, and Nolan County are examples of this. Kern County's plan stated that "agriculture and energy are solid pillars upon which Kern County can build its future economic base" (Hamilton, Kristen Keough, Ratnatunga, & Wong, 2015, p. 2). Wind development affected the rural economy on different aspects. Some of them are direct impacts such as employment, tax revenue and lease payments to farmers, while others are an indirect effect like effects on the local business and encouraging new development. These are discussed separately below.

4.8.2.1 Employment

Wind projects provide a large number of jobs in the construction phase, but relatively few in the operation phases. Some counties required local hiring and started a training program for residents to fill a high percentage of wind employment. The State of Texas law offers wind developers a tax abatement conditional upon hiring local workers. A Carson County interviewer mentioned that "a local job fair was required to try and hire as many local residents that would qualify, along with using businesses in the county that could do work for a competitive price." For example, a Nolan County representative mentioned that "it did create a significant number of local jobs and then generated persons who relocated here to great service companies and so forth.” As a result of the same law and the same requirement, Kenedy County, a county of four hundred people, the county’s local official said about the employment impacts, “it's kind of a net zero”, and he also mentioned that “with our small population we don't have enough workforce to take care of the needs that they have.” Despite this Kenedy County is still trying to increase local hiring. At the time of the interview, the county had a wind project under development. The county’s local official mentioned that there is a negotiation with the developers for an apprentice program and scholarship to increase local hiring.

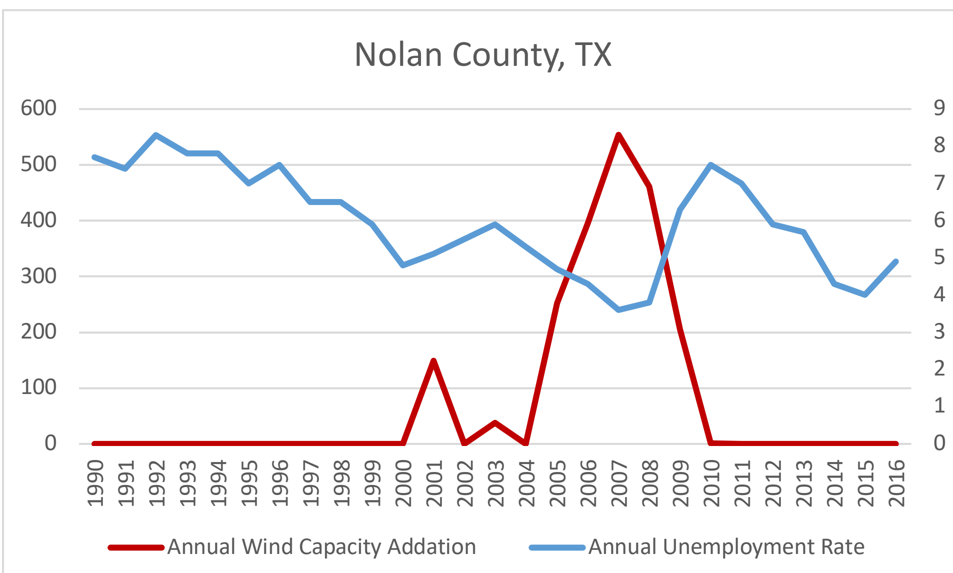
A hundred percent local hiring was difficult to reach, even after the training programs, not just due to the lack of the skills and the experience but also being able to successfully pass a mandatory drug test proved to be a problem. One Kern County official stated: “They try to hire locally. There were two problems here in Californian; one is the training that we fit. But the second was passing the drug test.”

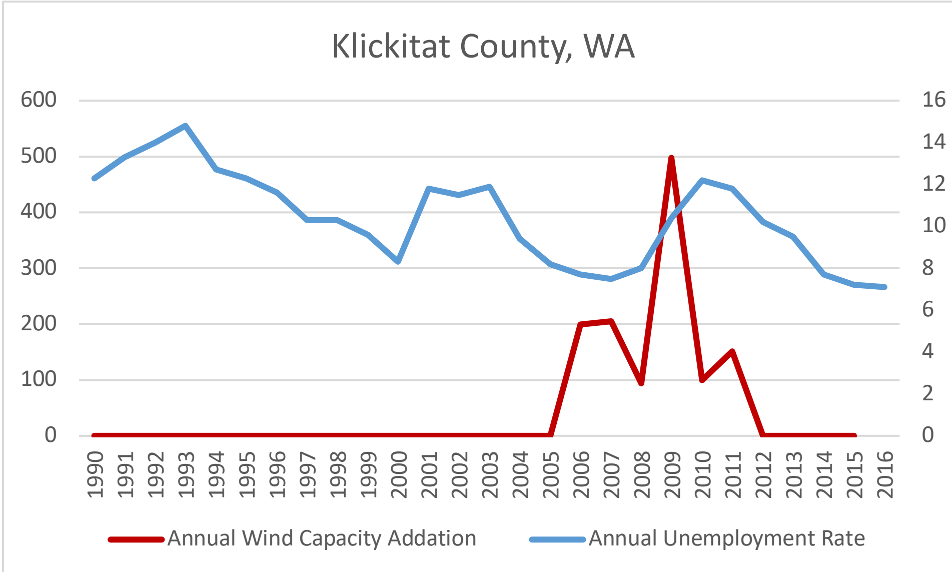
One of the positive impacts of wind power projects was the creation of construction jobs during the recession or hard financial times, when the county faced the difficulty of losing important sources of jobs and income. For example, Klickitat County’s aluminum plant closed and oil production cut on Kenedy County right before the wind projects started. Kern County, Klickitat County, and Kenedy County mentioned that wind development projects save the county during the hard time:

- Kern County’s representative said: “we went from 23% unemployment to 9% during the recession. They saved us during the recession.”

- Klickitat County's representative said: "that revenue help out, particularly during the recession to be able to maintain county services instead of shrinking in response to lower revenue."
- Kenedy County's representative mentioned, "we say that they help maintain jobs in areas that would have been lost because oilfield left."

The descriptive analysis found a relationship between the construction phase of wind projects and the unemployment rate. The construction jobs caused a decrease in the unemployment rate during the construction phase of wind power projects (Figure 4-5). As an example, Nolan county unemployment rate was around 6% before wind development and dropped to be approximately 3.5% in the construction period, but back again to 6% after the construction ended. This result agrees with the interview results and emphasized that wind power development provided temporary jobs in the construction phase, but not many in the operation phase.

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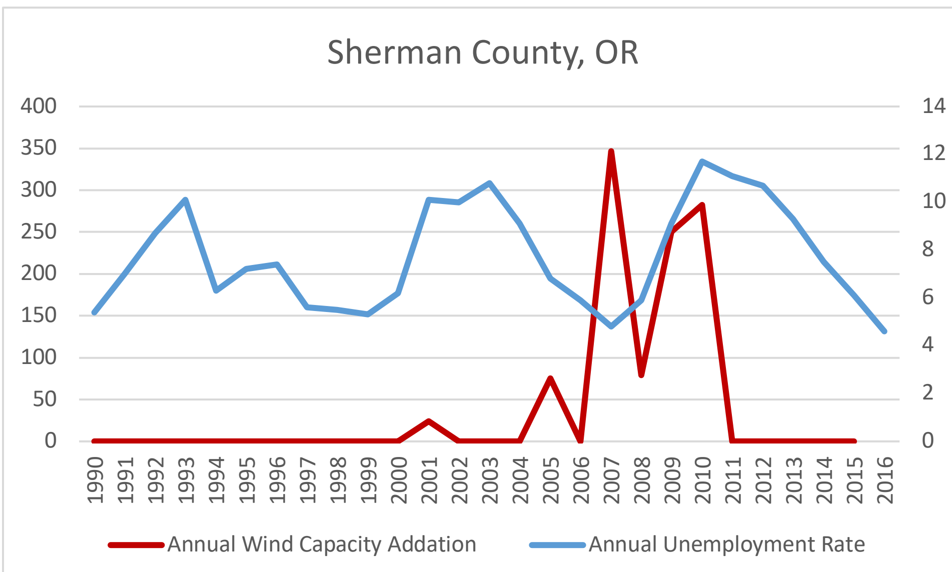
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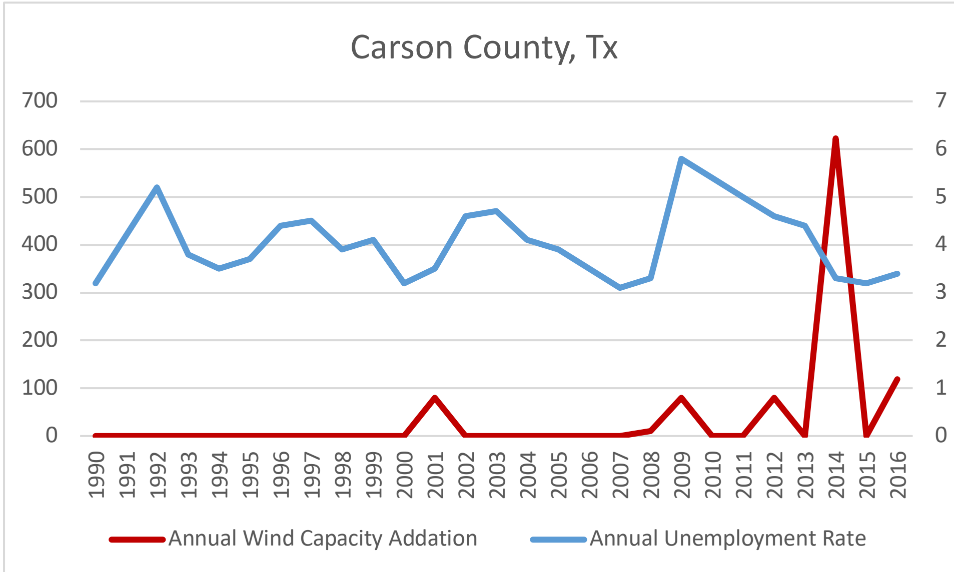

Figure 4-5: The relationship between the added wind power capacity (the construction phase) and the unemployment rate.

4.8.2.2 Encouraging New Development

Wind development encouraged new business and development in some of the rural counties. Most of this development is related to housing or providing services to wind employment such as hotels and restaurants. A few are more industrial material related to wind turbines. For example:

- Lincoln County comprehensive plan stated that: “the community experienced a pop up of small business of bed and breakfast in the town. Some local businesses who closed before reopened for rental” (Lincoln County Economic Development Corp [LCEDC], 2018, p. 14): “one of the residential community Genoa has recently restored an old town café as well as made a Camp park to attract business from the wind farm technicians” (LCEDC, 2018, p. 6).

