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Wind Power Development in China: An Assessment of Provincial Policies

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Abstract: Wind energy has become a fast growing industry in China in the last decade. The development of the wind energy industry presents interesting policy questions. In the context of China, in additional to national energy policies, provincial policies were designed and implemented to stimulate the growth of wind power. This paper examines factors, especially provincial wind energy policies, in driving the growth of wind power capacity in the Chinese provinces. Statistical analysis with a longitudinal data set for wind power capacity in Chinese provinces from 2001 to 2012 reveals that the adoption of wind energy policies and a general energy plan at the provincial level are having positive effects on the growth of wind capacity in Chinese provinces.

Keywords: wind power; policy designs; wind capacity; policy evaluation

1. Introduction

China has witnessed dramatic economic development during the last few decades, with the gross domestic product (GDP) growing at a yearly rate of approximately 10% [1]. The rapidly-growing Chinese economy is accompanied by increasing demand for energy and resources. Currently, the Chinese energy consumption structure is overly reliant on fossil fuels, leaving a negative impact on China's long-term energy sustainability—a policy issue that has captured considerable public attention.

At the same time, the environment in China has been deteriorating over the years, posing critical challenges to policy makers and citizens. Numerous environmental problems occur as byproducts of rapid urbanization and industrialization in China, among which air pollution, water pollution, and soil pollution are the typical environmental threats [2,3]. The increasing environmental awareness of Chinese citizens has pushed the Chinese government to seek alternative energy generation paths. As a reliable and affordable renewable energy option, wind energy is increasingly seen as an important part of the renewable portfolio across the globe, with fast deployment in the European Union and Unites States [4].

With a motivation to enhance environmental performance and promote green economic development [5], China has passed legislation and adopted policies in the past few years to fund wind energy research, to develop wind energy, and to elevate the contribution of wind in the power generation portfolio. Studies have been conducted to examine the passage and outcomes of the wind energy policies passed by the central government with case studies and quantitative regression analyses [6–8]. Both central and provincial governments in China have employed various renewable energy policies, especially wind policies. Studies on provincial policies are relatively rare, and they primarily draw conclusions from case studies, which are difficult to generalize [2]. While most of the extant research has paid much attention to the design, implementation, and effectiveness of the wind energy policy instruments adopted by the central government, few studies have investigated the nuanced rules, policies, regulations, and subsidies adopted at the provincial government level. As shown in Yi and Liu [5], provincial policies are significant drivers of the green energy economy at the local level, and the implementation of such local policies is instrumental in achieving renewable energy policy outcomes. Such gaps in extant research call for more serious attention to the role of provincial wind energy policies in stimulating the deployment of wind energy. Relevant questions include: have provincial governments adopted any policies to stimulate the deployment of wind energy capacity? If yes, how are the policies designed? Are provincial policies effective in driving the growth of installed wind capacity in Chinese provinces?

To address the above-mentioned research questions, this study is designed to examine the effectiveness of provincial clean energy policies in promoting wind energy development via quantitative panel data analysis. Specifically, this paper will quantify wind energy policies in Chinese provinces, and evaluate the influence of these policies on wind energy development in China. A detailed description of the research methods and data collection process will be provided, followed by the results and discussion, based on which several policy implications will be summarized at the end of the paper.

2. Methods

2.1. Wind Power in China: A Literature Review

In the extant literature, studies show that China's wind power industry is constrained by factors such as institutional barriers, grid integration problems, and technological weaknesses [9–13]. Firstly, the wind power industry in China is heavily controlled by state-owned enterprise, influenced by government policy decision, and characterized as an incomplete electricity market. Therefore, the development of potentially more efficient, non-grid-connected wind energy infrastructure, for example, is faced with strong institutional barriers [9]. The institutional barriers have blocked China's wind power industry from responding to system problems and adjusting efficiently. Stimulated by target-setting incentives, the extant policies in China are effective in improving the installed capacity of wind power; however, their ability to solve grid integration problems are weak [10]. This problem was not serious at the beginning, but as the installed wind power capacity rapidly grows, the grid-connected capacity in China has lagged behind [12].

