How Feed-in Tariff policy affects New installed capacity of wind energy in China

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Abstract

China promotes the development of the wind power generation industry to reduce carbon dioxide and tackle air pollution. Under China's wind generation subsidy policy, the wind power generation industry has developed rapidly and is also maturing. Feed-in tariff (FIT)is a significant subsidy policy for wind power. This policy entails the government offering a fixed electricity price to wind power enterprises, ensuring a share of renewable energy in the energy mix. An accurate assessment of the impact of subsidy policies on the development of the renewable industry is an essential basis for the scientific development of government subsidy policies. Here, we propose a study on the impact of China's Feed-in tariff subsidy on the change in the installed capacity of wind energy. We employ a panel data regression to rigorously assess the magnitude of the impact of the Feed-in Tariff specified by the Chinese government on the development of the wind power industry. Finally, we derive the effect of the Feed-in Tariff on increased wind power installed capacity in Jiangsu, Shandong, and Guangdong, all in China's Type IV zone. We expect our findings can contribute to the moderate control of government subsidies and the development of the renewable energy industry.

Key words: Feed-in tariff, Installed capacity, wind energy

1 Introduction

In recent decades, renewable energy is increasingly being emphasized by governments around the world and wind power is an important part of the renewable energy component. Feed-in tariff

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is a policy mechanism where the government guarantees renewable energy producers a fixed premium price for the electricity generated. Chinese Government places more emphasis on the use of subsidies as a policy instrument than developed countries. Since the promulgation of the Renewable Energy Law(2006), new installations of wind power have begun to expand enormously. Wind power production increased from 24.9 gigawatt hours in 2009 to 656.71 gigawatt hours in 2021 (Statista, 2023). The Chinese government established four zones to provide different amounts of FIT subsidies based on the size of wind power in different regions of China. According to data provided by the National Development and Reform Commission (NDRC) in their report on wind power development(NDRC, 2009; NDRC, 2016), the FIT for Type IV zone reduced from ¥0.61 per kWh starting in 2009 to ¥0.57 per kWh in 2018.

This study demonstrates the impact of changes in the amount of FIT on the percentage change of new wind power installations in three provinces all in Type IV zones. The focus on China is important for various reasons. Firstly, as of 2023, the population of China is over 1.4 billion, which is about twenty percent of the world's population. China's huge population and increasing urbanization as a developing country will result in the country consuming a lot of electricity. According to data provided by Statista (Statista, 2023), the electricity consumption of China is 7,805.66 Terawatt hours. Secondly, China tries hard to transform its main fossil energy generation into non-polluting renewable energy generation. Third, there is a lot of evidence to show that FIT has a huge support for the newly installed capacity of renewable energy. As Zhang(2019) pointed out, wind energy subsidy policies have been a significant driver of the wind industry at the national level and in most regions.

To tackle this question we use panel data analysis to explore the impact of changes in FIT subsidy of wind power on the percentage change in the number of new installations capacity in three provinces that are in Type IV zones. Panel data analysis combines cross-sectional and time-series data, allowing us to examine in an integrated way the differences between provinces and the evolution of trends over a given time horizon. By focusing on the impact of fluctuations in FIT subsidy prices on wind capacity, we aim to gain insights into the impact of these policy changes on local wind power generation. This methodology also allows us to control for potential unobserved factors, and dynamic effects, thus strengthening the reliability and robustness of our findings.

We plan to rely on various subsidy policies and data on the amount of newly installed capacity. We obtained the measures of Feed-in tariff for wind power between 2009 and 2018 from the National Development and Reform Department. According to the Statistical report on China's installed wind power capacity by the Chinese Wind Energy Association, we obtained the data for the installed capacity of wind power of Jiangsu, Shandong, and Guangdong from 2008 to 2018. Those data show the variety of different variables related to wind power subsidy (FIT) dynamics and wind power expansion. It includes historical records of FIT subsidy rates, wind capacity installations, spatial and temporal fluctuations, and socioeconomic factors in the selected provinces. Statistical report on China's installed wind power capacity.

We hope that our research can contribute to the development of moderate government subsidies to support the development of the renewable energy industry. In addition, when delving deeper into the broader impact of our research findings, we revealed insights beyond the scope of our research. By elucidating the complex relationship between changes in wind power subsidy (FIT) prices and percentage changes in wind power capacity across different provinces, our research provides deeper insights into the policy dynamics shaping the adoption of renewable energy. Our research findings provide valuable insights for stakeholders on the effectiveness of FIT subsidy adjustments and encourage sustainable energy transition.