- Kern County has a new hardware store related to wind turbines.
- A closed restaurant in Sherman County is reopening. This was confirmed in the interview and the newspaper article.
- Nolan County local official mentioned that: "We have got new business, new hotels, new restaurants, lots of above of the new improvements to our way of living that we didn't have before." Nolan County has the greatest share of hosting new industry related to wind turbines. Nolan County had three new industrial companies related to wind turbines such as a company of raw cement and sheet rocks that goes into construction, a company for electrical component for wind turbines, and underdevelopment recycling business for wind blades.

Despite the anecdotal evidence of new businesses in Lincoln, Sherman and Kern Counties, there were insufficient jobs generated to make a notable change in the employment structure. These new developments were mainly services like a hardware store, restaurant, or bed and breakfast, in contrast with turbine-related industry in Nolan County. Nolan County is the only county that mentioned in its plans and interview that there is a change in the employment structure of the county. Nolan County public representative said: "they were three to four percent manufacturing of all kinds, was the highest percentage. Now, we have about 12 percent of our working population worked in the manufacturing sector." Nolan County is a unique case. It is the only county that has these effects of wind development: change on employment structure; and encouraging other related industries in the county. I looked more further into the Nolan County case, and I found that the county location played a significant role on these impacts. The county is located on Interstate 20, a major local connector. Nolan County is the center of wind energy development in Texas. The Case Study of Wind Energy Economic Impacts in Texas mentioned that:

> "Together with the adjacent counties of Scurry, Taylor, Mitchell, and Coke, the Sweetwater region is home to well over half of all operational wind energy in Texas and approximately 15 percent of all the United States wind energy operations" (New Amsterdan Wind Source LIC [NAWSLIC], 2008, p. 4).

4.8.2.3 Tax Revenue

All the interviewees mentioned an increase in their tax base after hosting wind development, consistent with the findings of Khan (2013) and De Silva et al. (2016). This increase in the tax base, while small in most cases, is still significant to small counties with limited resources. For large counties with more resources, it can help augment their revenue but is not one of the primary sources. Tax revenue was stated as the main benefits of wind projects to the rural government. For example, a Kern County, California representative mentioned, "there are millions and millions of dollars tax revenue, and in reality, wind projects do not generate that many public services." For small counties, the tax revenue of wind projects represents a large percentage of the county tax base. For example, the local official of Klickitat County Washington said: "It is significant. Wind projects when they first were built comprise about one-third of the county's tax base. Now with some depreciation, I think it's around 28 percent, which is still significant." In some counties like Nolan County, the county's tax base increased after hosting wind projects as it mentioned on the county tax documents. Total taxable property values in Nolan County have increased from $500 million in 1999 to $2.4 billion in 2008 (projected to be $ 3.5 billion by 2010)

(NAWSLIC, 2008, p. 12). Figure 4-6 shows how the percentage of tax roll paid by wind farms is increasing to be approximately 25% of Nolan County's tax roll. The increased of the tax paid by wind projects from 2006 to 2010 because of the sales tax on the construction phase of the wind farms.

4.8.2.3.1 The amount of tax revenue

The amount of the tax revenue depends on: the county law and tax rate on the county; if the county offers a tax abatement or not; and if there are additional fees in addition to the tax. The tax rate is a county policy, but the tax abatement and the extra fees may either be set by state or county policy. Depending on the state's law, the county can offer some tax abatement or add some fees for the community fund. The community fund fees appear clearly in the state of Oregon. The state of Oregon has a strategic investment program where, during the negotiation process with the developers, the county can ask for what they call a local improvement fee.

Many states, including Texas, Colorado, and Oregon have tax abatement policies, although they differ from one place to another. For example, Lincoln County Colorado offered tax abatements for some of its earlier wind projects, but they refused to provide tax abatements for more recent wind projects. Although the county has criteria on its economic policy to give a project like wind farm some tax relief or tax abatement for four years, this abatement happened with early projects only. Texas' property tax code allows counties to give developers a tax abatement for up to ten years. After the ten years, developers pay the full property taxes.

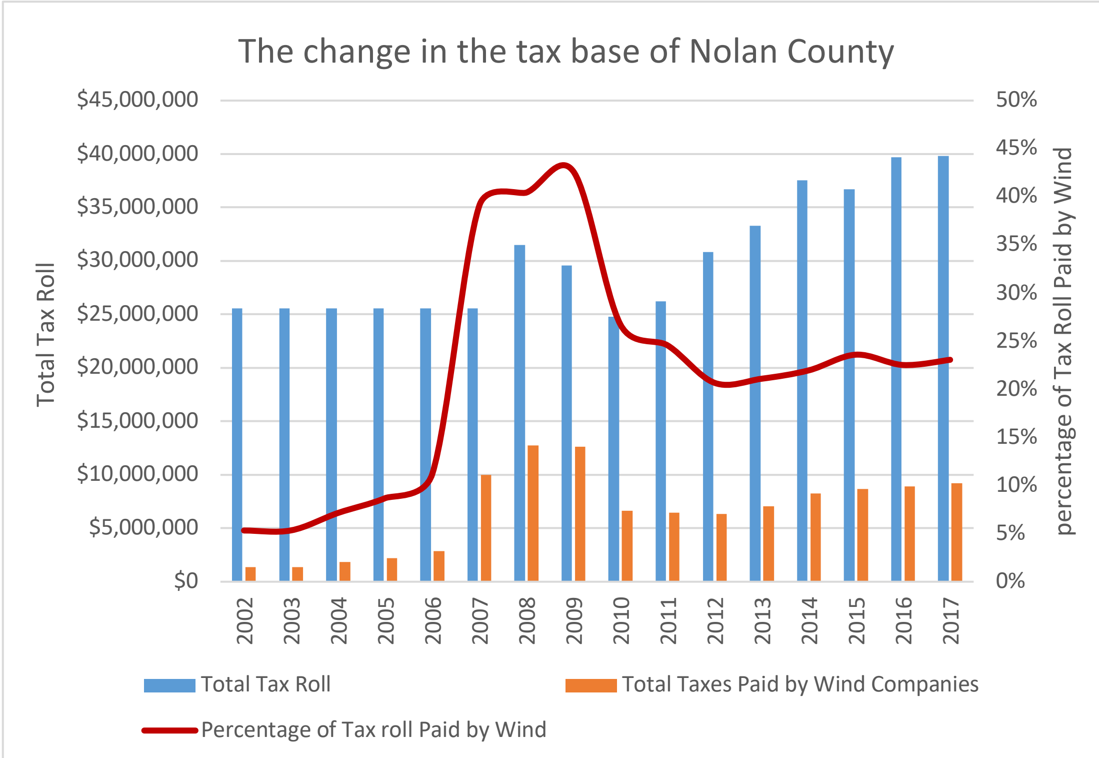

Figure 4-6: The change in the tax base of Nolan County (data provided by the county economic development) 13.

Each county worked out an arrangement with wind developers to pay only a percentage of the actual taxes under the name of community fund or in lieu of tax. Even within the same county, the arrangement differs from project to project. The amount of the community fund and how the county will spend the money depends on the county and how the agreement goes between the county and the developers. Sherman County, Oregon followed the same idea of Texas Counties. For example, "in 2011, wind companies will pay Sherman County about $9 million this year in wind turbine revenues in lieu of property

[13] Nolan county local official send me the actual number of the county tax revenue on excel file.

taxes" (Cockle, 2011, Nov 12). The following examples show different agreements for community fund:

- Pattern Energy Group announced it had begun construction of a $400 million wind farm in Carson County that will result in an $800,000 payment to establish a community fund for civic and educational causes (Welch, 2013, Aug20).
- Carson County Judge Lewis Powers said in newspaper speech "We provided a tax abatement agreement with EON to abate the taxes for a period of ten years. In exchange, we get an annual payment for $316,500 on an annual basis. That's $1500 a megawatt" (Media agent, 2015 April, 22).
- Kenedy County, Texas representative said in the interview "Right now, we are taking payment in lieu of taxes for the first ten years and then they go back to whatever the value of it is again. Every October, we get a check for $440,000 for the first five years and then that will almost double for the second five years, and then we'd go back to what the retail value."

4.8.2.3.2 How counties spend the extra tax money

The important point of the wind tax revenue is how this tax revenue and the community fund affects the public services and the rural communities. The interview asked a direct question of how the county spent the tax revenue of wind development and how this increase in the tax base affects the level of the public services on the county. Most of the counties incorporated the additional tax funds from wind projects into the county budget and they used these funds to cover some services that the county needed but could not afford before. For example, Sherman County Comprehensive plan stated

> "The property tax income stream, created by over 700 wind machines, at over 1.25 million dollars in value each, created a sizable annual revenue stream for public use and improvements in the County. The second phase is the direct benefit to Sherman County of an enhanced property tax revenue stream, which will significantly increase the ability of the County to solve its own problems without relying upon state or federal government assistance" (p. 37).

Although most counties did not have any special plan for wind projects tax income, there are two exceptional examples: one in Kern County, and one in Sherman and Gilliam County. Kern County, California created a special program that funded by property tax from wind projects to improve the infrastructure and public services in the county:

> "Renewable Energy Neighborhood Enhancement Wind Business Investment Zone, RENEWBIZ, grant program funded by property taxes from wind farms in East Kern County. It provides small matching grants to private businesses and non-profits in unincorporated communities to improve facades, landscaping, public spaces, infrastructure, and other amenities to make them more attractive places to live and work" (Hamilton et al., 2015, p.3).

Sherman County and Gilliam County in Oregon created a compensation program after the increase on their tax base from wind projects. The compensation programs of Sherman County and Gilliam County follows Alaska's sharing oil revenue idea. The idea of the compensation program is to share wind revenue through tax rebate, which pays $590 per year to each resident as a means of sharing surplus revenue and encouraging a positive outlook on new development. Even with small counties, the landowners, through leasing land to wind developers, benefit the most from wind power development. In the end, the benefits go to a few people. The purpose of the compensating program is to have an equitable distribution of the benefits.

> Sherman County local official said: "The county developed a county resident incentive program. So, if you lived in the county for more than a year and haven't moved or left, if you're a resident, you can get a resident incentive check. This was developed because of the wind farms."

4.8.2.4 Lease payments to farmers and ranchers

Farmers and ranchers receive payments from wind developers for leasing land to wind turbines. Lease payments has been emphasized as a great benefit of wind power development in the qualitative analysis. All the counties' local officials believed that lease payments helped farmers and ranchers to continue farming and keep their land, as they received a sustained income annually from leasing land to wind turbines. There were several newspaper articles reporting on farmers who were leasing land to wind developer, emphasized how this income helped them to improve their farm and life.

> "Hilderbrand, the first in Sherman County to allow turbines on his land, reaps about $30,000 a year in lease payments. And the checks come without fail, he says, unlike the income from his wheat operation, which is squirrelly as the weather (Cleveland, 2008, Nov 11)."