The problem has recently become more severe. In fact, since 2006, the percentage of wind power generators connected to the grid in China has been continuously declining [14]. Wind power technology has advanced dramatically. An increasing number of Chinese firms have the ability to produce large-size wind turbines, with less foreign technological assistance [13]. However, China's wind power industry is still very constrained by technological weakness, especially when dealing with sophisticated problems that need world-class innovation [12].

Some studies are also concerned with the market conditions and regulations of the wind energy industry [15–21]. Lema and Ruby [17] argue that the Chinese wind turbine manufacturing industry could be divided into three phases: import phase, incremental phase, and coordinated phase. In the early two phases, the wind market was not attractive for power companies embedded in a highly uncertain and incomplete competition environment. The regulations were inefficient because of local utilities and the fragmented bureaucratic power structure. In the 2000s, the Chinese government realized the problems and took actions to bring related government departments together, to build market-based incentives and competition, and to improve regulations. This resulted in a boom of the wind energy industry. Yang et al. [18] also argue that market and regulation will influence the development of the wind energy industry. They found that uncertain policy frameworks for electricity market regulation increased the risk of investing in the wind energy industry. The net present values of the wind energy industry are significantly affected by uncertain clean development mechanism benefits. Zhang et al. [21] found that domestic government interventions help the wind industry grow, and they argue for further strengthening international support, such as financial support and technology transfer. Although the market-oriented reforms have been in place for decades, the presently dominant operation mechanism of the wind market is still centrally planned. There is still plenty of room for reform, and the introduction of additional market mechanisms [19]. Lam et al. [22] found that the renewable portfolio standard (RPS) and tax incentives are less important, compared with policy drivers that have a direct effect on wind developers' financial status. Since wind power deployment in China also has a great impact on the short-term tax interests of local governments, it is important to align the incentive mechanisms of local governments [23].

Nevertheless, the extant literature on wind and energy policies mainly focuses on the central government's activities and policies [11,20]; fewer studies have been conducted to assess the effects of provincial wind energy policies on advancing wind power at the provincial level. The wind energy policies involved multiple government organizations from both state and local levels, various ministries, and commissions. Liao [7] carefully differentiated 72 wind energy policies published from 20 different organizations and analyzes the evolutionary processes, but failed to further evaluate the policy effectiveness. Shen and Luo [8] analyzed the intentions and effects of five different policies, but the discussions are based on national level policies. China's wind energy industry gets benefits from decentralized policy competition, but also are hindered by fragmented provincial protectionism [10,17]. Studies have also been conducted to evaluate the potential for and effects of renewable energy development in Hong Kong. It is found that the carbon intensity for the renewable energy scenario will be reduced by 57% by 2020 [24,25]. Evaluating the province-level policies and actions is crucially important, but few studies test the effectiveness of different policies at China's province level. Zhao et al. (2016) compare the effectiveness of price policy and non-price policy with province-level panel data. This study has successfully assessed in detail the different effects between the two kinds of policy instruments, but pays no attention to other important provincial government actions, such as regulations. In the next few sections, a research design will be presented to quantify and evaluate the effectiveness of local wind policies.

2.2. Model

The goal of this paper is not only to analyze policies, but also to examine the economic, social, and natural factors contributing to the growth of wind energy capacity in Chinese provinces from 2001 to 2012. A fixed-effect regression model is employed to account for unobserved province-level and time variations in wind capacity. A Hausman test will be performed to test if a fixed-effect model should be chosen over a random effect model. In the study of renewable energy capacity, numerous studies have employed fixed-effect models to examine the impact of state-level renewable energy policies on renewable capacities in the United States [26–28]. Following the literature, the mathematical representation of the fixed effect model is presented as:

$$Y_{p,t} = \alpha_p + \tau_t + \beta X_{p,t} + \varepsilon_{p,t} \tag{1}$$

where "p" denotes the province and "t" represents the year of the observation. $Y_{p,t}$ indicates the dependent variable, log-transformed wind generation capacity in province p for year t. $X_{p,t}$ are independent variables, including provincial wind policy, pollution fee collection, SO_2 emissions, GDP (per capita), unemployment rate, unexplored wind potential, income (per capita), and population density; α_p denotes a province-specific intercept; τ_t is a vector of time dummies that take into account fixed time effect, capturing the influence of national energy policies (for example Renewable Energy Law); and $\varepsilon_{p,t}$ varies independently across provinces and over the time period.

