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Research on the Impact of Government Subsidies on Total Factor Productivity of the New Energy Industry Under the "Dual Carbon" Vision

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Abstract: The Fifth Plenary Session of the 19th Central Committee of the Communist Party of China pointed out that the new energy industry has broad prospects and is expected to accelerate its development during the "14th Five-Year Plan" period. Whether new energy resources can be allocated more reasonably, how total factor productivity (TFP) changes, and what characteristics its driving factors have are crucial to the future development of new energy. This study selects data of A-share listed new energy enterprises from 2012 to 2023 as samples to explore the impact and mechanism of government subsidies on the TFP of new energy enterprises, and constructs a mediating effect model. The research results show that alleviating financing constraints plays a full mediating role in the process of government subsidies promoting the improvement of enterprises' total factor productivity. Therefore, the government should improve the subsidy mechanism, and enterprises should increase investment in innovation and R&D to continue promoting the improvement of enterprises' total factor productivity.

Keywords: Government subsidies; New energy industry; Total Factor Productivity (TFP); Financing constraints

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1. Introduction

In 2020, China proposed the "dual carbon" goals of "carbon peaking and carbon neutrality", aiming to reduce dependence on coal-based resources and achieve the sustainable development of the economy and society. Against this background, the new energy industry emerged as the times require. The high cost of renewable energy and the complex energy transformation have slowed down the development of the new energy industry, thus the government has played an irreplaceable role. Governments at all levels have increased tax incentives and subsidies for the new energy industry.

This study focuses on A-share listed new energy enterprises from 2012 to 2023. New energy enterprises are selected based on the criterion of taking non-fossil energy such as solar energy, wind energy, hydropower, biomass

energy, geothermal energy, and hydrogen energy as their core development directions. Different from previous studies, they focused on the impact of government subsidies on listed enterprises or the manufacturing industry, and only briefly discussed the new energy industry. This study starts from the micro level to conduct more targeted research on the development of the new energy industry. In addition, most existing studies regard corporate governance level as an independent influencing factor (such as directly acting on corporate innovation), while this study explores the dynamic regulatory value of governance level on the relationship between core variables. This study breaks the inertial cognition of "the more subsidies, the better". By accurately identifying the critical value of subsidy intensity, it clarifies the differentiated impact of subsidies on core indicators of new energy enterprises in different intervals, providing relevant theoretical support for financial reform [1].

2. Literature review and theoretical analysis

2.1. Government subsidies and total factor productivity of the new energy industry

The core of the incentive effect of government subsidies stems from the optimization of enterprises' "cost-benefit" structure. Wang pointed out that government subsidies have a significant role in promoting the total factor productivity of new energy enterprises, and this promoting effect is more obvious for state-owned enterprises and enterprises located in central and western regions; the mechanism shows that government subsidies can improve enterprises' resource allocation efficiency and innovation level by alleviating financing constraints [2]. Yang pointed out that there is a U-shaped relationship between technological innovation investment and total factor productivity of new energy enterprises. Only when technological innovation investment exceeds the extreme point can it promote the improvement of total factor productivity; government subsidies can regulate the inhibitory effect of financing constraints on the relationship between technological innovation investment and total factor productivity, thereby improving total factor productivity [3]. The following hypothesis is proposed: The hypothesis (H1) is government subsidies are positively correlated with the total factor productivity of new energy enterprises and can improve total factor productivity.

2.2. The impact of government subsidies on total factor productivity of new energy enterprises by alleviating financing constraints

The uniqueness of the new energy industry lies in its enormous capital demand at all stages of development, especially the initial stage. However, the particularity and income uncertainty of the new energy industry put them at a disadvantage when seeking external financing, making financing constraints a key issue that must be addressed in the process of improving the productivity of new energy enterprises [4]. The following hypothesis (H2) is proposed, where government subsidies improve the total factor productivity of new energy enterprises by alleviating financing constraints.

2.3. Government subsidies, corporate governance level and total factor productivity (regulatory effect of corporate governance level)

The impact of government subsidies on corporate governance level is realized through the linkage of resource support, external constraints, and market feedback. As policy-empowered resources, subsidies ease the capital pressure on enterprises, enabling them to improve internal control systems. Obtaining subsidies itself sends a positive signal about the enterprise's development prospects to the market, which can attract external investment, help enterprises optimize their equity structure, and drive the steady improvement of governance level. The

hypothesis (H3) is that the improvement of corporate governance level plays a positive regulatory role in the process of government subsidies affecting the total factor productivity of the new energy industry.

3. Research design

3.1. Sample selection and data source

This study excluded enterprises with missing financial data, ST and financial enterprises, and enterprises with asset-liability ratio greater than 1. It selected 800 new energy enterprises (including charging pile industry, lithium battery industry, etc.) from databases such as CSMAR for the period 2012–2023 as samples and conducts data processing.