The lease payments income appeared to change the counties' income per capita, especially for small counties where many of the residents are farmer and ranchers. For small isolated counties, there is a significant change in the income per capita of these counties after wind development. As it appears on the income per capita curve in the next figure, there is a real jump in 2006 in Sherman County and Gilliam County when wind projects started, and both counties at this time had a wind capacity around 100 MW. For Kenedy County, wind development started late in 2010 and was followed by a clear change on the income per capita of the county

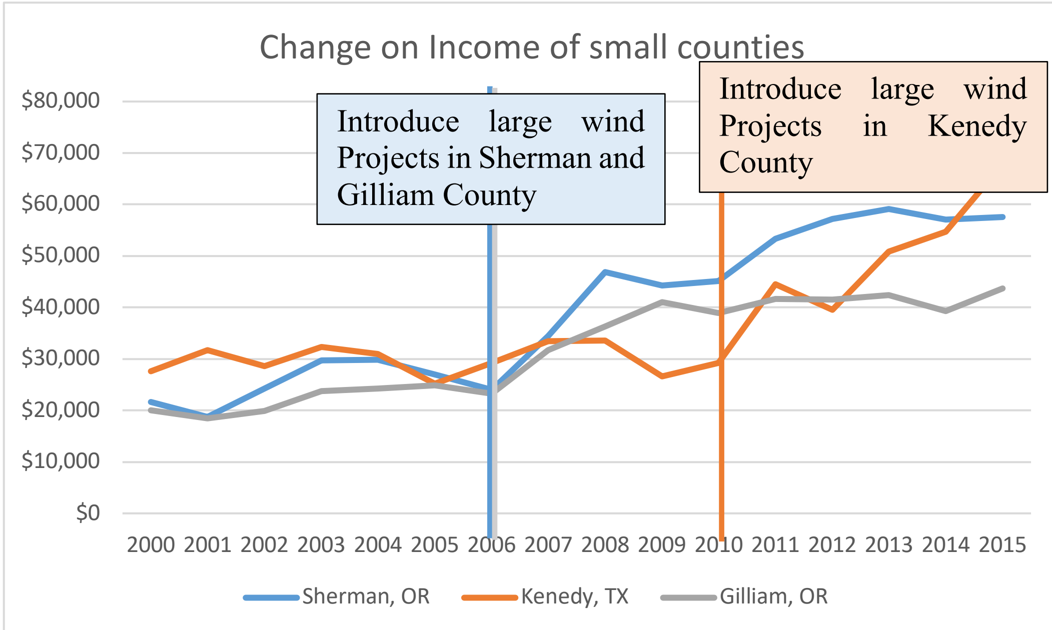

Figure 4-7: Change on per capita income after wind development

4.8.3 Public services

Wind development can affect public services in three ways: increase the population which requires more public services; create extraordinary turbine-related services; or provide additional income to improve public services. The analysis of the descriptive data, as well as the qualitative analysis, did not find any increase in the permanent resident population due to wind power development. All the counties agreed that wind power development did not require any public services, but it did require some cooperation and adoption of the new industry to deal with the safety of the wind turbines. For example, the fire department in most of the counties used to deal with single or two-story buildings and required training to adapt to the tall wind turbines. In this case, the fire and the police department worked with the wind developers to come up with a map of the wind turbines and unique code and location for an emergency.

In some cases, like Kern County, California, wind project development required special equipment like a water tank and foam for wildfires. The wind developers covered the expenses for the fire department training. Wind development did not increase the population, which means no required residents' services. At the same time, there was no required turbine-related services. This solved the problem of when the revenue comes and when the services are required. Even with the tax abatement, there is no problem insofar as there is no required services.

> The local official of Kern County California said "the wind company have built and fund water tanks and they are also responsible for water and having water available. The fire department told the wind company through our environmental process that they need a certain type of foam, there is a foam they can use in wildfire so they actually funded an 890,000-dollar fire truck and provided foam so it can be more efficient wildfire fighters and could hack that area."

The road conditions are a common issue with all the counties, as the construction traffic usually destroyed the roads, but all the local governments had an agreement with the wind developers to return the roads to the way they were before the construction. In all of the counties, the developers paid for all the road work, expect Lincoln County, Colorado, where the county helped pay for the road work. In Lincoln County, some roads were not ready for the construction, and needed some improvement to handle the construction traffic. The improvement was needed beforehand and was not caused by the wind projects. According to the local official of Lincoln County, "the county said well we will go ahead and do what we can to help with some of this infrastructure improvement because they understood that the county would be benefitting from the construction of the wind farms."

The qualitative analysis found that wind development improved public services in two ways: the community fund and the additional tax money that the county used to improve the local facilities. Most of the counties were able to enhance their public services or at least maintain the services in a hard time. For example, Kenedy County had a drop in the tax income from closing oil and gas, and wind projects helped them to return their tax base to normal by the time and maintain the public services on the county. The next table shows how the increased income and the donation has been used to improve the public services.

Table 4-4: The community services improvement, due to wind projects

County	Donation and community fund	County tax money
Solano County	Some donation happened when the projects are relatively new, but the interviewee did not remember what the donation for, and the county's plans did not mention the donation.	The tax income helped the county to improve its service in general.
Kern County	Donate money for solar street lights for the community, and give an electronic headboard to the high school.	The county used half of the wind projects tax money to create a special fund to cover community projects and services like paving roads and put restaurants in the park.
Lincoln County	A scholarship donation for healthcare.	Helped to build a new fairground facility, as additional monies became available, they were able to provide a higher level of service.
Castro County	Fund charitable things for fire departments, fundraisers to civic organizations, support the school sports organizations.	Built a new jail that has been needed for a long time, built a new elementary school, the hospital was able to build a nursing home because of the wind farm.
Floyd County	Supporting several local events and activities. The wind projects have just recently offered to pay for some road base material to assist in rebuilding the roads that they use the most.	The County uses the income from the wind projects to maintain and operate the County, and a lot of the tax money goes back into repairing of the roads.
Carson County	The wind developers made generous donations to local charities and non-profit organizations.	Built a jail, one small community in the county used funds to buy a much-needed new ambulance.

	Donation to the food bank, charities, and volunteer fire departments.	
Nolan County	Community fund to school in lieu of taxes: Built brand new school buildings; built sports stadiums, bought new school buses, bought fire trucks, and all the students got a laptop.	The county built a new jail facility and police department, a brand new law enforcement center, and renovations to the parks.
Klickitat County	Provided signs on the baseball court. The energy companies built a network of new and improved roads to haul their turbines to remote sites.	Some of the rural fire districts more than tripled their annual budgets because of the wind farms. The community of Bickleton built a new school and bought a new $160,000 ambulance, and plans are underway for a new fire hall. Property taxes from Iberdrola Renewables and other energy companies with wind farms in the school district will pay 97 percent of the school's cost.
Sherman County	Wind money paid for new computers, musical instruments, robotics equipment, portions of a greenhouse and a new teacher to instruct the most gifted of its 124 students last year.	Translates to meeting essential community needs like fire departments and health services, new supplies for students, and capital projects like construction of a new school, library and city hall." It's also paid down debt for wastewater systems in three towns and launched a renewable energy technician program at Columbia Gorge Community College.
Gilliam County	Scholarships are given out to students, and college students.	Improve health care facilities, replacing the broken fire truck, completely revamped the towns' downtown. Built industrial park, a brand-new library, a new fire hall, a new community center in Arlington.
Kenedy County	Kenedy Memorial Foundation lease 9,600 acres to wind developer and used all the lease monies to support its charitable causes to fight poverty, boost	Helped on acquiring, an emergency service 24/7. Improved parks and drainage, paved all the roads.

	education, and build stronger communities. The county negotiates a scholarship donation for its upcoming projects.	

4.8.4 Cost of Living

Cost of living is considered a direct indictor of the quality of life standard for rural residents. The interviews explored the impacts of substantial wind power development on the living cost on the eleven counties. According to the literature, wind power development can affect the living cost on three ways: tax rate, energy prices, and home prices. Exploring these effects can answer the question: Did wind power development increase the cost of living in the rural counties, or not? The interview included a direct question about the effect of wind power development on tax rate, energy prices and housing prices.

4.8.4.1 Tax Rate

Wind projects increased the tax base and was expected to reduce the tax rate. The effect on the tax rate depends on the county financial shape and policy. The public official of the five counties in Texas mentioned that wind projects helped them to stabilize their tax rate and expected that the tax rate would be decline after the tax abatement period. The tax revenue of wind power development helped the counties in the case studies to stabilize, reduce, or prevent a dramatic increase in the tax rate, or caused a tax rebate or tax relief for residents as the interview analysis found (Figure 4-8). Stable or decreasing the tax rate in the county will lower the living cost on this county.

- Wind development decreased the tax rate in Klickitat County, WA according to the interview and editorial articles. "The tax rate for the Goldendale School District dropped from \$15.50 per \$1,000 in 2001 to \$9.17 this year because of property tax revenue paid by wind energy companies" (Durbin, 2010, Oct 10).

- In Lincoln County, Colorado, a local official mentioned: "the county has offered its local citizens, it's local landowners, a four or five mill levy relief because they're doing so well on the wind farms."
- Carson County local official said: "Money generated from property tax revenue from the wind project kept tax rates from dramatically increasing from the drop in values of oil and gas property over the previous years. We will be able to reduce the tax rate when the bond is paid off early.

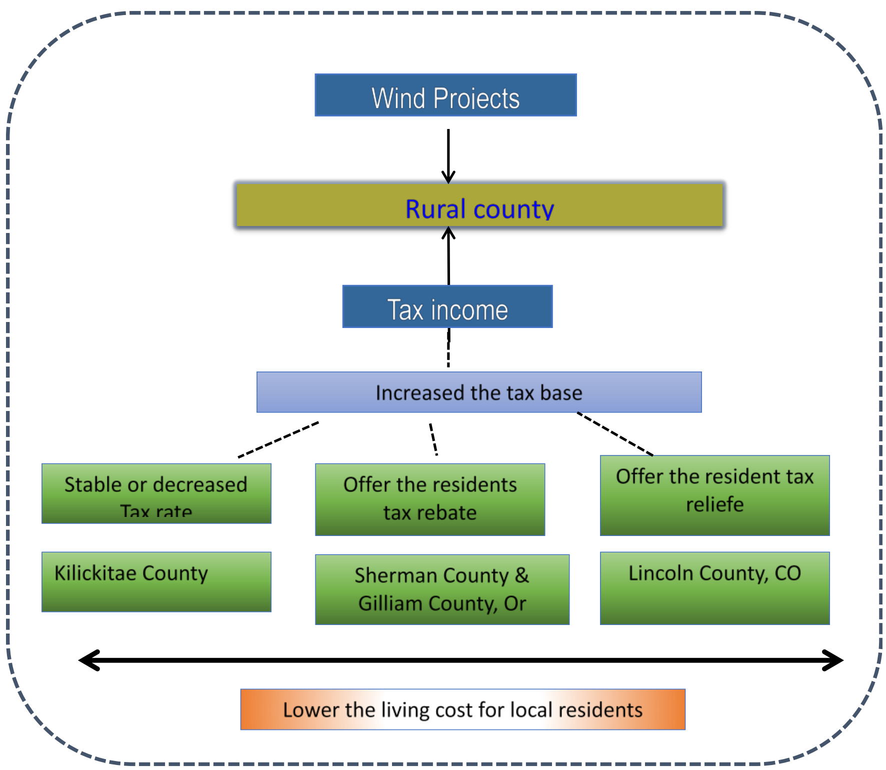

Figure 4-8: How the tax income of wind projects affects the quality of life.