2.3. Dependent Variable

The dependent variable of this study is wind energy generation capacity in Chinese provinces from 2001 to 2012. This measure was coded from the Chinese Wind Energy Association (CWEA). Wind resources in China are more abundant in the northeast, north, and northwest, but the power load is located primarily in the coastal regions. Due to the spatial mismatch between wind resources and power load, grid integration and market absorption are gradually becoming major constraints of wind power development. As a result, the major drivers for wind power deployment are local policy and market factors, instead of energy demand from load centers in coastal provinces. As shown in Figure 1, the cumulative installed wind capacity is unevenly distributed among provinces, with Inner Mongolia, Hebei, and Gansu being the leaders in wind power development. Figure 2 provides a graphical demonstration of the geographic distribution of wind capacity among the Chinese provinces. Although most of the provinces with high installed wind capacity are located in northern China, it remains unknown whether such variation is driven by variation in policies or wind potentials. This paper will empirically analyze the underlying factors leading to the differences among provinces in wind power development.

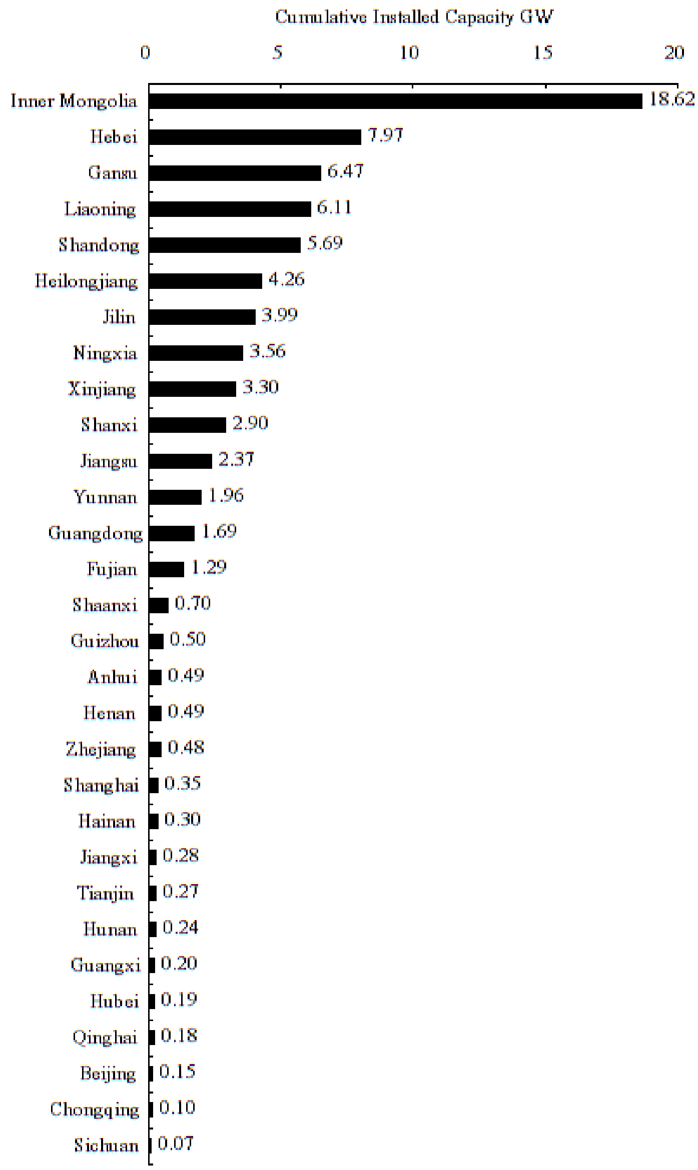

Figure 1. Cumulative Installed Wind Capacity in 2012 by Province.

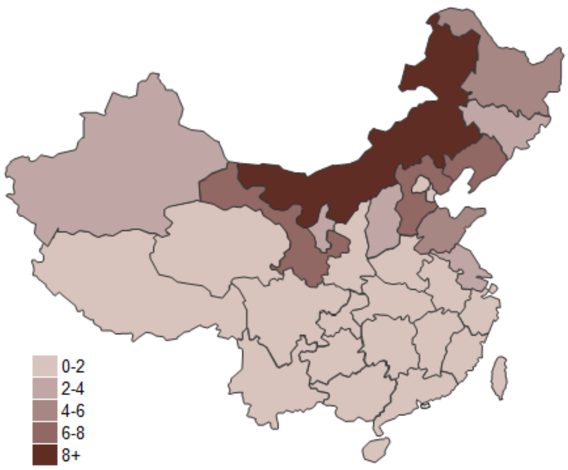

Figure 2. Geographical distribution of cumulative Installed Wind Capacity in 2012 (unit: GW).

