An Empirical Analysis of the Impact of Government Subsidies on the Innovation of New Energy Automobile Companies before and after the subsidy policy declines

Ye Lu¹, Qin Liu¹, Ming dan Han¹,*
¹ Wuhan University of Technology
* Corresponding author: Ming dan Han, email: hmd@whut.edu.cn

Abstract. This article uses 2016 as the time node, divides 2009-2019 into two phases before and after the subsidy policy declines. It uses the panel data of 15 listed companies whose main business of new energy is the production and sales of new energy vehicles. Regression model and panel regression model respectively analyze the relationship between government subsidies and the innovation performance of new energy automobile companies.

1. Introduction

New energy vehicles are one of China's strategic emerging industries. Since 2009, China has gradually established a supporting policy system based on fiscal and taxation policies, which has promoted the development of China's new energy vehicle industry from scratch. The new energy automobile industry policy has played a key role in promoting the innovation and development of China’s industry, but it also faces questions about “intervention in the market”, “intervention in technology routes”, and “overdraft consumption”, and “fraud to compensate” and “subsidy dependence” Disease" and other issues. How to make policy formulation more scientific and effectively promote the innovative development and technological breakthroughs of the new energy automobile industry is a major issue facing the current development of the new energy automobile industry.

In the existing literature, there are a large number of studies on the impact of government subsidy policies on enterprise innovation output. Li Lei¹ introduced the extended Cobb Douglas production function and concluded that government subsidies have a significant incentive effect on enterprise innovation. Li Shuang² used the Stochastic Frontier Production Model (SFPM) to conclude that the role of government subsidies in promoting the innovation activities of new energy companies has not been effectively brought into play, but instead has a significant "crowding out" effect on the innovation efficiency of enterprises. Using balanced panel data, Pan Xiongfeng³ et al. concluded that there is an inverted "U" curve relationship between government funding and technological innovation based on the production knowledge function.

Regarding the impact of the government subsidy policy on new energy companies after the decline, there are currently few relevant documents. Yan Mi⁴ et al. used 2016-2018 panel data to construct a regression model, and concluded that corporate innovation is not only affected by external government intervention, but also by corporate differences. Therefore, companies increase investment in innovation to increase corporate profitability after government policy declines.

In view of the current few literatures to discuss the impact of subsidy policies on the innovation output of new energy companies from the two stages before and after the policy decline, this paper studies the substantial innovation of enterprises before the policy decline in these two stages. The impact
of the policy and the way companies respond after the policy declines. Moreover, most of the current literature uses the number of patent applications of new energy automobile companies to measure the innovation output of enterprises when studying the impact of government subsidies on the innovation output of new energy automobile companies.\[5\] However, due to the frequent occurrence of "fraud compensation" phenomenon, it is still controversial whether the innovation performance of new energy automobile companies can be directly measured by the number of patent applications. This article refers to the innovation output measurement indicators in the existing literature\[6\], and uses the patent authorization volume indicator to replace the patent quantity indicator to measure the enterprise innovation output.

2. Research design

2.1. Research hypothesis
From 2009 to 2016, China, from the central to various local governments, directly or indirectly formulated various policies to promote the promotion and application of new energy vehicles to help new energy vehicles achieve technological breakthroughs. According to statistics by He Wentao\[7\] and others, from 2009 to 2015, Chinese auto companies applied for a total of 73,802 patents, of which 5,560 patent applications related to new energy vehicles, and the number of patent applications is increasing year by year. However, in 2016, the Ministry of Finance of China revealed that some companies in the new energy automobile industry intend to defraud the state's financial subsidies to exceed 1 billion yuan, and some companies have already cancelled their vehicle production qualifications. This leads to the thinking of this article: Have government subsidies promoted a substantial increase in the number of patent applications? At the same time, is the number of patents applied for by enterprises only the "superficial" innovation output, and how many patents can really be granted? The first part of this article uses data from 2009 to 2016 to analyze the impact of government subsidies on the substantive innovation output of enterprises before the subsidy policy declines. In summary, this article proposes hypotheses:

H1 The impact of government subsidies on the number of patent applications by new energy automobile companies is far greater than the impact on the number of patent grants.