The rest of this research proposal is structured as follows. Section 2 provides a more profound overview of the literature that is relevant to our question. In section 3, we provide a conceptual framework to illustrate how we can derive the change of FIT on the percentage change of the newly installed capacity of wind energy in three provinces. Then, I provide an overview of the data source and summary statistics in section 4 and show the method that we choose to employ in section 5. Finally, we conclude in the last section and will discuss our study's further steps.

2 Literature review

Gwec(2021) points out global wind power capacity is growing rapidly and has become a major force in the renewable energy market. Governments around the world have implemented positive policy measures to support the development of wind power, such as on-grid pricing policies, subsidies, tax breaks, and renewable energy targets. As (Chin-Hsien Yu,2021) points out these measures have created a stable investment environment and encouraged both private and public sector investors to participate in wind power projects. Additionally, the wind power market is rapidly expanding globally, with emerging markets like China and India experiencing explosive growth and becoming some of the largest wind power markets in the world.

The implementation of renewable energy sources is impeded by the significant costs associated with their initial development, especially when compared to traditional fossil fuels. However, various policy measures can be implemented to address this issue, such as investing in research and development of new technologies, offering subsidies, and establishing feed-in tariffs (FITs). Rufei Ma(2021) points out that with the right public policies in place, private companies can be motivated to enhance renewable energy technologies (RET) and overcome challenges such as knowledge externalities, market uncertainties surrounding new technologies, and financing difficulties for research and development (R&D) projects. This statement also sideways illustrates the significant role that Feed-in Tariffs (FIT) play in driving the utilization of wind power for electricity production. FIT serves as a mechanism that provides renewable energy producers with long-term contracts at predetermined rates, thereby incentivizing the adoption of renewable energy. This approach not only promotes energy security but also helps to reduce carbon emissions.

For the FIT, to encourage investment in the renewable energy sector, the government implemented various policies aimed at providing energy producers with a guaranteed cost-based price. This incentive scheme was designed to attract more investors to the industry by offering them a stable and predictable return on investment, while simultaneously promoting the use of clean and sustainable energy sources. Such measures have been widely praised for their positive impact on the environment and the economy, as they not only reduce greenhouse gas emissions but also create new job opportunities and spur economic growth.

By utilizing these measures, it is possible to create strong domestic markets for renewable energy and promote a more sustainable future. In this paper, we are going to explore How the Feed-in Tariff policy of wind power affects the new growth rate of wind power installations. There is no study to quantify the impact of on-grid benchmark electricity price on the change of new installed capacity. The findings of the study have the potential to provide valuable direction for the formulation of policies aimed at promoting sustainable environmental practices while also fostering economic growth and development.

Vericourt (2016) points out, that wind power is characterized by instability, that is, the power generation of wind power will be affected by wind speed and change. This also causes the uncontrollability of wind power generation energy, and it is necessary to ensure a stable power supply through energy storage equipment and other forms of auxiliary power generation. This further raises the cost of wind power. Therefore, to encourage and drive the development of wind power, the feed-in tariff is an important consideration. If the feed-in tariff is too high, it may lead to insufficient demand for wind power, limiting its development. However, too low a feed-in tariff can not cover the cost of wind power generation, so wind power enterprises can not make profits, and also cause difficulties in its development.

Our main focus is to analyze the impact that the benchmark tariff has on the growth and development of recently established wind power facilities. Our analysis will be limited to this specific focus and will not include an exploration of the wider scope of the wind energy industry. Our analysis will involve a more in-depth exploration of the recent trends in wind power installations, with a specific focus on how electricity prices have impacted these changes.

3 Data

Our study seeks to quantify how the feed-in tariff affects the newly installed capacity of wind energy. To conduct a thorough analysis of the impact of feed-in tariffs on the growth of new wind power installations, a diverse range of data is indispensable. This data must encompass information regarding the installed wind power capacity across various regions, feed-in tariff policy, energy market data, as well as policy and regulatory documentation. By assimilating this data, we can gain valuable insights into the factors that influence the wind power market. Subsequently, this information can be used to guide the formulation of policies aimed at promoting sustainable energy development.

