The impact of government subsidies on the green innovation capability of new energy automobile companies

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Abstract. The rapid development of the new energy automobile industry is inseparable from the support of government policies. The subsidy policy is an important policy tool that promotes the improvement of new energy green innovation capabilities to a certain extent. This paper divides government subsidies into two types, direct subsidies and indirect subsidies, and uses a panel regression model to compare and analyze the impact of the two types of subsidies on the green innovation capabilities of enterprises. The research results show that direct subsidies have a greater impact on the green innovation input of new energy companies than indirect subsidies, while indirect subsidies have a greater impact on new energy green innovation output than direct subsidies.

1. Introduction

With the continuous innovation of science and technology, environmental protection actions have also entered a new stage: a wave of environmental protection driven by innovation. From the perspective of green environmental protection, the rise of the new energy automobile industry is undoubtedly an important milestone in the new stage of environmental protection actions. Under the leadership of the government, new energy automobile companies are constantly improving the level of green innovation.

With the increasing competition in the field of new energy vehicles, how to formulate effective policies to encourage auto companies to innovate, especially green innovations related to new energy vehicles, to promote the rapid development of new energy industry technologies, is an urgent task for governments of all countries today. The Chinese government has also formulated various policies to promote the innovative development of the new energy automobile industry, among which the subsidy policy is a very important policy tool. There are many studies on the impact of subsidy policies on the innovation of new energy automobile companies in the existing literature. Zheng Guihua et al. [1] adopted the propensity score matching method and found through empirical tests that financial subsidies can effectively stimulate innovation in new energy automobile companies. Wen Xuwu et al. [2] established a fixed-effect regression model and concluded that Chinese government subsidies have a crowding-out effect on the innovation and R&D investment of new energy automobile companies. Based on panel data, Yao Cheng et al. [3] analyzed that government subsidies are negatively correlated with the profitability of new energy companies, and have an "inverted U-shaped" relationship with innovation capabilities.

However, the measurement indicators of “government subsidies” in most of the literature are different, which can be divided into three categories: the government subsidies in the non-operating income obtained by enterprises are calculated as government subsidies [4], or only the tax refund is used to measure Government subsidies [5] are also used to measure government subsidies by the sum of government subsidies and tax refunds [6]. Therefore, this article divides government subsidies into two...
categories: direct subsidies and indirect subsidies. Direct subsidies refer to enterprises that independently apply to the government through the establishment of technological innovation projects. After the government approves the establishment of the project, they can obtain special subsidies for innovation, which are ex-ante subsidies; indirect subsidies are some tax incentives implemented by the government to enterprises, such as tax refunds, which are ex post subsidies. This article will specifically analyze the impact of these two types of subsidies on the green innovation capabilities of new energy vehicle companies.

2. Research design

2.1. Research hypothesis

China is one of the first countries to initiate a new energy vehicle financial subsidy policy. In 2012, the State Council of China made a specific plan for the development of the new energy industry from 2012 to 2020, and the "Interim Measures for the Management of Financial Incentive Funds for Technological Innovation in the New Energy Automobile Industry" were also promulgated subsequently. This is China's beginning to increase government subsidies. To promote a landmark node of technological innovation in the new energy industry. According to incomplete statistics, before 2012, the number of patent applications related to new energy vehicles in China was only about 50,000, while the number of patent applications related to new energy vehicles during 2012-2019 exceeded 250,000. At the same time, in recent years, key vehicle companies have established a complete positive development system for new energy vehicles. New energy vehicle and power battery key companies have invested more than 8% in research and development, which is higher than the industry's world average. From this point of view, the subsidy policy has a certain promotion effect on the innovation ability of new energy automobile companies.

Therefore, is there any difference between direct subsidies and indirect subsidies in promoting the green innovation capabilities of enterprises? Although for the government, both direct subsidies and indirect subsidies can be regarded as a reduction in fiscal funds, they are different for enterprises. From the perspective of enterprises, the source of direct subsidies is government funds, and the source of tax refunds is the return of fees paid by the enterprises themselves. As for the green innovation capability, according to Tian Hongna's [7] research on the evaluation system of the green innovation capability of automobile manufacturing enterprises, the green innovation capability of new energy enterprises can be divided into green innovation input and green innovation output.