4.8.4.2 Energy Prices

A survey with the local residents in inland rural townships in Huron County, Michigan found out that residents believed that wind farms caused an increase in the energy prices in their community (Groth & Volt, 2014b). My interviews included a direct question about the effect of wind development on energy prices. All the counties' representatives disagreed that the wind energy affects their energy prices. Only Kern County, California's representative believed that energy prices in the county increased due to the renewable energy, not just wind. Most of the counties' representatives denied any relationship between the produced wind energy and local energy prices. Mainly, none of the eleven counties use any of the wind energy they provide, and their local energy prices depend on the utility they belong to and what kind of power this utility uses. Kern County agrees with Borenstein and Bushnell (2018) who found that renewable energy tax incentive offered by the state increased the energy price rate in the state. It is an indirect impact of adopting renewable energy on the energy prices which differs depending on the state policy.

4.8.4.3 Housing

Any effects on housing were expected to come from the wind power employment and the increased population. However, the descriptive analysis and qualitative analysis proved that there is no noticeable effect on permanent population size. Most of the counties stated that it was challenging to house the construction crew of wind farms. In the construction phase, all local rental units were rented, and the hotels were full. For small counties with less available rental units, they used RV parks. Many of the construction crews brought their trailer houses. The local government worked with the wind construction team to assign a place to serve as an RV park for these trailers. Gilliam County has an RV park for their first time for wind projects. The state of Oregon has laws against pulling trailers over and camping. The county tried to figure out how they can find places for these people to park their trailers.

The interview had a direct question about the effect of wind development in rental prices and median house sales prices. As it shown in Table 4-5, the effects on the housing depended on the county size and the housing capacity of the county. For bigger counties, new wind projects had no discernible effect at all on rental prices or median home sales prices. For small counties that did not have any housing to offer (rental units or housing for sale) was the same with no discernible effect at all. For medium counties, despite the short time of the construction phase, it affected the rental prices in these counties. The increase in rental prices was moderate and, during the construction time, this was the case only in Castro County and Nolan County. In Lincoln County, the increased in the rental prices continued after the construction. In Nolan County and Lincoln County, it created some new business. Nolan County local official said: “so we had companies that would love the places that would buy up a number of rent houses and then completely furnish them with TVs and furniture and make where these men and women could lease this place for a period of time, but a much higher rate .”

Table 4-5: The effects of wind development on housing.

County	Effects on the rental price	Effects on the median home sale prices	The county housing market
Bigger counties: Kern County and Solano County	No	No	The housing capacity can handle the new development without any effects.

Medium Counties: Nolan, Carson, Castro, Floyd, Lincoln, and Klickitat County.	Yes. Rental prices increased during the construction phase. After the construction, the rental prices got down but did not back to pre-construction prices.	No	The housing capacity in the county has an ongoing problem.
Small Counties: Gilliam County and Kenedy County	No	No	The county does not have the housing capacity for the wind employment: no renting units available or housing for sale. Construction crews lived on RV parks or neighbouring counties.

The lack of housing is an ongoing problem in most rural counties, except the large counties such as Kern and Solano. Usually, there are no effects on home sales prices, except in Lincoln County. The Lincoln County plan discussed one instance where wind power development effected the housing availability. This case happened in Hugo Town, which "is experiencing a shortage of available housing since the flood of wind farm technicians purchasing and/or renting much of what was available" (LCEDC, 2018, p. 5). Also, the county plan mentioned that wind power employees affected the availability of houses. For home sales prices, both the interview and the county plan agreed that the current increase on the home sales prices in the county is not related to wind power development. A Lincoln County local official believed that increasing the house sale prices in the county goes back to the ongoing houses problem in the county and the collective increase of house sales prices in all of Colorado, not to wind farms.

4.8.5 Community changes

Bigger counties like Sloan and Kern California have fairly urban/suburban areas very close or attached to bigger cities. Wind power development added to the communities but did not change the community. In isolated small rural counties like Kenedy County, Texas and Gilliam and Sherman County in Oregon, wind development introduced new industry and opened the world for the rural communities. Wind development also changed the life dynamic, and the belief of these communities and who invests in these communities as most of the wind developers are big companies. The interview analysis found that interviewees felt that wind power development put their communities 'on the map', opened the rural residents' minds and increased the acceptance of changes in their communities. Interview analysis found that the experience of the eleven counties with wind power encouraged them to look for more renewable energy like solar panel, and some of them already started on a path toward their solar power, like Kern County.

Carson County local representative stated that:

> "One of the main benefits that I believe is to open the minds of the rural community of worldly affairs and issues. Too often in a rural setting, we believe that the world just passes us by and we are not affected or even that we cannot change from doing things like they have always been done. I personally know of local high school graduates then went on to college and received degrees in wind generation and now work for large developers around the United States. History has shown us that progress has been difficult to accept at times. And it is no different here".

A Nolan County public presentative likewise mentioned that "There's just no comparison between living here 25 years ago. Today, it's a lot more civilized, I guess you could say you can have a nice dinner, and there are nice places for people to stay. They now have alcohol retail businesses that have moved here. So, there are lots of good economic spin-offs that have resulted from wind development".

4.9 Conclusion

Wind development benefitted small rural counties economically, especially those of Sherman County, Gilliam County, and Kenedy County. Before wind development, these counties faced a common fate of many small rural United States communities with only an agricultural base. They had a declining population, very few employment opportunities, and low income. Although wind development did not provide many permanent jobs, it did offer a sustainable source of tax income, as well as lease income to farmers and ranchers. When wind development blows in, these counties earned additional tax revenue to cover their needs and improve their community services. Some counties like Sherman and Gilliam County, Oregon shared the wind revenue through a compensation program, which pays residents yearly as a means of sharing surplus revenue and encouraging a positive outlook on new development. This program follows Alaska's sharing oil revenue idea. Even with small counties, the landowners, who benefit the most of leasing their land to wind companies, are few. The purpose of the compensation program is to have an equitable distribution of the benefits.

Wind development provides good tax revenue for rural counties, with no reported increase in public services nor any sudden increase in the permanent population. Rural counties with good wind resources are looking for renewable energy as a parallel economic base to agriculture and a perfect way to diversify their economic base without any changes on the rural nature of these communities. Although wind jobs are few, it gives a chance to some residents who want to stay on the community to find a job other than farming, especially with the training programs and the recommendation of hiring local people. Wind development positively affects the local business during the construction phase and the operation, too. In one exceptional county, Nolan County, Texas, it encouraged new development and industry related to wind turbines.

Wind development has some indirect effects on the living standard. It improves the living standard by improving the public services and the school in the community; it has stabilized or decreased the tax rate. It did, however, bring some increases in the rent prices in some counties.

Finally, substantial wind power development changes the rural community. It may bring a more open view of the world and new industry. Wind power development increased the knowledge of the rural community about renewable energy and made them look for more renewable energy sources like solar. As a result, rural governments understand the benefits of sustainable development like wind.

CHAPTER 5

THE MAIN CONCLUSION OF THE DISSERTATION

This chapter summarizes the research findings previously outlined as well as the study's contributions. Section 5.1 reviews the limitations of the research, followed by an overall conclusion and the research implication in section 5.2 and 5.3. Finally, section 5.4 offers recommendations for future research.

5.1 Limitations

The findings of this dissertation have to be seen in the light of some limitations. The first limitation was in the second chapter - the systemic review chapter - as there is limited literature on the impacts of wind development on rural development indicators such as poverty rate, education, rural immigration. These indicators are essential to answer the research question of whether wind development in rural counties caused a rural development or not. For this, I could not answer the research question precisely, using the available literature review only.

The second limitation was the limited access to some data such as yearly measured educational attainment, yearly data about age and gender, and data about immigration in and out from rural counties. Educational attainment data were available for three years only 1990, 2000, and 2011 to 2015. I considered the 2011 to 2015 data as 2015. The results of the effects of wind development on the educational attainment on chapter three were dependent on the limited data. If there was more available data on the educational attainment, I might have different results.

The third limitation is the limited time and fund. If I had funds and more time, I would like to do more interviews with a different scale of wind development such as counties with small wind projects 100 to 500 MW, and counties with medium wind projects 500 to 1000 MW. In chapter four, our findings were built specifically around counties with large wind projects over 1000 MW only. If I had the funds, I might have different cases of different sizes of wind development. The findings of the dissertation as build on these limitations, and I tried to do the best with the available data.

5.2 Conclusion

This dissertation concerns the topic of whether and how wind development projects impact on rural communities. This dissertation includes three articles presenting three different stages of the impacts of wind development on rural communities. Chapter two is a systematic review of the previous research about the socioeconomic impacts of wind power development in the United States. The recommendation of this chapter shaped chapters three and four. The systematic review article found a significant limitation in the literature in failing to cover the impacts of wind projects on rural development outside economic growth. This limitation triggered two questions: 1) what are the impacts of wind development on poverty and educational attainment in rural counties and 2) does the increase in the tax base and municipal finance improve public services and the whole community, or not?

Chapter three utilizes statistical analysis to answer the first question and to measure the economic and demographic impacts of wind development on rural counties. The analysis included two longitudinal analysis: mixed-effects longitudinal model, and fixed-effects longitudinal model with a comparison group. The research collected data that includes measurements for 26 years starting from 1990 to 2015, and all data was at the county level. The statistical analysis started with a mixed-effects model for counties in the continental United States (3072 counties). The longitudinal analysis found that increasing the accumulated wind power capacity led to economic growth in terms of increasing income per capita, median household income, per capita employment, and farm income. It also affected economic development by bringing a small decrease in the poverty rate. After the longitudinal analysis, I did an additional longitudinal analysis to measure the impact of wind power development on nonmetropolitan rural counties using a quasi-experimental approach. Longitudinal data analysis is the preferred method of evaluating outcomes of development because it provides more efficient estimators than cross-sectional analysis and can distinguish the impacts of the timing (Caruana et al., 2015). However, longitudinal data analysis cannot capture the counterfactual situation of what would have been the outcomes if the wind projects had not been implemented, and quasi-experimental comparison group design did. A quasi-experimental comparison group design is the closest solution to mimic the randomized experimental approach in selecting “treatment” and “comparison” groups that are similar to a variety of parameters and confounding features. The comparison group captures the counterfactual situation of what would have been the outcomes if the wind projects had not been implemented. At the same time, A quasi-experimental comparison group design eliminated some counties to reach a good matching which weakens the external validity. To reach a robustness external validity and capture the counterfactual situation at the same time, this research employed pure longitudinal analysis and longitudinal analysis with quasi-experimental design.