3.2. Variable design

The variables are as follows:

(1) Dependent variable: TFP (Total Factor Productivity)
Referring to the research of Lu, this study adopts the OP method, LP method, and OLS method. The OP method is used for benchmark regression, and the LP method and OLS method are used for robustness tests [5];

(2) Independent variable: Government Subsidies (SUB)
Referring to the method of Wei, it is expressed as the natural logarithm of government subsidies [6];

(3) Mediating variable: Financing Constraints (FC)
Referring to Chen, it is expressed as the proportion of enterprise cash holdings [7];

(4) Control variables
(i) Enterprise size (size): Natural logarithm of the total assets of listed enterprises at the end of the period;
(ii) Return on assets (roa): Net profit / total assets at the end of the period;
(iii) Asset-liability ratio (lev): Total liabilities / total assets at the end of the period;
(iv) Enterprise age (Age): Current year minus the year of enterprise establishment;
(v) Ownership concentration (Gr10): Sum of the shareholding ratios of the top ten shareholders.

3.3. Model construction

$$TFP_{i,t}=\alpha_0+\alpha_1 SUB_{i,t}+\sum\alpha_j Controlsi,t+\varepsilon_{i,t+}\sum YEAR+\sum STKCD \quad (1)$$

In Model (1), TFP is total factor productivity, Controls are control variables, ε is the random disturbance term, and year and enterprise fixed effects are controlled.

Mediating models:

$$FC_{i,t}=\alpha_0+\alpha_1 LnSUB_{i,t}+\sum\alpha_j Controls_{i,t}+\sum YEAR+\sum STKCD+\varepsilon_{i,t} \quad (2)$$

In Model (2), FC is financing constraints.

4. Empirical tests and results analysis

4.1. Descriptive statistics

Using Stata 18.0 for descriptive statistics of the sample data, the results show that the maximum and minimum

values of TFP are 10.94 and 3.783, indicating that there is no significant gap in total factor productivity among enterprises. The difference between the maximum and minimum values of corporate governance level (CG) is only 0.5, indicating that the overall governance level of the sample is relatively concentrated.

4.2. Benchmark regression analysis

The test results show that TFP (1) does not include control variables, while TFP (2) includes control variables. In the first column, SUB is significantly positive at the 1% level with a coefficient of 0.087. In the second column, the correlation coefficient of SUB is 0.079, indicating that after considering control variables, government subsidies still have a positive impact on the total factor productivity of new energy enterprises. Hypothesis (H1) is supported.

4.3. Robustness tests

4.3.1. Endogeneity test

Referring to the test method of Wang, this study uses the 2SLS method and selects the lagged one-period government subsidy as the instrumental variable. The weak IV test results show that both Model 1 and Model 2 pass the weak instrumental variable test; the K-Paark LM statistic of the identification test rejects the null hypothesis at the 1% level, satisfying the identifiability of the instrumental variable [8]. The number of instrumental variables is equal to the number of independent variables, and there is no over-identification problem; government subsidies promote the improvement of the total factor productivity level of the new energy industry.

4.4. Mediating effect test

The test results show that LnSUB is negatively correlated with FC at the 1% level (-0.039) and positively correlated with TFP at the 1% level (0.003), indicating that government subsidies can alleviate enterprises' financing constraints. Hypothesis (H2) is supported.

4.5. Regulatory effect regression

Referring to the research of Pang for the regulatory effect test, to avoid the problem of "multicollinearity between interaction terms and main effect terms", the independent variable, regulatory variable, and interaction term are centered. The results show that the coefficient of SUB in the first column is 0.079, which is significantly positive at the 1% level. The coefficient of the interaction term between SUB and CG in the third column is 0.286, which is significantly positive at the 10% level, indicating that corporate governance level plays a positive regulatory role. Hypothesis (H3) is supported. Standardized decision-making can ensure that subsidies are accurately invested in R&D and equipment upgrading without being misappropriated or idle.

4.6. Heterogeneity test

The above verifies that Hypothesis (H1) holds, but are there differences in the policy effect impact of policy implementation in different regions?

4.6.1. Division by Eastern, Central, and Western regions

The test results show that the impact coefficients of the policy on the Central and Western regions are 0.180 and 0.164, respectively, which are more obvious than that in the Eastern region (coefficient 0.160). The reason is that China has long been committed to promoting coordinated regional development, and the economic development

level of the Eastern region is ahead of the Central and Western regions. To achieve the goal of common prosperity, the government has implemented policies inclined to the Central and Western regions. Enterprises in the Central and Western regions are more dependent on policy subsidies and have greater room for improvement; while the Eastern region has a high economic development level, and the development level will not fluctuate significantly.

5. Conclusions and suggestions

Taking A-share listed new energy enterprises from 2012 to 2023 as samples, this study puts forward hypotheses based on research questions and verifies them. It was concluded that He pointed out that government subsidies improve industrial total factor productivity by suppressing financing constraints [9]. Based on the above research conclusions, the following suggestions are put forward. From the perspective of government subsidies, Lu pointed out that since the new energy industry is in a stage of rapid development, various subsidy methods such as direct subsidies, tax reductions and exemptions, and loan interest discounts should be flexibly adopted according to the actual needs of new energy enterprises to improve the efficiency of subsidy fund use [10]. Additionally, the regulatory effect shows that corporate governance level will enhance the promoting effect of government subsidies on the total factor productivity of the new energy industry. From the perspective of enterprises, government subsidies should focus on supporting the technological R&D activities of new energy enterprises, encouraging enterprises to increase R&D investment, and promoting technological innovation and product upgrading. The government should build an industry-university-research cooperation platform to promote cooperation between new energy enterprises and universities in joint technological R&D and talent training.

Disclosure statement

The author declares no conflict of interest.

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