Since the direct subsidy is applied independently by the company, after receiving the subsidy, the company will naturally increase investment in innovation to ensure the smooth implementation of the project. It is difficult for the company to estimate the value of the tax refund before the project, and the tax refund is equivalent to "Own money" is more likely to be used by companies to expand their own scale. Therefore, tax refunds may have less impact on the company's investment in innovation. Based on this, hypothesis H1 is proposed: direct subsidies promote green innovation input of new energy companies more than indirect subsidies.

The acquisition of direct subsidies does not require the product to be inspected by the market. It only needs the government to consider the project feasible to obtain approval. In contrast, the conditions for obtaining tax refunds are more stringent, and only the products produced by the company are welcomed by the market and earn money. The money can only be returned. Therefore, for innovative projects, only after the enterprise has a certain innovation output can it be refunded, and the enterprise will accelerate the production of the innovation to get the tax refund. Based on this, hypothesis H2 is put forward: indirect subsidies promote more green innovation output of new energy than direct subsidies.

2.2. Data source and sample selection

According to the analysis in the research hypothesis, this paper takes 2012 as the starting point, collects panel data related to listed companies in the new energy automobile industry from 2012 to 2019, builds an econometric regression model, and compares and analyzes direct subsidies and indirect subsidies to
new energy companies’ green innovation input. And the impact of innovation output. The patent data used in this article comes from the wisdom bud patent database, and the company’s financial indicators are all from the annual report information disclosed by the listed companies in the resset financial database. Before data analysis, the sample data was screened and supplemented as follows: ①The number of new energy related patent applications is based on the search formula “(company name) AND (time range) AND (new energy vehicle OR electric vehicle OR fuel cell vehicle OR Hybrid Electric Vehicle OR Power Battery OR Drive Motor)” to search. ②Due to the incomplete disclosure of government subsidies or tax return indicators for some research samples, this article reads the company’s annual reports one by one to complete the missing data as much as possible. This paper finally selected the data of 15 companies listed on the Shenzhen-Shanghai Stock Exchange and whose main business is new energy vehicle manufacturing companies from 2012 to 2019 as the research sample.

2.3. Variable definition
The dependent variables in this article are the innovation input and innovation output of enterprises. The specific research direction is green innovation, so the measurement index of innovation output only uses the number of patent applications related to new energy vehicles. included. The independent variables are direct subsidies and indirect subsidies, which are measured by government subsidies and tax refunds respectively. The control variables are firm size and firm age. The specific variables and indicators are explained in the following table:

| Variable nature | Variable name | name | Description |
|-----------------|---------------|------|-------------|
| Dependent variable | Innovation input | IP | Use the R&D expenditures of the enterprise in the current period to represent the enterprise’s innovation input |
| | Innovation output | OP | Measured by the number of patent applications related to new energy vehicles |
| Independent variable | Direct subsidy | gov | Use the non-operating income-government subsidy items in the company’s annual report income statement to measure |
| | Indirect subsidy | tax | Measure with tax refund |
| Control variable | Business size | size | Use the current total assets of the company to represent the scale of the company |
| | Business age | age | Years of establishment as of 2019 |

2.4. Model settings
Due to the large gap between company financial data and patent data, in order to narrow the absolute difference between the data and make the data more stable, the natural logarithm of the model data is taken. The main measurement model is set as:

\[
\ln IP_i = \alpha + \beta_1 \ln gov_i + \beta_2 \ln tax_i + \beta_3 \ln size_i + \beta_4 \ln age_i + \epsilon_{it} \tag{1}
\]

\[
\ln OP_i = \alpha + \beta_1 \ln gov_i + \beta_2 \ln tax_i + \beta_3 \ln size_i + \beta_4 \ln age_i + \epsilon_{it} \tag{2}
\]

Among them, model (1) is used to verify hypothesis H1, and model (2) is used to verify hypothesis H2. i means different companies, i=1,2,3,...15. t means different years, t=2012,2013,2014,...2019. \( \epsilon_{it} \) is a random error term, which represents the total impact of explanatory variables and other random factors that are not included in the model on the explained variables.
3. Empirical analysis