I used propensity score matching and nearest-neighbor matching to identify a set of "controls" that most closely matched the treatment based on observable characteristics. I matched 94 treated counties to 94 control counties. After the matching, I ran a fixed-effects model to test the effect of the accumulated wind power capacity on the outcome variables. The impacts of wind power development on nonmetropolitan rural counties are similar to the impacts on the whole population on most of the attributes. However, the economic growth of wind development is limited to an increase in income per capita only for nonmetropolitan rural counties. The results of the fixed effect model combined with matching analysis are limited to a small population of 188 counties (94 treated counties and 94 matched counties). However, the results of the mixed model are generalized to the whole counties in the United States.

Chapter four used case studies analysis to answer the second question. This chapter addresses the impacts of large wind development on the community services and the standard of living, using case studies analysis to investigate the effect on the eleven rural counties when they hosted substantial wind farms over 1000 MW. Results from the case studies analysis showed that wind power development increased the tax revenue of the rural community without any required public services and without increasing the population size of the rural communities. The significant increase of the tax revenue broadly benefitted the community through an improvement in public services. For instance, counties used tax money to improve their infrastructure, renovate parks, build new schools, improve the health services and buying new ambulances, fire trucks, and school buses.

The three chapters together concluded that wind development increased the income in the rural counties and enhanced public services. Finally, while wind development leads to only small economic growth in the rural economy, this economic growth has been reflected in an improvement on the community services without any negative social impacts. Wind development is a suitable economic source to diversify the rural economy.

5.3 Research implication

The purpose of this doctoral dissertation has been to better understand the influence of wind development on rural counties in the United States. Previous research covered the impacts of wind development on the economic aspects but none to my knowledge focused on the demographic and community services. The dissertation examined the influence of wind development on rural communities from three sides: economic, demographic, and community services. The research findings proved that there are positive economic effects of wind development on rural communities. At the same time, wind development had no significant effects on the population growth of rural communities.

The dissertation findings emphasized and showed the effects of the local policy to maximize the local benefits of new development such as wind development. The role of the local policy appears in chapter four - the case studies research, where some counties obtained more benefits and a higher level of equity than others.

The local policy appeared first at dealing with the tax abatement. Even with the tax abatement policy, some counties made a good deal with wind developers and receive a percentage of the property taxes under community funds or in lieu of taxes, and used these community funds to cover the cost of needed services such as building a new school and buying a needed fire truck. Second, how the county has used the tax revenue from wind development. For example, Kern County created a special fund using some of the wind tax money to improve the community infrastructure. Another example, Sherman and Gilliam

County used the extra tax money to create a compensation program to reach some income distribution equity. Finally, this research emphasized the importance of the local policy and local decision to deal with their local choice and to manage the local resources.

5.4 Suggestions for Future Work

There is a room for future research on the effects of wind development on population losses in rural areas. In the statistical model in chapter three, I used population size as an indicator of wind development's effect on rural population. The model showed no significant effect of wind development on the population size of rural communities. However, the effect of wind development on population might be more significant if I used the immigration data (in/out migration). This data is unavailable yet, especially on a large scale, but it may be easy to obtain in the future. If I had access to immigration data such as data about immigration in and out from rural counties, and yearly data about age and gender, I could do more research about immigration and gender profiles in rural counties. In the case study interviews, local officials did not believe wind development affected their communities' population, however, they believe that wind development helped some local residents to find a job and stay in the community. Most of the rural communities are facing population losses. Wind development cannot alone stop these losses, but it may help reduce youth out-migration. I suggest Nolan County, Texas as a future case study to examine the effect of wind development in migration. The case studies research in chapter four found unique effects of wind development in Nolan County such as encouraging new development related to wind turbines, and the highly rural county may have higher migration outcomes than other more urbanized counties.

For more future statistical analysis, I suggested examined the demographic effects of wind development on a multi-county scale. As argued by Edmiston (2004), demographic changes may not be limited to the specific county but may spill over into neighboring counties as well. In this case, it may be better to measure the demographic impacts of large wind power projects on multi-county regions.

There is another future research stream studying the effects of different scales of wind development on community services such as counties with small wind projects 100 to 500 MW, and counties with medium wind project 500 to 1000 MW. In chapter four, my findings were built specifically around counties with substantial wind projects over 1000 MW only. The validity of my results is limited to large wind projects only. If I had sufficient resources, I would like to do more interviews with different scales of wind development, and compare these effects with my results. In the context of renewable energy, there is also a lot of room for future studies focusing on the effects of solar energy on the rural development in the United States, comparing the solar energy effects with those of wind power energy.

APPENDIX

INTERVIEW QUESTIONS-CHAPTER FOUR

Q1 Location characteristics/basic demography

Which of the following do you consider the county?

Open countryside county	Rural county with rural town	Urban county as a part of a metropolitan area

How would you describe the county?

Q2 Personal experience of wind projects

For how many years have you work with the county?

Did you witness the wind projects planning process?

If yes, what is the role that you have taken as part of the county's wind power planning process?

Did the County's planning team face any challenges during wind power development? What are the challenges the planning team face?

How the planning team act?

Did the county ask for any community benefit fund?

Q3 Population

Do you think the wind projects brought more population to the area or helped people to stay here?

What do you think about wind projects workers?

Where do they live?

From, where are they?

Q4 Employment

Do you think wind power projects brought new employment to the county?

Q5 Questions about Tax income:

I notice an increase in the county's tax income in the last few years (from 2005 to 2015).

The county is expecting to receive tax income from wind development in the next few years.

Does the county have any plan for this income?

What is the county's plan to use the wind power project tax revenue?

Q6 Questions about public services:

Did the county have a public services demand related to wind power development?

The research means by public services as: schools, fire services, water, and sewer.

Did the county have any public services deficit before wind power projects?

Did the county plan to add more public services due to wind power projects?

Q7 Questions about general impacts

Did the county or the community receive any fund from wind developers other than the tax income? Maybe under donation, or community trust fund?

If yes, How the county uses this fund? Who decides how to use it? Do the local residents know about this fund and have any role in how to use this fund?

From your own perspective as a local official person on the county, what are the changes that happen in the county after hosting wind power projects?

How do you see these changes?

Did these changes benefit the county or not?

Has the development of a turbine discouraged development of other sorts?

Q8 Questions about housing

Depend on the county numbers there are (increase, or decrees) on the housing numbers? Do you think that this increase related to jobs provided by wind projects?

Depend on the county numbers there are (increase or decrease) on the average house prices from 2000 to 2015.

The energy prices in the county have been (decreased or stable), is this has any related to wind power projects?

Q9 Questions about the county's future

How wind development affects the county's future plans?

Are there any effects of wind power projects on the coming plans of the county?

How do you expect that wind power project will affect the county's future?

BIBLIOGRAPHY

Allen, J. C., Chang, C.-Y., Madsen, G. E., & Dawson, S. E. (2008). A social relationship response to a proposed coal-fired power plant: network theory and community change. Community Development : Journal of the Community Development Society, 39(1), 35–49.

American Wind Energy Association's (AWEA) (2016) AWEA Second Quarter 2016 Wind Project Database. Release Date: July 21, 2016. Retrieved from: www.stats.awea.org

American Wind Energy Association's (AWEA) (2019). Retrieved from https://www.awea.org/wind-101/basics-of-wind-energy/wind-facts-at-a-glance

Arjas, E., & Parner, J. (2004). Causal Reasoning from Longitudinal Data. Scandinavian Journal Of Statistics, 31(2), 171-187. doi:10.1111/j.1467-9469.2004.02-134.x

Baer, A.(2012, Sept 23). Wind Farm Opens In Arlington. Local news. Retrieved from: https://www.opb.org/news/article/wind-farm-opens-in-arlington/

Baser, O. (2006). Too Much Ado about Propensity Score Models? Comparing Methods of Propensity Score Matching. Value in Health, 9, 6, 377-385.

Bird, L., Bolinger, M., Gagliano, T., Wiser, R., Brown, M., & Parsons, B. (2005). Policies and market factors driving wind power development in the United States. Energy Policy, 33, 1397–1407.

Bolinger, M., & Wiser, R. (2006). A comparative analysis of business structures suitable for farmer-owned wind power projects in the United States. Energy Policy, 34, 1750–1761.

Borenstein, S. & Bushnell, J. (September 2018). Do Two Electricity Pricing Wrongs Make a Right? Cost Recovery, Externalities, and Efficiency. Energy Institute WP 294

Brannstrom, C., Wendy, J., &Persons. N. (2011). Social Perspectives on Wind-Power Development in West Texas. Annals Of The Association Of American Geographers, (4), 839. doi:10.1080/00045608.2011.568871

Bristow, G., Cowell, R., & Munday, M. (2012). Windfalls for whom? The evolving notion of 'community' in community benefit provisions from wind farms. Geoforum, 43(Themed issue: Spatialities of Ageing), 1108-1120. doi:10.1016/j.geoforum.2012.06.015

Brown, J. P., Pender, J., Wiser, R., Lantz, E., & Hoen, B. (2012). Ex post analysis of economic impacts from wind power development in U.S. counties. Energy Economics, 1743–1754.

Brown, J. P., Weber, J.G., & Wojan, T.R. (2013). Emerging Energy Industries and Rural Growth. U.S. Department of Agriculture, Economic Research Service, ERR-159, November 2013.

Bublitz, W. (2014, Jan 10). More wind towers coming to Lincoln County!. Retrieved from: http://www.thelimonleader.com/2014/01/more-wind-towers-coming-to-lincoln.html.

Bublitz, W. (2016, May 6). Lincoln County to see more wind energy. Retrieved from: http://www.thelimonleader.com/2016/05/lincoln-county-to-see-more-wind-energy.html.

Caliendo, M., & Kopeinig, S. (2008). Some practical guidance for the implementation of propensity score matching. Journal of Economic Surveys, 22, 1, 31-72.

Carter, J. (2011) The Effect of Wind Farms on Residential Property Values in Lee County, Thesis, Illinois State University, Spring 2011, pp. 1-35.