2.4. Provincial Wind Energy Policy and Energy Plans

The central government plays a leading role in Chinese clean energy legislation. The renewable Energy Law in 2006 set the foundation for clean energy development in China. After the Renewable Energy Law in 2006, many new energy policies and plans were intensively enacted from 2006 to 2013—not only at the national level, but also, more importantly, among the provinces.

As shown in Table 1, nine provinces have adopted provincial-level wind energy policies to stimulate the development of wind energy within the provincial boundaries. In the following paragraphs, we discuss and present the provincial wind energy policies for each province in detail. In Inner Mongolia, "*Wind Power Development 11th "FYP" and Long-term Objectives for 2020*" was implemented in 2006 (FYP: five year plan). This policy divided Inner Mongolia into 26 functional zones for wind energy development, and developed a planning goal to achieve an installed wind energy capacity by 2010. The policy placed an emphasis on developing five key projects and ten pilot projects in a few counties and towns to develop industrial bases for wind power. The policy was renewed and further developed in 2011, under the policy document named "*Wind Power Development and Grid Integration 12th FYP*". Hebei province developed a provincial-level plan to start the *Baihuapo Wind Power Project*, located in Chengde City. The planned installed wind energy capacity is 49.5 MW.

Table 1. Provincial wind energy policies and plans. FYP: five year plan.

Province	Year	Wind Energy Policies and Plans
Inner Mongolia	2006 2011	Wind Power Development 11th "FYP" and Long-Term Objectives for 2020 Wind Power Development and Grid Integration 12th "FYP"
Hebei	2011	Baihuapo Wind Power Project
Gansu	2008	Regulation for Wind Power Development and Construction Order
Jilin	2008	Interim Measures of Wind Power Project Preliminary Work
Ningxia	2011	Land Management Measures of Wind and Solar Photovoltaic Power Generation Project
Xinjiang	2005 2007	Tax Exemption of Urban Land Using for Wind Power Plants Energy 11th "FYP" and Wind Power Development for 2020
Jiangsu	2006	Wind Power Development Plan from 2006 to 2020
Yunnan	2004	The Power Industry 11th "FYP" and Long-Term Objectives for 2020
Shanghai	2008	Interim Measures of Wind Power Project Preliminary Work
Jiangxi	2007	New Energy Development 11th "FYP" (wind power)

In Gansu province, the "*Regulation for Wind Power Development and Construction Order*" was passed in 2008. The policy put into effect a bidding process for wind energy projects, administered centrally by the Development and Reform Commission of Gansu province. Jilin province's wind energy policy, adopted in 2008, featured the "*Interim Measures of Wind Power Project Preliminary Work*", which stipulated the development approach of wind energy in Jilin mainly via a bidding or delegated development process, if approved by the provincial government. Ningxia province approached policy support for wind energy through preferential land use policies, as stipulated in "*Land Management Measures of Wind and Solar Photovoltaic Power Generation Project*" in 2011.

The *Tax Exemption of Urban Land Use for Wind Power Plants* was adopted in 2005 in Xinjiang; the policy provided tax exemptions for land use taxes for wind power plants to stimulate their development and business operations. Jiangsu province developed a specialized plan for wind power development in 2006, titled "*Wind Power Development from 2006 to 2020*". The plan stated that Jiangsu should have an installed wind energy capacity of 1500 MW, and an industrial value of 30 billion Chinese RMB *yuan* for the wind manufacturing businesses. Shanghai adopted "*Interim Measures of Wind Power Project Preliminary Work*" in 2008, which defined the rights for wind power development mainly through a bidding process. In 2007, Jiangxi province adopted the "*New Energy Development 11th FYP*", which planned to have an installed wind power capacity of 100 MW by 2010, and explore 43% of the available wind resources by 2020.