3.1 Data descriptive statistics

Table 2. Descriptive statistics (The result obtained after taking the natural logarithm)

| Variable | AVERAGE | MIN     | MAX     | STDEV     |
|----------|---------|---------|---------|-----------|
| IP       | 20.8763844 | 16.0253408 | 23.4909637 | 1.59989206 |
| OP       | 4.26800556  | 1.09861229  | 6.38350664  | 1.05069433  |
| gov      | 19.1768976  | 13.4968193  | 22.1999855  | 1.97158458  |
| tax      | 18.8602507  | 0        | 21.8435388  | 2.59885859  |
| size     | 24.4607669  | 21.3436501  | 27.4677175  | 1.4224584  |
| age      | 2.978907    | 1.38629436  | 3.4677175  | 0.5162016  |

Perform data descriptive statistics on the collected data through EXCEL, and the results obtained are as shown in the above table. It can be seen that there is a large gap between the direct subsidies and indirect subsidies received by different companies, and some companies even receive zero indirect subsidies. At the same time, there is also a gap in innovation input and innovation output between different companies. The hypothesis proposed in this article is to study the relationship between these two gaps, so the hypothesis proposed in this article is of research significance.

3.2 Regression analysis results

3.2.1. Government subsidies and innovation input. The results of stepwise regression analysis with innovation input as the dependent variable are shown in the following table. The model is established (1) Separately analyze the influence of the control variable on the dependent variable, thereby reducing the error caused by the influence of the control variable on other independent variables. On the basis of model (1), two independent variables are added to form models (2) and (3) to better analyze the influence of a single independent variable on the dependent variable. In order to compare the effects of direct subsidies and indirect subsidies more intuitively, two independent variables are added to model (1) to form model (4).

This paper uses Eviews8.0 to analyze the data. First, the HAUSMAN test is used to obtain the model (3) using the FE model, and all other models use the RE model.

It can be seen from the regression results that the $R^2$ of the four models are all above 0.8, indicating that the fit of the four models is very high. It can be seen from model (1) that when independent variables are not added, the control variable firm scale has a significant positive influence on firm innovation input, while firm age has no significant influence on innovation input. The other three models are added to the self There is no significant difference between the results after the variables, which indicates that the control variables have no significant influence on the independent variables. At the same time, model (2) and model (3) reflect that at a significant level of 1%, direct subsidies have a significant impact on the innovation input of enterprises, while indirect subsidies have no effect on the innovation input of enterprises. Model (4) is a complete model used to verify H1. It can more intuitively see the difference in the impact of direct subsidies and indirect subsidies on innovation inputs, that is, direct subsidies have a greater impact on new energy companies' green innovation inputs than indirect subsidies. Therefore, H1 is proven.

Table 3. Panel model regression results

|       | (1)       | (2)          | (3)         | (4)         |
|-------|-----------|--------------|-------------|-------------|
| intercept | -7.748   | -6.945  | -7.490  | -6.707  |
|        | (-4.745***)| (-4.469***)| (-4.997***)| (-4.408***)|
| gov    | 0.102    |              |             | 0.107    |
|        | (2.873***)|              |             | (2.833***)|
| tax    | 0.012    |              |             | -0.003   |
|        | (0.758)  |              |             | (-0.201)|

3.2.2. Government subsidies and innovation output. The model construction process and meaning in this section are the same as the previous section, and the model regression results are as follows. Through the HAUSMAN test, we can see that except for model (1) using the RE model, the other models all use the FE model.

The $R^2$ of the four models is above 0.6, and the fit is good. Model (1) shows that the control variables of firm age and firm size both have a significant positive impact on firm innovation output. Model (2) shows that indirect subsidies have a significant impact on innovation output at a significant level of 1%, while model (3) shows that direct subsidies have no effect on innovation output. Model (4) can intuitively see that the impact of indirect subsidies on the output of new energy green innovation is greater than that of direct subsidies. Therefore, H2 is proven.