After conducting a thorough analysis of the provided data and charts, it has become evident that there are clear patterns in the development of wind power installed capacity and its correlation with subsidy policies. Specifically, the implementation of subsidy policies in the year 2009 resulted in a noteworthy surge in the growth rate of wind power installed capacity, exceeding an impressive 50%. This remarkable increase was observed across all three cities and was sustained with a consistent annual growth rate of approximately 25%. However, beginning in 2016, there was a gradual reduction in subsidy policies, which led to a significant decline in the growth rate of wind power installed capacity, even reaching a downward trend. This shift in policy had a noteworthy impact on the growth of wind power, which is evident in the resultant decline in installed capacity. It appears that there is a positive correlation between the feed-in tariff rate and the growth of wind power. This finding suggests that areas with higher feed-in tariff rates for wind power may be more likely to experience growth in this sector.

Table 1. The specific feed-in tariff policy in China with exact province

Classifications of wind resource regions

Region	FIT rates(CNY/kWh)	Administrative divisions
Region I	0.51	All regions in Inner Mongolia Autonomous Region except Chifeng City, Tongliao City, Xing'anmeng and Hulunbeir;Urumqi City, YiliKazak Autonomous Prefecture,ChangjiHui Autonomous Prefecture, Karamay City,Shihezi City in Xinjiang Uygur Autonomous Region
Region II	0.54	Zhangjiakou City and Chengde City in Hebei Province;Chifeng City, Tongliao City,Xing'anmeng and Hulunbeir in Inner Mongolia;Zhangye City, Jiayuguan City and Jiuquan City in Gansu Province
Region III	0.58	Baicheng City and Songyuan City in Jilin Province; Jixi City, Shuangyashan City, Qitaihe City, Suihua City, Yichun City,DaxinganlingArea in Heilongjiang Province; all regions in Gansu Province except Zhangye City,Jiayuguan City and Jiuquan City; all regions in Xinjiang Uygur Autonomous Region except Urumqi, Yili Kazak Autonomous Prefecture, ChangjiHui Autonomous Prefecture, Karamay City and Shihezi City; Ningxia Hui Autonomous Region
Region IV	0.61	Other regions not identified in Regions I, II and III

Table 2.The specific percentage change on the installed wind power capacity from year to year

Region	year	capcity	Region	capacity1	fit
Jiangsu	2008	648.25	Jiangsu		0
Guangdong	2008	366.89	Guangdong		0
Shandong	2008	562.25	Shandong		0
Guangdong	2009	569.34	Guangdong	0.5518	0.61
Shandong	2009	1219.1	Shandong	1.168253	0.61
Jiangsu	2009	1096.75	Jiangsu	0.691863	0.61
Jiangsu	2010	1467.75	Jiangsu	0.338272	0.61
Guangdong	2010	888.78	Guangdong	0.561071	0.61
Shandong	2010	2637.8	Shandong	1.163727	0.61
Guangdong	2011	1302.4	Guangdong	0.46538	0.61
Shandong	2011	4562.3	Shandong	0.729585	0.61
Jiangsu	2011	1967.6	Jiangsu	0.340555	0.61
Guangdong	2012	1691.3	Guangdong	0.298603	0.61
Shandong	2012	5691	Shandong	0.247397	0.61
Jiangsu	2012	2372.1	Jiangsu	0.20558	0.61
Shandong	2013	6980.55	Shandong	0.226595	0.61
Jiangsu	2013	3275	Jiangsu	0.380633	0.61
Guangdong	2013	2218.6	Guangdong	0.311772	0.61
Guangdong	2014	2758.38	Guangdong	0.243298	0.61
Jiangsu	2014	3676.15	Jiangsu	0.122489	0.61
Shandong	2014	8263.3	Shandong	0.183761	0.61
Shandong	2015	9523	Shandong	0.152445	0.61
Jiangsu	2015	4888	Jiangsu	0.329652	0.61
Guangdong	2015	3103	Guangdong	0.124936	0.61
Jiangsu	2016	6088	Jiangsu	0.245499	0.6
Guangdong	2016	3537	Guangdong	0.139865	0.6
Shandong	2016	11185	Shandong	0.174525	0.6
Jiangsu	2017	6556	Jiangsu	0.076873	0.6
Guangdong	2017	4050	Guangdong	0.145038	0.6
Shandong	2017	12700	Shandong	0.135449	0.6