In addition to policies targeting wind energy development, provinces have also developed strategies for overall energy development by adopting the Energy Development Plans into the provincial Five Year Plans. Provincial energy development FYPs are shown in Table 2. Sixteen provinces adopted the 11th FYP for Energy Development.

Table 2. Summary of provincial energy policies and plans.

Policies and Plans	Provinces
Energy Development 11th "FYP"	Inner Mongolia, Hebei, Gansu, Ningxia, Xinjiang, Shanxi, Guangdong, Anhui, Henan, Shanghai, Hubei, Qinghai, Beijing, Sichuan, Shaanxi, Guizhou

It can be hypothesized that provincial wind energy policies and energy plans play significantly positive roles in stimulating wind energy deployment in the provinces. Given that wind energy policies are targeted solely for the development of wind generation, while energy plans cover a broader spectrum of energy sources, we can expect that wind energy policies will have a larger positive impact than general energy plans on wind power deployment.

To measure wind energy policy, a binary variable is used to indicate whether a province adopts wind energy policy in a year, with "1" representing that a province adopts a wind energy policy in that year, and "0" otherwise. In a similar way, another binary variable is created to indicate whether a province adopts an energy plan in a year, with "1" representing a province that adopts an energy plan in that year, and "0" otherwise.

2.5. Stringency of Environment Regulation

Wind energy development in China is not separable from its environmental regulation and governance. In a province with more effective environmental regulation, wind power industries get substantive support from the government. This measure is very similar to the measure of government ideology in terms of environmental sustainability. Thus, it is hypothesized that provinces with more stringent environmental regulation will have more wind capacity. To measure the stringency of environmental regulation, the collection of a pollution fee is used as a proxy. The data for this variable are collected from the Ministry of Environmental Protection.

2.6. Pollution-Intensive Interest Groups

Pollution-intensive industries are one of the major actors that oppose the development of wind power. Thus, it can be hypothesized that the more SO_2 emissions produced by the industries in a province, the slower the pace of wind energy deployment in that province will be. The data on SO_2 emissions are collected from the China Statistical Yearbook [1], and this variable is measured in tens of thousands of tons.

2.7. Economic Environment

Two economic environment variables are taken into account. The first factor is per capita Gross Domestic Product (GDP) in the province. Per capita GDP is measured in GDP (one hundred million RMB Yuan) divided by year-end population (ten thousand persons), collected from the China Statistical Yearbook [1]. Also collected from the China Statistical Yearbook [1], the unemployment rate in the province is another important economic factor included in the analysis. The unemployment rate, measuring the local economic health, could directly influence the economic environment for wind energy industries. As shown in Yi [29], there are two possibilities. A high unemployment rate means a stagnant local economy in need of less electricity, making it harder to add more renewable capacity. Alternatively, when the unemployment rate is high, local governments are pressured to search for alternative policy solutions to promote local economic development, with wind energy development being part of the solution [30]. In this study, we do not have a clear hypotheses regarding the direction of the relationship between unemployment rate and wind capacity. We include it as an important control variable.

2.8. Unexplored Wind Potential

Unexplored wind potential measures the amount of unexplored wind energy in a province. It can be expected that higher unexplored wind energy potential is associated with stronger motivations for faster wind power deployment and utilization.

A set of control variables, including per capita income and population density, are also considered in the analysis. Per capita income is measured as Disposable Personal Income, collected from the China Statistical Yearbook [1]. Population density is measured as persons per square kilometer, collected from the China Statistical Yearbook [1]. A summary of variables, measurements, and data sources is presented in Table 3.

Table 3. Data sources.

Variables	Measures	Predicted Relationship	Data Sources
Wind capacity	Annual cumulative wind installation from 2001 to 2012 in five Ethnic autonomous regions, four centrally-controlled municipalities and 22 provinces	Dependent variable	Chinese Wind Energy Association, CWEA
Wind policy	Binary variable: "1": with wind policy; "0" otherwise	-	Statistics office by province
Energy plan	Binary variable: whether a province has 11th "Five Year Plan" for Energy Development. "1": with energy plan; "0" otherwise	-	Statistics office by province
Pollution fee	Pollution fee (tens of thousands RMB Yuan)	Control	China Statistical Yearbook [1]
SO_2 emissions	SO_2 emission (tens of thousands of tons)	Control	China Statistical Yearbook [1]
Per capita GDP	GDP (one hundred million RMB Yuan) divided by population year end (tens of thousands of persons)	Control	China Statistical Yearbook [1]