After the "fraud compensation" incident, the government adopted subsidies and retreat measures in due course, and under the guidance of policies, through raising the barriers to entry, leading technological progress. During the "13th Five-Year Plan" period, the government implemented a subsidy policy for new energy vehicles and reduced the subsidy standard year by year. After 2020, the subsidy policy will be completely withdrawn. Simultaneously, the technical threshold for enterprises to receive subsidies has increased, forcing enterprises to carry out technological innovations related to new energy vehicles. Therefore, after the new energy vehicle subsidy policy declines, how companies should formulate appropriate response strategies to continue to promote their own development is the second issue that this article will study. The second part of this article focuses on the data from 2016 to 2019 and analyzes the decline of subsidy policies. Compared with the company's own R&D investment, which aspect of the external impact of government subsidies on enterprises can promote the development of enterprises? R&D investment is the internal driving force and source of technological innovation, while government subsidies are only used as external support to promote enterprise innovation. As a result, this article proposes hypotheses:

H2 The influence of enterprises' own R&D investment on enterprise development is greater than the influence of policy subsidies on enterprise development.

2.2. Data source and sample selection
This paper selects the panel data of listed companies in the new energy automobile industry to construct an econometric regression model to analyze the impact of government subsidies on the innovation performance of new energy companies in the two stages before and after the subsidy policy declines. The patent data used in this article comes from the Wisdom Bud patent database, the government subsidy data comes from the Cathay Financial database, and other company financial indicators are from the
annual report information disclosed by the listed companies in the resset financial database. Before data analysis, the sample data was manually supplemented and screened as follows: ① Since most of the government subsidy indicators disclosed incomplete information in the research samples, this article read the company's annual report one by one to complete the missing data. ② Some companies did not disclose the company's annual report before 2009, and the data was seriously missing, so the data of these companies were excluded. ③ In order to avoid data omissions, the patent data of the parent company of the listed company and its holding subsidiaries are summed up. Therefore, this article finally selected 15 listed companies (BYD, King Long, Foton, JAC, FAW, Jiangling, Dongfeng, Changan, GAC, SAIC, Great Wall, Zhongtong, CRRC, Zotye, Ankai) whose main business was the production and sales of new energy vehicles in Shanghai and Shenzhen from 2009 to 2019 as the research sample.

2.3. Variable definition
As mentioned above, this paper starts from 2009 and uses 2016 as the node to divide the subsidy policy into two phases before and after the subsidy policy declines. Judging from the existing policy data, the impact of subsidy policies before and after the decline is very different, so it is necessary to study in stages. The specific empirical research process is chronological, using 2016 as the time node to split the data into two stages: 2009-2016 and 2016-2019. In this way, we can analyze the hypotheses at different stages, study the effects of subsidies and the response methods after subsidies decline, and analyze the relationship between government subsidies and the innovation of new energy automobile companies more comprehensively.

Due to the different problems and assumptions studied in the two stages, the model construction, the selection of dependent variables and independent variables are also different. The variable index selection and index explanation of the two stages are as follows:

| Research phase | Variable nature | Variable name | Name | Description |
|----------------|-----------------|---------------|------|-------------|
| Pre-subsidy phase | Dependent variable | Number of patent applications | PA | Number of patents applied for by the enterprise in the current period |
| | Number of patents granted | PG | | Number of patents granted |
| | Independent variable | Government subsidies | sub | The current government subsidy fees for business |
| | Control variable | Business size | size | Use the current total assets of the company to represent the scale of the company |
| Post subsidy phase | Dependent variable | Operating income | OI | Use the current operating income of the company to reflect the current operating situation of the company |
| | Independent variable | R & D spending | rd | Use the R&D expenditures of the enterprise in the current period to represent the enterprise's innovation investment |
| | Control variable | Business size | size | Use the current total assets of the company to represent the scale of the company |