Caruana, E. J., Roman, M., Hernández-Sánchez, J., & Solli, P. (2015). Longitudinal studies. Journal of Thoracic Disease, 7(11), E537–E540. https://doi-org.silk.library.umass.edu/10.3978/j.issn.2072-1439.2015.10.63

Castleberry, B., & Scott Greene, J. (2017). Impacts of wind power development on Oklahoma's public schools. Energy, Sustainability & Society, 7(1), 1-14. doi:10.1186/s13705-017-0138-8

Clemmer, S. (2001). Strong Winds: Opportunities for rural development blow across Nebraska. Union of Concerned Scientists. February 2001.

Cleveland, J. (2008, NOV,11). Sherman County farmers reap stability from wind. Oregon live. Retrieved from: https://www.oregonlive.com/news/index.ssf/2008/11/sherman_county_farmers_reap_st.html.

Cockle, R. (2011, Nov 12). Wind blows money into pockets of Sherman County residents. THE OREGONIAN. Retrieved from: https://www.oregonlive.com/pacific-northwest-news/index.ssf/2011/11/wind_blows_money_into_pockets.html.

Collaborative Economics (November 2009) Solano County’s Energy Cluster. Solano Economic Development Corporation. Retrived from: https://www.solanocounty.com/SubApp/SolanoIndex/Reports/Solano_EnergyCluster.pdf.

Collaborative Economics. (January 2010). Solano County 2009 Index of Economic and Community Progress. Solano Economic Development Corporation. Retrevied from: https://www.solanocounty.com/SubApp/SolanoIndex/Reports/SolanoIndex2009.pdf.

Cook, T., and D. Campbell. (1979) . Quasi-Experimentation: Design and Analysis Issues for Field Settings. Chicago, IL: Rand McNally College Publications.

Costanti, M. (2004). Quantifying the economic development impacts of wind power in six rural Montana counties using NREL'JEDI model. Report No, NREL/SR-500-36414.

County of Kern Comprehensive Economic Development Strategy (CEDS). 2012-2013 Annual Report. County of Kern Comprehensive Economic Development Strategy Update https://www.kerncounty.com/econdev/pdf/ceds-2012-2013.pdf.

Crespo, R., & Grêt-Regamey, A. (2013). Local hedonic house-price modeling for urban planners: advantages of using local regression techniques. Environment & Planning B: Planning & Design, 40(4), 664-682. doi:10.1068/b38093

Cummings, R . G & Mehr, A. F. (1977). Investments for Urban Infrastructure in Boomtowns, 17 Nat. Resources J. 223, 240

De Silva, D. G., McComb, R. P., & Schiller, A. R. (2016). What Blows in with the Wind?. Southern Economic Journal, 82(3), 826-858. doi:10.1002/soej.12110

De Vries, B. d., Vuuren, D. v., & Hoogwijk, M. M. (2007). Renewable energy sources: their global potential for the first-half of the 21st century at a global level: an integrated approach. Energy Policy, (4), 2590.

Durbin, K. (2010, Oct 10). Washington's wind power windfall: The harnessing of Columbia Gorge winds has transformed the landscape and the lives of rural residents. Retrieved from. https://www.columbian.com/news/2010/oct/10/washingtons-wind-power-windfall-the-harnessing-of/

DuVivier, K. K. (2014). RURAL WIND WINDFALLS. Kansas Journal Of Law & Public Policy, 23(3), 401-420.

Eberling, B. (2018). New wind farm does more with less in Solano County. Daily Republic Solan County News Source. Retvied from: https://www.dailyrepublic.com/all-dr-news/solano-news/solano-county/solanos-new-wind-farm-does-more-with-less/.

Eder, J. F. (1999). A generation later: Household strategies and economic change in the rural Philippines. Honolulu: University of Hawai'i Press.

Editorial (2013).Harvesting Wheat and Wind in Sherman County, Oregon. Retervied from: http://www.3estrategies.org/resources/new-economy-resources/new-economy-successes/sherman-county/.

Editorial. (2001, Nov 15) Press Release- Condon Wind Energy Project Takes to the Skies. Retrieved from: https://renewablenw.org/node/condon-wind-energy-project-takes-skies RNP Press Release

Editorial. (2014, June 24). Tri Global Energy Announces the Sale of Floyd County Wind Farm. NEWS FROM TRI GLOBAL ENERGY. Retrieved from: https://www.triglobalenergy.com/news/tri-global-energy-announces-the-sale-of-floyd-county-wind-farm

Editorial. (2014, June 26). Solano County Wind Farm Receives First-Of-Its-Kind Permit To Allow Eagle Deaths. Retrieved from: https://sanfrancisco.cbslocal.com/2014/06/26/shiloh-solano-county-wind-farm-golden-eagle-deaths-permit-windmill-turbines-rotor-blades-california/.

Editorial. (2017, Aug 9). Floyd County: ideal spot for wind turbines. Retrieved from http://www.kcbd.com/story/36101388/floyd-county-ideal-spot-for-wind-turbines/

Edmiston, k. d. (2004). The net effects of large plant locations and expansions on county employment. Regional science, 44, 289–319

Edwards LJ. (2000). Modern statistical techniques for the analysis of longitudinal data in biomedical research. Pediatr Pulmonol Vol 30:330-44

Ervin, O. (1978) Local Fiscal Effects of Coal Development: A Framework for Analysis and Management. Policy Studies Journal Vol. 7:1

Ezeala-Harrison, F. (1996). Economic development : theory and policy applications. Praeger.

Fargione J., Kiesecker J., Slaats MJ., & Olimb S., (2012) Wind and Wildlife in the Northern Great Plains: Identifying Low-Impact Areas for Wind Development. PLoS ONE 7(7): e41468. https://doi.org/10.1371/journal.pone.0041468

Flammang, R.A. (1979). Economic Growth and Economic Development: Counterparts or Competitors?. Economic Development and Cultural Change, Vol. 28, No. 1, October, pp. 47-61.

Flatt, C. (2011, Dec 8). Sherman County Gets Boost from Wind Farms.OPB.retrived from: https://www.opb.org/news/article/sherman-county-gets-boost-from-wind-farms/.

Florence Neymotin. (2010). The Relationship between School Funding and Student Achievement in Kansas Public Schools. Journal of Education Finance, 36(1), 88.

Gibbons, S. (2015). Gone with the wind: Valuing the visual impacts of wind turbines through house prices. Journal of Environmental Economics And Management, 72177-196. doi:10.1016/j.jeem.2015.04.006

Gilliam County TSP update Virtual Workshop. Goals and Objectives. Retrieved from: http://workshops.kaiproject.com/workshops/12-gilliam-county-tsp-update/rooms/52-goals-and-objectives.

Gilmore, J. S. (1976). Boom Towns may hinder energy resource development: Isolated rural communities can- not handle sudden industrialization and growth without help. Science 191:535-540.

Gilmore, J.S., & Duff., M.K (1975). Boom Town Growth Management: A Case Study of Rock Springs-Green River, Wyoming. Boulder, CO: Westview.

Goldberg, M., Sinclair, K., & Milligan, M. (2004). Job and Economic Development Impact (JEDI) Model: A User-Friendly Tool to Calculate Economic Impacts from Wind Projects. the 2004 Global WINDPOWER. Chicago, Illinois: NREL/CP-500-35953.

Goldman, J. C. (2006) A Study in the Impact of Windmills on Property Values in Tucker County, West Virginia for the Proposed Beech Ridge Energy, L.L.C. project in Greenbrier County, West Virginia. Goldman Associates Inc. Prepared for Spilman Thomas & Battle, P.L.L.C., Charleston, WV. April, 2006. 51pages. West Virginia Case No. 05-1590-E-CS.

Government Accountability Office (GAO). (2004). Renewable Energy: Wind Power's Contribution to Electric Power Generation and Impact on Farms and Rural Communities. U.S. Government Accountability Office.

Grandolfo, J.D (2015). Wind Energy in Klickitat County, Washington. Master of Public Policy essay Oregon State University. presented on June 12th, 2015

Greene, J. S., & Geisken, M. (2013). Socioeconomic impacts of wind farm development: a case study of Weatherford, Oklahoma. Energy, Sustainability and Society, 3:2

Greider, T. R. & Krannich, R.S. (1985) . Perceptions of Problems in Rapid Growth and Stable Communities: A Comparative Analysis. Community Development Society Journal 16:80–96.

Groth, T. M., & Vogt, C. A. (2014a). Rural wind farm development: Social, environmental and economic features important to local residents. Renewable Energy, 631-8. doi:10.1016/j.renene.2013.08.035

Groth, T. M., & Vogt, C. A.(2014b). Residents' perceptions of wind turbines: An analysis of two townships in Michigan. Energy Policy, 65251-260. doi:10.1016/j.enpol.2013.10.055

Grover S.(2002). Economic Impacts of Wind Power in Kittitas County. Wind Engineering, 26, 315–3 28.

Guo, S., & Fraser, M. W. (2010). Propensity score analysis: Statistical methods and applications. Los Angeles: SAGE.

Hall, S. A., Kaufman, J. S., & Ricketts, T. C. (2006). Defining Urban and Rural Areas in U.S. Epidemiologic Studies. Journal of Urban Health, 83(2), 162–175. http://doi.org/10.1007/s11524-005-9016-3

Halvatzis, S., & Keyser, D. (2013). Estimated Economic Impacts of Utility Scale Wind Power in Iowa, National Renewable Energy Laboratory. Technical Report NREL/TP-6A20-53187 November 2013

Hamilton, P., Kristen Keough, k., Ratnatunga, M., & Wong,.P. (March 2015) An Economic Road Map for KERN COUNTY https://www.kerncounty.com/econdev/pdf/economic-road-map.pdf.

Hamin, E. (2002). Western European approaches to landscape protection: A review of the literature. Journal of planning literature. 16, 3, 339-358, ISSN: 08854122.

Heintzelman, M. D., & Tuttle, C. (2012). Values in the Wind: a Hedonic Analysis of Wind Power Facilities. Land Economics, 88, 571–588.

Hinman, J. L. (2010). Wind farm proximity and property values: a pooled hedonic regression analysis of property values in central Illinois. Master's thesis. Normal, IL: Illinois State University.

Hoen, B. (2006). Impacts of Windmill Visibility on Properties Values in Madison County, New York. Thesis, Bard College, 2006.

Hoen, B., & Atkinson-Palombo, C. (2016). Wind Turbines, Amenities and Disamenities: A Study of Home Value Impacts in Densely Populated Massachusetts. Journal Of Real Estate Research, 38(4), 473-504.

Hoen, B., Brown, J.P., Jackson, T., Thayer, M.A., Wiser, R. & Cappers, P. (2015). Spatial Hedonic Analysis of the Effects of US Wind Energy Facilities on Surrounding Property Values. The Journal of Real Estate Finance and Economics, 51 (1), 22-51.