Table 3. *Cont.*

Variables	Measures	Predicted Relationship	Data Sources
Unemployment rate	Unemployment rate (%)	Control	China Statistical Yearbook [1]
Unexplored wind potential	Unexplored theoretical potential (MW)	Control	China Statistical Yearbook [1]
Per capita income	Disposable Personal Income, DPI, (RMB Yuan)	Control	China Statistical Yearbook [1]
Population density	Population density (person per square kilometer)	Control	China Statistical Yearbook [1]

3. Results and Discussion

Table 4 presents descriptive statistics for the variables in this study. A series of tests have been performed to ensure that the assumptions of the fixed effect model are met, including the Hausman test, which favors the choice of fixed effect model. The standard errors are clustered robust standard errors. Time dummies could account for the impacts of the national renewable energy policies, such as the Renewable Energy Law.

Table 4. Descriptive statistics.

Variable	Observation	Mean	Standard Deviation	Min	Max
Wind capacity	324	624.21	1919.82	0	18,623.8
Wind policy	324	0.15	0.36	0	1
Energy plan	324	0.27	0.44	0	1
Pollution fee	324	46,086.95	45,800.11	357	287,343
SO_2 emissions	324	72.14	46.35	0.1	200.30
Per capita GDP	324	2.25	1.71	0.29	9.13
Unemployment rate	324	3.71	0.69	1.2	6.9
Unexplored wind potential	324	118,278.8	182,452.2	7849.3	786,868.2
Per capita income	324	13,311.02	6348.30	5267.42	40,188.34
Population density	324	2121.96	1393.40	56	6307

3.1. Wind Energy Policy and Energy Plan

The results of the analysis are very supportive of the hypotheses discussed earlier, as presented in Table 5. Because the dependent variable is log-transformed, the percent change is used in the interpretation of the coefficients in the model. The first set of results to be discussed is policy variables. This study measures provincial energy policies with two dummy variables, one for wind energy policy and the other for the general energy plan. The coefficient for wind energy policy, measuring whether there is a wind energy development policy in the province, is positive and statistically significant at the 0.01 level. This means that wind capacity on average increases by 70% with the adoption of wind policy over time. This indicates that wind policy, as the most important province-level wind energy policy, is driving the growth of wind capacity in the provinces. As the compliance ratio of wind policy is very high in most provinces over the years, the positive impacts of wind policy on wind capacity growth is within expectations.

One additional variable, "general energy plan", is used to measure the presence of the province-level general energy policy. The coefficient for the variable indicating the impact of a province level energy plan on its provincial wind capacity development is significant. Specifically, the magnitude of the coefficient means that the installed wind capacity in a given province increases by 48.5% on average with the adoption of a general energy plan, controlling for other factors. This confirms the hypothesis presented earlier that a general energy plan could have significant local policy impacts, and that implementing an energy plan would greatly benefit the survival and growth of the wind industry.

Table 5. Fixed Effect model of drivers of wind development in Chinese provinces. Dependent variable: wind generation capacity in megawatts (log-transformed).

Variables	Coefficient	Standard Errors
Wind policy	0.701 ***	0.269
Energy plan	0.485 **	0.232
Pollution fee	0.515 **	0.239
SO_2 emissions	−0.844 **	0.369
Per capita GDP	−0.280	0.283
Unemployment rate	0.025	0.202
Unexplored wind potential	−6.779	4.255
Per capita income	0.346 ***	0.063
Population density	0.078	0.078
Constant	70.802	46.073
Observation	324	-
Province Fixed Effect	Yes	-
Year Fixed Effect	Yes	-
R-squared (within)	0.772	-

** $p < 0.05$; *** $p < 0.01$ (two-tailed).

The significance of both wind energy policy and general energy plan at the provincial level confirms the importance of studying energy policy at the provincial level. Given the overwhelming dominance of extant studies focusing on national-level energy policies, more empirical studies are needed to investigate the effect and mechanism of provincial energy policies.