2.4. Model settings
As the panel data model is used to analyze the influencing factors of the development of new energy automobile enterprises, in order to make the data more stable, the natural logarithm of the model data is taken, and the basic measurement model is set as:

\[
\ln AQ = \alpha + \beta_1 \ln age_{it} + \beta_2 \ln size_{it} + \beta_3 \ln sub_{it} + \varepsilon_{it} \quad (1)
\]

\[
\ln LQ = \alpha + \beta_1 \ln age_{it} + \beta_2 \ln size_{it} + \beta_3 \ln sub_{it} + \varepsilon_{it} \quad (2)
\]

\[
\ln OR = \alpha + \beta_1 \ln age_{it} + \beta_2 \ln size_{it} + \beta_3 \ln sub_{it} + \beta_4 \ln \ln rd + \varepsilon_{it} \quad (3)
\]
Among them, models (1) and (2) are used to verify hypothesis H1, and model (3) is used to verify hypothesis H2. i means different companies, i=1,2,3,...15. t means different years, t=2009,2010, ...2019. ε_it is a random error term, which represents the unobservable error caused by the different nature of enterprises and changes in time. Since H1 is assumed to have two dependent variables, the study by Guo Xiaodan[8] et al. uses multiple linear regression to analyze the impact of the same dependent variable on different independent variables; as for H2, panel data regression is used to test and analyze.

3. Empirical analysis

3.1. Before subsidy policy declines (2009-2016)

3.1.1. Data descriptive statistics

Table 2. Descriptive statistics of the main variables (all calculated after taking the natural logarithm)

| Variable | AVERAGE | MIN | MAX | STDEV |
|----------|---------|-----|-----|-------|
| size     | 24.15905| 21.34365| 27.10445| 1.35734 |
| age      | 3.089962| 1.386294| 4.189655| 0.576495 |
| sub      | 19.10997| 14.39629| 22.1058| 1.763504 |
| PA       | 6.261968| 3.091042| 8.746239| 1.489248 |
| PG       | 5.896487| 2.772589| 8.453188| 1.572956 |

Descriptive statistics of data through EXCEL are shown in the above table. From the above data analysis, it can be seen that there is a large gap in the government subsidies received between different enterprises. At the same time, there is also a gap between the statistical values of the number of patent applications and the number of patent grants, which proves that the research on hypothesis H1 in this article is meaningful.

3.1.2. Regression analysis results

This paper uses Eviews 8.0 software to perform regression analysis with the number of patent applications and the number of patent grants as dependent variables.

It can be seen from Table 3 that the company age, company size, and government subsidies are used as independent variables, and the number of patent applications is used as the dependent variable to perform linear regression analysis. The model R^2 is 0.708, and the model passes the F test (F=37.131, p=0.000<0.05). In addition, the VIF values in the model are all less than 5, which means that there is no collinearity problem; and the DW value is near the number 2, which means that the model does not have autocorrelation and the model is better overall.

A specific analysis of the effect of independent variables on dependent variables shows that the age of the company does not affect the number of patent applications (t=-0.729, p=0.469>0.05); the regression coefficient of the company size is 0.447 (t=3.473, p=0.001<0.01), which means that the size of the company will have a significant positive impact on the number of patent applications; the regression coefficient of government subsidies is 0.265 (t=2.697, p=0.010<0.01), which means that government subsidies will affect patents The number of applications has a significant positive impact relationship.

Table 3. Multiple regression analysis results

| Regression coefficients | VIF |
|-------------------------|-----|
| constant                | -8.786 (-3.814***) |
| age                     | -0.168 (-0.729) |
| size                    | 0.447 (3.473***) |
| constant                | - |
From Table 4, we can see that the company age, company size, and government subsidies are used as independent variables, and the number of patent grants is used as the dependent variable for linear regression analysis. This model has a high degree of fitting and does not have a collinearity problem. Specific analysis of the effect of independent variables on dependent variables shows that the age of the company does not affect the number of patent grants (t=-1.070, p=0.290>0.05); the regression coefficient of total assets is 0.707 (t=5.274, p =0.000<0.01), which means that total assets will have a significant positive impact on the number of patent grants; government subsidies will not have an impact on the number of patent grants (t=0.693, p=0.492>0.05).