Jiangsu	2018	8650	Jiangsu	0.319402	0.57
Guangdong	2018	3573	Guangdong	-0.11778	0.57
Shandong	2018	11460	Shandong	-0.09764	0.57

The date is obtained from www.docin.com

Table 3.Summary Statistics of Variable

Region	Observations	Max Capacity	Min Capacity	Average Capacity	Average Percentage Change	Average FIT	Variance in FIT
Guangdong	11	4050	367	2187	0.27	0.55	0.033
Jiangsu	11	8650	648	3699	0.31	0.55	0.033
Shandong	11	17200	562	6799	0.41	0.55	0.033

4 Conceptual framework

Government-subsidized feed-in tariff (FIT) programs are crucial in reducing the investment risk in wind energy projects. Firstly, the FIT guarantees a fixed price for the electricity generated by a wind energy project, providing a stable revenue stream. This revenue predictability reduces the sensitivity of the project's financial returns to market fluctuations, thereby reducing investment risk. Second, the guaranteed returns under the FIT enhance the financial viability of wind energy projects. Investors can anticipate more stable returns, critical to securing the initial capital investment. Third, the long-term price guarantee provided by the FIT attracts investors seeking stable, long-term returns, such as pension funds and insurance companies, effectively reducing the cost of capital. Finally, government subsidies under the FIT reduce uncertainty caused by policy changes. Consistency and continuity of policy support are crucial in guaranteeing the success of renewable energy projects. Overall, the FIT policy provides financial incentives and enhances the attractiveness of investment in the wind sector by reducing market and policy risks, thus contributing to the increase in installed capacity.

To investigate the relationship between changes in feed-in tariff (FIT) subsidies and the percentage change in wind power capacity across multiple provinces, we adopt a panel data analysis framework. This framework provides a structured approach to examine the dynamics of the variables involved. The core equation in our analysis is given by:

$$Capacity_{it} = \beta Fit_{it} + \alpha_i + \varepsilon_{it}$$

Wind Power Capacity (Dependent Variable): The central focus of our investigation is wind power capacity $Capacity_{it}$ representing the installed wind energy generation capacity in province (i) at time (t). This variable serves as a measure of the scale of wind power integration.

Feed-In Tariff (Independent Variable): The main independent variable is the feed-in tariff rate Fit_{it} in province (i) at time (t). FIT represent the financial incentive provided to wind power producers and are expected to influence the expansion of wind power capacity.

Province-Specific Fixed Effects: To account for unobservable province-specific characteristics that may impact wind power capacity but remain constant over time, we include province-specific fixed effects.

Based on the theoretical foundation, we hypothesize that higher feed-in tariff rates Fit_{it} will be positively associated with increased wind power capacity $Capacity_{it}$ across provinces and over time. The rationale behind this hypothesis is that more attractive FIT rates are likely to stimulate greater investment in wind power projects, leading to expanded capacity.

The relationship between feed-in tariff rates and wind power capacity can be visually depicted in a conceptual model. This model illustrates the hypothesized positive impact of FIT rates on wind power capacity growth, while accounting for province-specific effects.

The conceptual framework provides a theoretical lens through which we examine the interplay between feed-in tariff policies and wind power capacity integration. The framework guides our empirical analysis, helping us to discern the implications of policy incentives on renewable energy development.

5 Method

At the core of our study lies the policy instrument of feed-in tariff (FIT). FIT policies are designed to incentivize the adoption of renewable energy sources, such as wind power, by providing fixed premium prices for generated electricity. These policies aim to encourage renewable energy development, reduce reliance on fossil fuels, and mitigate environmental impact. The equation of our study is given by:

$$Capacity_{it} = \beta Fit_{it} + \alpha_i + \varepsilon_{it}$$

Where the dependent variable $Capacity_{it}$ is new wind power installations in province i in half year t. The independent variable Fit_{it} is the level of wind energy subsidy. β is the parameter for the slope of the variable Fit_{it} .α_i is a provincial fixed effects. ε_{it} is the error term.