Hoen, B., Wiser, R., Cappers, P., Thayer, M., & Sethi, G. (2009). The impact of wind power projects on residential property values in the United States: a multi-site hedonic analysis. Report no. LBNL-2829E. Berkeley, CA: Lawrence Berkeley National Laboratory.

Hoen, B., Wiser, R., Cappers, P., Thayer, M., & Sethi, G. (2011). Wind Energy Facilities and Residential Properties: The Effect of Proximity and View on Sales Prices. Journal of Real Estate Research, 33(3), 279–316.

Hoffer D. (2002). The Economic Benefit of Wind Farm Development in Vermont. Renewable Energy: Vermont: Montpelier, VT, 2002.

Hoffman, M. J., Wiggall, R. L., Dereshiwsky, M. I., & Emanuel, G. L. (2013). State School Finance System Variance Impacts on Student Achievement: Inadequacies in School Funding. EJEP: EJournal of Education Policy.

Hogan, J. (2004). Instrumental variables and inverse probability weighting for causal inference from longitudinal observational studies. Statistical Methods In Medical Research, 13(1), 17-48.

Jacquet, J. (2009). Energy Boomtowns and Natural Gas: Implications for Marcellus Shale Local Governments and Rural Communities. Rural Development Working Paper No. 43. State College, PA: Northeast Center for Rural Development

Jacquet, J. B., & Stedman, R. C. (2013). Perceived Impacts from Wind Farm and Natural Gas Development in Northern Pennsylvania. Rural Sociology, 78, 4, 450–472.

Jensen, C.U., Panduro,T.E., Lundhede, T.H., Nielsen, A.S.E., Dalsgaard, M., & Thorsen, B.J. (2018).The impact of on-shore and off-shore wind turbine farms on property prices, Energy Policy, Volume 116, May 2018, Pages 50-59, ISSN 0301-4215, https://doi.org/10.1016/j.enpol.2018.01.046. https://www.sciencedirect.com/science/article/pii/S0301421518300557)

Jobes, P. C. (1986). The Disintegration of Gemeinschaft Social Structure from Energy Development: Observations from Ranch Communities in the Western United States. Journal of Social Research 3:219–29.

Jones, C. R., & Eiser, J. R. (2009). Identifying predictors of attitudes towards local onshore wind development with reference to an English case study. Energy Policy, 37(11), 4604-4614.

Kahn, M. E. (2013). Local non-market quality of life dynamics in new wind farms communities. Energy Policy, 59800-807. doi:10.1016/j.enpol.2013.04.037

Kaplan, J. L. (2008). Wind Power in the United States: Technology, Economic, and Policy Issues.

Kempton, W., Firestone, J., Lilley, J., Rouleau, T., & Whitaker, P. (2005). The Offshore Wind Power Debate: Views from Cape Cod. Coastal Management, 33(2), 119-149. doi:10.1080/08920750590917530

Kern County Planning Department (September 22, 2009) kern county general plan_ energy element: retrieved from https://psbweb.co.kern.ca.us/planning/pdfs/kcgp/KCGPChp5Energy.pdf.

Kittelson & Associates, Inc & Tenneson Engineering Corporation Browne Consulting, LLC (October 2015). Gilliam county transportation system plan.retrived from https://www.oregon.gov/ODOT/Planning/TPOD/tsp/county/county_of_gilliam_tsp_2015.pdf.

Klick, H., & Simth, E.R. (2010). A Public understanding of and support for wind power in the United States. Renewable Energy 35, 1585–1591.

Klickitat County Public Economic Development Authority (EDA). (May 2017). Advancing economic prosperity in Klickitat county-10 -year economic development strategic plan. Retrieved from: https://www.klickitatcounty.org/documentcenter/View/3482/2017-05-22-Klickitat-County-Strategic-Plan-V14-FINAL-1.

Kohler, J. (2018, Sept 19). Xcel Energy opens huge, billion-dollar wind farm on Colorado's Eastern Plains. Retrieved from: http://www.journal-advocate.com/business/sterling-agriculture/ci_32162260/xcel-energy-opens-huge-billion-dollar-wind-farm

Kohrs, E. V. (1974). Social Consequences of Boom Growth in Wyoming. Rocky Mountain American Association Advancement of Science Meeting, April 24–26.

Krannich, R. S. & Greider, T. R. (1985). Rapid Growth and Fear of Crime. Rural Sociology, 50:193–209.

Lang, C., Opaluch, J.J,& Sfinarolakis,G. (2014) The windy city: Property value impacts of wind turbines in an urban setting, Energy Economics, Volume 44,2014, Pages 413-421, ISSN 0140-9883, (http://www.sciencedirect.com/science/article/pii/S0140988314001182)

Lantz, E., & Tegen, S. (2008). Variables affecting economic development of wind energy. National Renewable Energy Laboratory. http://purl.access.gpo.gov/GPO/LPS110255.

Lantz, E., & Tegen, S. (2011). Jobs and Economic Development from New Transmission and Generation in Wyoming. National Renewable Energy Laboratory Report TP-6A20-50577, Golden, CO.

Lantz, E.,& Tegen, S. (April 2009). Economic Development Impacts of Community Wind Projects: A Review and Empirical Evaluation. WINDPOWER 2009 Conference and Exhibition, Chicago Illinois, NREL/CP-500-45555.

Lantz, Eric. (2009). Economic development benefits from wind power in Nebraska a report for the Nebraska Energy Office. Golden, Colo: National Renewable Energy Laboratory. http://purl.fdlp.gov/GPO/gpo2852.

Lapoint, P., & Haggard, C.R. (2011). Stoneham County: the impact of public policy on wind power economic development. Journal of the International Academy for Case Studies, 17, 41-47.

Laposa, S. P., & Mueller, A. (2010). Wind Farm Announcements and Rural Home Prices: Maxwell Ranch and Rural Northern Colorado. Journal of Sustainable Real Estate, 2(1), 383–402

Ledec, G., Rapp, K. W., & Aiello, R. (2011). Greening the wind: Environmental and social considerations for wind power development. Washington, D.C: World Bank.

Leistritz, F. L., & Coon, R. C. (2009). Socioeconomic impacts of developing wind energy in the great plains. Great plains research, 19(1), 3.

Lincoln County (2009)Lincoln County, Colorado Economic Development Incentive Policy. Retrieved from: http://lincolncountyco.us/economic_development/Economic%20Development%20Incentive%20Policy2009.pdf.

Lincoln county comprehensive plan 2000: Retrieved from http://lincolncountyco.us/land_use/Comprehensive_Plan.pdf.

Lincoln County Economic Development Corp (LCEDC). (2018).Lincoln County strategic plan 2018-2019. Send by email from the Executive Director of Klickitat Public Economic Development Authority.

Linden, A., & Adams, J. L. (2012). Combining the regression discontinuity design and propensity score-based weighting to improve causal inference in program evaluation. Journal of Evaluation in Clinical Practice, 18(2), 317–325.

Logan, J., & Kaplan, S.M. (2008). Wind Power in the United States: Technology, Economic, and Policy Issues. CRC report for Congress, Order Code RL34546

Loomis, D., & Aldeman, M. (2011). Wind farm implications for school district revenue. Normal, IL: Illinois State University, Center for Renewable Energy. www.RenewableEnergy.ilstu.edu

Loomis, D., Hayden, J., & Noll, S. (2012). Economic impact of wind energy development in Illinois. Normal, IL: Illinois State University, Center for Renewable Energy

Lzard, B. (2015). Mind-Blow in' Wind Farms of Nolan County, Texas. PorterBriggs.com. retrieved from: http://porterbriggs.com/mind-blowin-wind-farms-of-nolan-county-texas/.

Malizia, E. E., & Feser, E. J. (1999). Understanding local economic development. New Brunswick, N.J: Center for Urban Policy Research.

Marie, G.(2010, Jul 29). California's Kern County Will Host the Largest Wind Farm In the U.S. Retrieved from: https://www.triplepundit.com/2010/07/california-kern-county-will-host-the-largest-wind-farm-in-the-u-s/.

Markussen, A. (1978). Socioeconomic Impact Models for Boomtown Planning and Policy Evaluation Presented at the Western Regional Science Association Meetings February 25, 1978.

Marquez, D. (2015, Aug 5). Hundreds of wind turbines being built in Floyd County as part of new farm. Retrieved from https://www.lubbockonline.com/business/2015-08-05/hundreds-wind-turbines-being-built-floyd-county-part-new-farm

Marquez, D. (2016, May 28). Wind turbines to fill Floyd County skies. Local news. Retrieved from https://www.lubbockonline.com/local-news/2016-05-28/wind-turbines-fill-floyd-county-skies

McCubbin, D., & Sovacool, B. K. (2013). Quantifying the Health and Environmental Benefits of Wind Power to Natural Gas. Energy Policy, 53(1), 429-441. doi:http://dx.doi.org.silk.library.umass.edu/10.1016/j.enpol.2012.11.004

Media Agent. (2013, Aug 22).$400 million wind project brings jobs, revenue to Carson County. News channel 10. Retrieved from: http://www.newschannel10.com/story/23232260/400-million-wind-project-brings-jobs-revenue-to-carson-county/

Media Agent. (2013, Nov 25). Wind project set for Construction in Castro County. A-J MEDIA. Retrieved from: https://www.lubbockonline.com/local-news/2013-11-25/wind-project-set-construction-castro-county

Media Agent. (2015, April 22). Carson County wind farm now open. ABC News. Retrieved from https://abc7amarillo.com/news/local/carson-county-wind-farm-now-open

Meier, G.M. (1976), Leading Issues in Economic Development, 3rd Ed., New York, Oxford University Press.

Moné, C., Stehly,T., Ben Maples,B., &Edward Settle,E. (2015). 2014 Cost of Wind Energy Review. National Renewable Energy Laboratory (NREL) (2005) at www.nrel.gov/publications

Mongha, N., Staffor, E.R., & Harman, C.L. (2006). An analysis of the economic impact on Utah County, Utah from the development of wind power plants. Renewable Energy for Rural Economic Development College of Business, Utah State University, DOE/EERE: DOE/GO-102006-2316, 2006.

MULKERN, A.C. (2010, Oct 18). Wind Is the New Cash Crop in Rural Wash. Town. Local news. Retrieved: from:https://archive.nytimes.com/www.nytimes.com/gwire/2010/10/18/18greenwire-wind-is-the-new-cash-crop-in-rural-wash-town-3529.html

Mulvaney, K. K., Woodson, P., & Prokopy, L. S. (2013). A tale of three counties: Understanding wind development in the rural Midwestern United States. Energy Policy, 56322-330. doi:10.1016/j.enpol.2012.12.064

Murdock, S. H., & Leistritz , F. L. (1979). Energy Development in the Western United States: Impact on Rural Areas. Westport, CT: Praeger.