Table 4. Panel model regression results

|        | (1)        | (2)        | (3)        | (4)        |
|--------|------------|------------|------------|------------|
| intercept | -11.057    | -6.945     | -10.127    | -10.075    |
|         | (-7.184***)| (-4.469***)| (-7.001***)| (-6.786***)|
| gov         | 0.066      | 0.179      | 0.009      | 0.177      |
|         | (1.231)    | (3.920***)| (0.178)    | (3.673***)|
| tax         | 0.623      | 0.608      | 0.533      | 0.532      |
|         | (4.341***)| (4.236***)| (3.948***)| (3.918***)|
| age         | 0.555      | 0.486      | 0.388      | 0.381      |
|         | (10.405***)| (6.282***)| (5.961***)| (4.902***)|
| size         | RE         | FE         | FE         | FE         |
| model | 0.652      | 0.659      | 0.619      | 0.619      |
|         | (54.136)   | (36.808)   | (47.104)   | (34.943)   |

Dependent variable: OP

**Dependent variable: IP**

* p<0.05  ** p<0.01 *** p<0.001 The t value is in the brackets (the same below)

4. Conclusions and recommendations

After empirical testing, the main conclusions drawn in this article are as follows: (1) Combining the previous two conclusions, it is concluded that the direct subsidy promotes the green innovation input of new energy enterprises far greater than the indirect subsidy, and the indirect subsidy promotes the green innovation output of new energy far greater than the direct subsidy. (2) The scale of the enterprise itself has a significant positive influence on the innovation input and output of the enterprise, that is, the larger the total assets of the enterprise, the greater the proportion of innovation input. (3) The age of an enterprise has a significant effect on the innovation output of an enterprise, but has no effect on the innovation input. This may be because long-established companies have more mature technology and more innovation output, and the establishment time of a company does not affect the company’s input in innovation.

In response to the above conclusions, the following recommendations are made to the government and new energy vehicle companies: (1) For the government. First, because direct subsidies have a significant positive impact on the green innovation input of new energy companies, when companies apply for innovation project subsidies, the government can measure the subsidy intensity according to the technical difficulty of the company’s projects, and can add more to projects with high technical
difficulties. Large subsidies, and consider technical subsidies or technical training for companies that have not been established for a long time. Second, because indirect subsidies have a significant positive impact on the green innovation output of new energy companies, the government can appropriately provide companies with additional tax incentives based on the company's new energy patent conversion results and new product sales, and strict review Enterprises report data, thereby effectively promoting the improvement of their innovation output rate. Third, the government needs to balance the relationship between direct subsidies and indirect subsidies, formulate appropriate subsidy standards, and jointly promote the improvement of the green innovation capability of the new energy automobile industry.  

(2) For new energy automobile companies. First, companies should actively apply for innovation projects to obtain direct government subsidies, and consider the intensity of innovation input according to their own scale, so that the project can proceed smoothly, in order to gain government trust. Second, while accelerating innovation output, enterprises must also pay attention to quality while focusing on speed. Only when the quality of new products passes market testing can they receive more indirect subsidies. Third, companies that have been established for a long time should grasp their own technological experience advantages, accelerate innovation output, and enhance their own competitive advantages.

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Reference
[1] Zheng Guihua, Li Heli. Research on the Impact of Financial Subsidies on the Innovation Input of New Energy Automobile Industry——An Empirical Analysis Based on Propensity Score Matching Method[J]. Journal of Hunan University of Technology (Social Science Edition), 2019, 24(01) : 78-83.
[2] Wen Xuwu, Cao Yining. The impact of government subsidies on the innovation investment of new energy automobile companies[J]. Journal of Hangzhou Dianzi University (Social Science Edition), 2020, 16(02): 1-6.
[3] Yao Cheng, Xu Feng. The impact of government subsidies on the development of new energy industry[J]. Science and Technology Management Research, 2020, 40(21): 256-262.
[4] Jiang Cailou, Zhang Ying. Research on the impact of government subsidies on the innovation of new energy automobile companies[J]. Yuejiang Academic Journal, 2018, 10(04): 64-70+145.
[5] Yan Mi, Tan Dan. The development strategy of the new energy automobile industry under the influence of subsidy policy decline[J]. Modern Business, 2020(02): 32-35.
[6] Shao Wei, Yang Ke, Liang Jie. Government subsidies, R&D incentives and new energy vehicle innovation[J]. Progress in Science and Technology, 2018, 35(15): 69-75.
[7] Tian Hongna, Sun Qinqi. Research on the evaluation of the green technology innovation capability of automobile manufacturing enterprises based on cloud model[J]. Management Review, 2020, 32(02): 102-114.