By comparing the results of the two linear regressions, it can be seen that when the number of patent applications is used as the dependent variable, for every 1% increase in government subsidies, the number of patent applications will increase by 0.625%, that is, government subsidies have a significant positive impact on it; but when the number of patent grants is used as the dependent variable, the independent variables and control variables remain unchanged, but government subsidies have no significant influence on it. This verifies the above conjecture and shows that the influence of government subsidies on the number of patent applications by new energy automobile companies is far greater than the influence on the number of patent grants. In other words, government subsidies have greatly affected the growth of the number of patent applications by enterprises, but the number of patents that can be granted has not increased simultaneously, reflecting that a large number of patent applications by enterprises may only be used to obtain government subsidies with a high number of patents. Without effectively focusing on patent quality.

### 3.2. Subsidy policy decline period (2016-2019)

#### 3.2.1. Data descriptive statistics

| Variable | AVERAGE | MIN   | MAX   | STDEV |
|----------|---------|-------|-------|-------|
| size     | 24.64961| 22.13745| 27.46722| 1.299542 |
| age      | 3.089962| 1.386294| 4.189655| 0.576495 |
| sub      | 19.15659| 13.49682| 22.19999| 2.08147 |
| rd       | 21.20015| 17.93219| 23.49096| 1.375348 |
| OI       | 24.28489| 19.24928| 27.51182| 1.538291 |
The descriptive statistics of the data at this stage are shown in the above table. It can be seen from this that there is a large gap in the government subsidies received between different enterprises. At the same time, there is also a gap between the number of patent applications and the statistical values of the number of patent grants, so the research on the hypothesis H1 in this article is meaningful.

3.2.2. Regression analysis results. First test the panel data. The panel regression model usually involves three models, namely the mixed POOL model, the fixed-effect FE model and the random-effect RE model. The test results are as follows, and the random-effect RE model is the final result.

Table 6. Summary of inspection results

| Inspection type     | Inspection purpose                                      | Test value | test results  |
|---------------------|--------------------------------------------------------|------------|---------------|
| F test              | Comparison between FE model and POOL model             | F =5.412, p=0.000 | FE model     |
| BP test             | Comparison between RE model and POOL model             | χ²(1)=13.594, p=0.000 | RE model     |
| Hausman test        | Comparison and selection of FE model and RE model      | χ²(3)=1.670, p=0.644 | RE model     |

The random effects model is used as the regression analysis result, and the regression analysis is carried out step by step. In the following table, model (1) is the regression model of controlled variables enterprise scale and enterprise age on operating income, and model (2) is introduced on the basis of model (1) Independent variable government subsidies, model (3) introduces independent variable R&D expenditure on the basis of model (1), model (4) introduces independent variable government subsidies and R&D expenditure at the same time.

It can be seen from the regression results that the R-square values of the four models are all above 0.9, indicating that the fit of the four models is very high. The four models all reflect that the size and age of the company have a significant positive impact on the company's operating income. At the same time, model (2) and (4) reflect that government subsidies have no influence on the operating income of enterprises. Model (3) and (4) reflect that, at a significant level of 1%, the company's own R&D expenditure has a positive impact on the company's operating income. Therefore, it is assumed that H2 is supported, that is, the impact of the company's own R&D investment on the development of the company is greater than the impact of policy subsidies on the development of the company.