$Capacity_{it}$ represents the wind power capacity at time 't' and in region 'i'. We selected ten years of data on the annual percentage change in installed wind power capacity in each province, while conforming to the FIT subsidy policy adjustments from 2009 to 2018. At the same time, the reason we chose the percentage change in the number of new installations per year in each province is that the Wind subsidy does not affect the number of installations over the past few years, as well as the fact that each province has a different demographic profile and a different electricity consumption profile. The percentage change more directly reflects the relationship between the two variables. In panel data analysis, this transformation enhances accuracy and interpretability.

βFit_{it} it signifies the coefficient corresponding to feed-in tariff (FIT) subsidies. These subsidies constitute a policy mechanism that incentivizes renewable energy production by offering fixed premium prices for generated electricity. The coefficient βFit_{it} it offers insights into the extent to which changes in FIT subsidies impact the growth of wind power capacity. The districts we have chosen are all in the same FIT subsidy zone, so their subsidy policy changes are the same.

α_i captures the fixed effects associated with region 'i'. This variable accounts for the unobserved heterogeneity among regions, which can influence wind power adoption due to factors not captured by the other variables. Region-specific characteristics such as geographical conditions, regulatory environment, and technological readiness may influence wind power capacity.The fact that the three provinces we have selected are all in the same type of fit subsidy zone shows that for all three provinces the contribution of wind size to wind power generation is very similar.

ε_{it} it denotes the error term, encompassing unobservable factors and random fluctuations that may impact wind power capacity changes but are not accounted for by the other variables.

We estimate the fixed-effects panel data model using appropriate statistical software. The estimated coefficient β quantifies the effect of FIT rates on wind power capacity, while controlling for province-specific characteristics. A positive β would suggest that higher FIT rates are associated with increased wind power capacity.

Furthermore, we assess the statistical significance of the coefficient β using t-tests to determine if the relationship is robust and not due to random chance. The inclusion of province-specific fixed effects helps mitigate concerns about omitted variable bias and endogeneity.

We have regressed our equation by a suitable method and obtained the R Squared. The results show a coefficient of determination R squared value of 0.228 .This relatively low R squared value suggests that the model explains 22.8 per cent of the variance in wind capacity, implying that there are other factors that are not captured by the model that are affecting the variation in wind capacity.

We interpret the relationship between the wind FIT tariff rate Fit_{it} and wind capacity $Capacity_{it}$ from the estimated model parameters. The coefficient β reflects the change in wind generation capacity with unit change in the benchmark tariff rate, holding other factors constant. The constant term α_i represents province-specific effects to account for unobserved heterogeneity among provinces.

6 Conclusion

The central question of this study is: How Feed-in Tariff policy affect the new installed capacity of wind energy in China? This question has important implications in the context of the energy transition. As the global demand for renewable energy continues to grow, understanding the relationship between policies and actual energy production is critical to achieving sustainable energy goals.

Our expected result is that there is a positive association between wind benchmark tariff policy and wind power capacity, controlling for other influencing factors. However, we also need to be aware of some limitations of this study, such as possible omitted variables, reliability of the data, and specification of the model.

Through this study, we have deeply explored the impact of the wind benchmark tariff policy on the consolidation of wind power capacity. Despite facing an anomalous (R^2) value (0.228), we still draw some valuable conclusions and reveal directions for future research. Our analyses show that there is a correlation between wind FIT tariff policies and wind power capacity. Although the model explains a portion of the variation, other factors may play an important role in influencing changes in wind power capacity. This suggests that we should consider more influencing factors, such as climatic conditions, technological development, and policy environment, to obtain a more comprehensive understanding. While this study provides a preliminary understanding of the relationship between wind benchmark tariff policies and wind capacity, many aspects warrant further exploration. Future research could consider more refined data analyses, comparisons across periods, and the effects of policy changes on the relationship. In addition, other renewable energy policy factors could be combined to deepen the understanding of policy integration effects.

This study provides an empirical basis for understanding the relationship between wind benchmark tariff policies and wind capacity integration. Despite the limitations, we believe that this study will provide a useful reference for the formulation and implementation of sustainable energy policies and contribute to the energy transition.

7 Appendix

Table 4.Regression Analysis Result Table

Variables	capacity1
Fit	10.607**
	(4.211)
constant	-6.078
	(2.544)
Oberservation	30
R-suqared	0.228
standard errors in paretheses	

Note: Standard errors in parentheses. *** p<0.01, **p<0.05, *p<0.1

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