Murdock, S. H., & Leistritz, F. L. (1978). Social and Economic Effects of Large-Scale Energy Development in Rural Areas: An Assessment Model.

Murdock,S.H., & Leistritz,F. L. (1978). Demographic and Economic Effects of Large scale energy development in rural areas: An assessment model. in Summers, G. F., Selvik, A., & Rural Sociological Society. (1979). Nonmetropolitan industrial growth and community change. Lexington, Mass: Lexington Books.

Natural, R. D. C. (March 21, 2017). The Job Market Is Spinning for Colorado's New Wind Workforce. Nrdc, 2017-3.

New Amsterdan Wind Source LIC (NAWSLIC). (2008). Nolan County case study of wind energy economic impacts on Texas. Retvied from: https://www.citizen.org/sites/default/files/nolan_county_case_study_070908_0.pdf.

Nixson, F. (1989). Economic developmenta suitable case for treatment?. International Development Centre. Manchester Diccussion papers in Devlopment Studies.

Osphey, C. N. (2009). Wind power: Technology, economics and policies. New York: Nova Science.

Ouderkirk, B. & Pedden, M. (2004). Windfall from the Wind Farm Sherman County, Oregon. Renewable Northwest Project. Retrived from https://renewablenw.org/sites/default/files/pdfs/Klondike%20Paper.pdf

Palmer, J. F. (2015). Research Paper: Effect size as a basis for evaluating the acceptability of scenic impacts: Ten wind energy projects from Maine, USA. Landscape And Urban Planning, 14056-66.

Paul, D.A. (1979). Technical Choice, Innovation and Economic Growth in Summers, G. F., Selvik, A., & Rural Sociological Society. (1979). Nonmetropolitan industrial growth and community change. Lexington, Mass: Lexington Books.

Pedden, M., & Eugene, O. (2006). Analysis: Economic Impacts of Wind Applications in Rural Communities. National Renewable Energy Laboratory Report SR-500–39099, Golden, CO.

Phillips, M; Watson, D; Barnes, W; & Feldman, H,.(2013). Winds of change in Klickitat County: the Harvest Wind Project. Business Faculty Publications and Presentations. 25. http://pilotscholars.up.edu/bus_facpubs/25.

Planning and Natural Resources Department Kern County CA, (2017, May 25). General Plan Update Workshop #5- overview of Kern County general plan Energy and the military readiness elements.retreived from: https://psbweb.co.kern.ca.us/planning/pdfs/GPupdate/gpu_pc052517_sr.pdf

Poletti, P. J. 2007. A Real Estate Study of the Proposed White Oak Wind Energy Center, McLean and Woodford Counties, Illinois. Collinsville, IL: Poletti and Associates, Inc.

Ragwitz, M., Schade, W., Breitschpf, B., Walz, R., Helfrich, N., Rathman, M., Resch, G., Faber, T., Panzer, C., Haas, R., Nathani, C., Holzhey, M., Zagame, P., Fougeyrollas, A., & Konstantinaviciute, I., (2009). The impact of renewable energy policy on economic growth and employment in the European Union. Published for the European Commission DG Energy and Transport.

Rajewski D. A., Takle E. S., Lundquist J.K.., Oncley, S., Prueger J. H., Horst T. W., Rhodes,.M.E., Peeiffer.R., Hatfielf,.J.l., Spoth, K.K., & Doorenbos, R.K. (2013). CROP WIND ENERGY EXPERIMENT (CWEX) : Observations of Surface-Layer, Boundary Layer, and Mesoscale Interactions with a Wind Farm. Bulletin Of The American Meteorological Society, (5), 655.

Reategui, S., & Hendrickson, S. (2011). Economic development impact of 1,000 MW of wind energy in Texas. In National Renewable Energy Laboratory [database online]. Golden, CO, 2011.

Reategui,S. & Tegen, S. (August 2008). Economic Development Impacts of Colorado's First 1000 Megawatts of Wind Energy. WIND POWER 2008. Houston, Texas: NREL/CP-500-43505.

Reed, W. R., & Rogers, C. L. (2003). A study of quasi-experimental control group methods for estimating policy impacts. Regional Science and Urban Economics, 33, 1, 3-25.

Ricketts T, Johnson-Webb K, &Taylor P. (1998). Definitions of Rural: A Handbook for Health Policy Makers and Researchers. Washington: US Department of Health and Human Services:1–12.

Rossman, G.B., & Rallis, S.F. (2012). Learning in the field an introduction to qualitative research. SAGA Publication, INC

Saidur, R., Rahim, N., Islam, M., & Solangi, K. (2011). Environmental impact of wind energy. Renewable & Sustainable Energy Reviews, 15(5), 2423-2430.

Santos, H., Rodrigues, L., Jones, G., & Rebelo, H. (2013). Using species distribution modelling to predict bat fatality risk at wind farms. Biological Conservation, 157178-186.

Shadish, William R., Thomas D. Cook, & Donald T. Campbell. 2001. Experimental and quasi-experimental designs for generalized causal inference. Boston: Houghton Mifflin

Shrimali, G., Lynes, M., & Indvik, J. (2015). Wind energy deployment in the U.S.: An empirical analysis of the role of federal and state policies. Renewable and Sustainable Energy Reviews. 43 (2015) 796–806

Sims, S. and Dent,P. (2007). Property Stigma: Wind Farms Are Just the Latest Fashion. Journal o f Property Investment and Finance, 25, 626-51.

Sims, S., P. Dent, P., &G.R. Oskrochi, G.R. (2008). Modeling the Impact of Wind Farms on House Prices in the U.K. International Journal o f Strategic Property Management, 12, 251-69.

Singer, J. D., & Willett, J. B. (2003). Applied longitudinal data analysis: Modeling change and event occurrence. Oxford: Oxford University Press.

Slattery, M. C., Johnson, B. L., Swofford, J. A., & Pasqualetti, M. J. (2012). The predominance of economic development in the support for large-scale wind farms in the U.S. Great Plains. Renewable and Sustainable Energy Reviews, (6), 3690.

Slattery, M.C., Lantz, E., & Richards, L.J. (2011). State and local economic impacts from wind energy projects: Texas case study. Energy Policy, (39), 7930-7940.

Smith, M., Krannich, R., & Hunter, L. (2001.). Growth, decline, stability, and disruption: A longitudinal analysis of social well-being in four western rural communities. RURAL SOCIOLOGY, 66(3), 425–450

Summers, G. F., Selvik, A., & Rural Sociological Society. (1979). Nonmetropolitan industrial growth and community change. Lexington, Mass: Lexington Books.

Sunak,Y., & Madlener,R. (2016). The impact of wind farm visibility on property values: A spatial difference-in-differences analysis, Energy Economics, Volume 55,2016, Pages 79-91,ISSN 0140 9883,https://doi.org/10.1016/j.eneco.2015.12.025.(http://www.sciencedirect.com/science/article/pii/S014098831600044X)

Swanson, L. E. (1988). Agriculture and community change in the U.S: The congressional research reports. Boulder: Westview Press.

Swofford, J., & Slattery, M. (2010). Public attitudes of wind energy in Texas: Local communities inclose. Energy Policy38, 2508–2519.

Tegen, S., (2006). Comparing Statewide Economic Impacts of New Generation from Wind, Coal, and Natural Gas in Arizona, Colorado, and Michigan. National Renewable Energy Laboratory Report TP-500-37720, Golden, CO.

Tegen, S., Goldberg, M., & Milligan, M. (June 2006) User-Friendly Tool to Calculate Economic Impacts from Coal, Natural Gas, and Wind: The Expanded Jobs and Economic Development Impact Model (JEDI II). United States. doi:10.2172/1218072.

The comprehensive land use plan Sherman county Oregon (1994 updated 2007). Retrieved from: https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/8674/Sherman_County_Compplan_2007.pdf;sequence=1.

The Midland Reporter-Telegram(MRT). (2015). As tax abatements expire for wind farms,county budgets prosper By Brandon Mulder bmulder@mrt.com Published 4:00 pm, Wednesday, December 9, 2015 http://www.mrt.com/news/article/As-tax-abatements-expire-for-wind-farms-county-7417294.php.

Thompson, M., Beston, J. A., Etterson, M., Diffendorfer, J. E., & Loss, S. R. (2017). Factors associated with bat mortality at wind energy facilities in the United States. Biological Conservation, 241. doi:10.1016/j.biocon.2017.09.014

Torgerson, M., Sorte, B., & Nam, T. (2006). Umatilla County's Economic Structure and the Economic Impacts of Wind Energy Development: An Input–Output Analysis. Oregon State University Extension Service, Special Report 1067.

US. Bureau of Labor Statistics (BLS) . (2010). Careers in Wind Energy. n.d. Advanced Technology Environmental and Energy Center. http://ateec.org/ateec-downloads/careers-in-wind-energy.

Van Der Voo, L. (2011, May 30). Money Blows in to a Patch of Oregon Known for Its Unrelenting Winds. New York times. Retrived from: https://www.nytimes.com/2011/05/31/us/31wind.html.

Vyn, R.J. & McCullough, R.M. (2014).The Effects of Wind Turbines on Property Values in Ontario: Does Public Perception Match Empirical Evidence? Canadian Journal of Agricultural Economics, 2014, 62, 365-92.

Welch, K. (2013, Aug20). Construction begins on $400M wind farm in Carson County. Retrieved from: https://www.amarillo.com/news/local-news/2013-08-20/construction-begins-400-million-wind-farm-carson-county.

Welch, K. (2014Jan 14). Google invests $75M in Carson County wind farm. Retrieved from. https://www.amarillo.com/news/local-news/2014-01-14/google-invests-75m-carson-county-windfarm.

William, S. K., Acker, T., Goldberg, M., & Greve, M. (2008). Estimating the Economic Benefits of Wind Energy Projects Using Monte Carlo Simulation with Economic Input/Output Analysis. Wind Energy, 11, 397–414

Wiser, R., Bolinger, M., (2010). 2009 Wind Technologies Market Report.DOE/GO-102010-3107.U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, Washington, DC, /http://www.nrel.gov/docs/fy10osti/48666.pdfS.

Wooldridge, J. (2009). Introductory Econometrics: A Modern Approach. 4th edition. South western Cengage Learning.

Workforce Development Board of Solano County. (2017). Workforce Innovation and Opportunity Act Local Plan Program Year 2017 – 2020. http://www.solanoemployment.org/sites/default/files/attachments/WDB%20Local%20Plan%20FINAL.pdf

Wright, P. D. (2005). Beyond NIMBYism: towards an Integrated Framework for Understanding Public Perceptions of Wind Energy. Wind Energy, 125–.

Yin, R. K. (2014). Case study research : design and methods. SAGE.