3.2. Energy and Emission Markets

Three variables were included to measure energy and emission market conditions: SO_2 emissions, pollution fees, and unexplored wind potential. The impact of SO_2 emissions on wind capacity growth was hypothesized to be negative, with more SO_2 emissions associated with slower wind capacity growth. The result shows that the coefficient for SO_2 emissions in the provinces is negative and statistically significant at the 0.05 level. This means that there is an eight percent decrease in the amount of wind capacity associated with a one percent increase in the province SO_2 emissions, controlling for other factors. This result is consistent with information found in the literature that posited that carbon-intensive interest groups may negatively affect wind power growth.

The coefficient for pollution fees in the provinces is statistically significant at the 0.05 level. To interpret the coefficient, there is a five percent increase in the amount of wind capacity associated with a one percent increase in the provincial pollution fee collected, controlling for other factors. The other variable of the energy and emission market conditions is unexplored wind potential. The result of the analysis indicates that this variable is negative but insignificant. This might indicate that unexplored wind potential is a necessary but not a sufficient condition for wind power development.

3.3. Economic and Social Environments

Regarding the influence of economic and social circumstances, the discussion is now focused on the results for per capita income, per capita GDP, unemployment rate, and population density. The coefficient of population density was insignificant, indicating that there is no linear relationship between provincial population density and wind capacity growth. The positively significant coefficient means that per capita income is positively correlated with wind capacity growth. To put the size of the coefficient into perspective, as the amount of per capita income increases by 1 percent, the amount of installed wind capacity increases by 3.4 percent.

The results for per capita GDP and unemployment rate are either insignificant or in opposite directions, suggesting a counter cyclical pattern of wind capacity growth. The size of electricity generation, electricity consumption, electricity price, and research and development input of funds in the provinces were included as controls, but none of them were significant in the results.

4. Conclusions and Policy Implications

Wind energy has become a fast-growing industry in China in the last decade. The development of the wind energy industry presents interesting policy questions. In the context of China, provincial policies were designed and implemented to stimulate the growth of wind power. This paper examines factors driving the growth of wind power capacity in the provinces, especially the impacts of provincial wind energy policies. A fixed-effect panel data statistical analysis is estimated with a longitudinal data set. With an R-squared value of 77.2%, the overall statistical model explains 77.2% of the variation in the installed wind energy capacity in the Chinese provinces—a very strong model fit. The results reveal that the adoption of wind energy policies and the adoption of a general energy plan at the provincial level are having positive effects on the growth of wind capacity in Chinese provinces. Specifically, with the adoption of wind policy over time, the installed wind power capacity increases by 70%. Similarly, the adoption of a general energy plan also leads to a 48.5% increase in wind generation capacity on average over time. The strong and positive policy-induced effects on the growth of renewables mirrors the findings from other national contexts on the research on Renewable Portfolio Standards [4,26]. The provincial wind energy policies serve as de facto renewable portfolio standards in setting the goals for renewable energy development, especially wind power.

Multiple policy implications can be drawn from this analysis. First, it is essential to maintain and strengthen current wind energy legislation to keep the strong momentum of wind capacity development in the provinces. As shown in this analysis, a province with wind policies is more likely to have a strong and robust wind capacity and relatively stable growth trajectories over time. The important policy implication of this study lies in the fact that effective wind power development in China is not only driven by implementing policies designed by the central government, but that provincial and local governments have a critical role to play in the process. This study demonstrated that substantial policy commitment is needed for provinces without such wind power policies, in order to speed up the development of wind energy.

Second, more aggressive provincial policies are needed to coordinate wind policies for grid connections. Ideally, the best solution is a national wind power grid legislation. Given that the central government of China has failed to pass national wind power grid legislation, provincial governments need to take policy actions to reduce the barriers for newly installed wind capacity to get connected to the grid. Given the widespread concern over provincial governments' restrictions on wind power's right to access to the grid, the best solution is to design and implement province-level grid connection policies to make a stronger commitment to wind power development.

Third, interconnection standards are needed to facilitate the utilization of existing wind power capacity. When comparing the wind power policies in the United States, Germany, and China, we find that the US has put into place strong policy guidelines on the interconnection standards between distributed generation and the electricity grid, and that Germany has been successful in making full use of its feed-in-tariff. Both interconnection standards and feed-in-tariff call for equal treatment of the renewable energy generators. The policy implication for China is that both national government and provincial governments should consider drafting rules facilitating the interconnections of distributed wind power generators to the electricity grid.

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