Table 7. Panel model regression results

|           | (1)       | (2)       | (3)       | (4)       |
|-----------|-----------|-----------|-----------|-----------|
| intercept | -4.420    | -4.379    | -3.225    | -3.266    |
|          | (-4.010***)| (-3.867***)| (-2.976**)| (-3.000**)|
| size      | 1.123     | 1.117     | 0.834     | 0.829     |
|          | (29.592***)| (22.928***)| (8.209***)| (8.121***)|
| age       | 0.374     | 0.374     | 0.357     | 0.356     |
|          | (4.386***)| (4.335***)| (4.569***)| (4.534***)|
| sub       | 0.006     | (0.027)   | -0.023    | (0.844)   |
| rd        |           | 0.282     | 0.311     | (3.022***)|
|          |           |           |           | (3.119***)|
| R²        | 0.962     | 0.962     | 0.969     | 0.970     |
| F value   | 535.223   | 348.697   | 428.960   | 319.644   |

Dependent variable: OI

4. Conclusions and recommendations

This paper takes 2016 as the time node and analyzes it in two stages before and after the subsidy decline. The main conclusions are as follows: (1) Before the subsidy policy declines, the influence of government subsidies on the number of patent applications of new energy automobile companies is much greater than on the number of patents granted. That is, subsidies have less impact on the substantial innovation output of new energy companies. (2) In the post-subsidy period, the impact of enterprises' own R&D investment on enterprise development is far greater than the impact of government subsidies on enterprise development.
In response to the above conclusions, this article makes recommendations to the government and enterprises respectively: (1) For the government, first, intensify the examination of patent applications, raise the technical threshold of patent applications, and when granting innovation subsidies to enterprises cannot be measured by the number of enterprise patent applications, severely punish enterprises for fraudulent acts and prevent enterprises from applying for a large number of "useless" patents to obtain more subsidies, thereby reducing the average quality of patent applications. Second, the subsidy policy needs to slowly decline, increase the threshold for enterprises to receive subsidies and the accuracy of subsidies, gradually reduce their dependence on government subsidies, stimulate the internal motivation of new energy vehicle companies to innovate, and force new energy vehicle companies to carry out related activities. Technological innovation. (2) For new energy automobile companies. First, companies should not blindly pursue the number of patents and neglect quality. Instead, they should strive for excellence and improve the quality of their innovation output. Only by strengthening technological breakthroughs and mastering cutting-edge technologies can we hope to gain greater advantages in the industry. Second, after the subsidy policy declines, new energy vehicle companies should reduce their dependence on government subsidies and increase their own innovation investment, and use new products developed by the company as their own competitive advantage to promote corporate development and increased profitability.

Acknowledgment
This work is supported by the National Social Science Foundation of China(No. 19BSH105), the Fundamental Research Funds for the Central Universities(WUT: 2020VI028), and National innovation and entrepreneurship training program for college students S202010497038 and 202010497018.

References:
[1] Li Lei. Research on the impact of government R&D subsidies on the technological innovation output of the new energy automobile industry[J]. Science and Technology Management Research, 2018, 38(17): 160-166.
[2] Li Shuang. R&D intensity, government support and technological innovation efficiency of new energy enterprises[J]. Soft Science, 2016, 30(03): 11-14.
[3] Pan Xiongfeng, Pan Xianyou, Li Changyu. Study on the impact of Chinese government R&D funding on technological innovation[J]. Journal of Management Engineering, 2020, 34(01): 9-16.
[4] 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.
[5] Qi Te, Chen Lianghua, Wang Huiqing. An Empirical Analysis of the Relationship between Government R&D Subsidies and New Energy Automobile Companies' Innovation Performance—Based on the Intermediary Regulation Effect of R&D Expenditure and Technology Level[J]. Forecast, 2020, 39(05): 16-20.
[6] Tao Changqi, Zhou Xuan. Research on Provincial Technology Innovation Capability Evaluation under the Coupling of Environmental Regulation and Technology Spillover[J]. Scientific Research Management, 2016, 37(09): 28-38.
[7] He Wentao, Xiao Xingzhi. The impact of new energy automobile industry promotion policies on the patent activities of automobile companies—Based on the research of enterprise patent application and patent transformation[J]. Contemporary Finance, 2017(05): 103-114.
[8] Guo Xiaodan, He Wentao, Xiao Xingzhi. Government subsidies, additional behaviors and changes in R&D activities in strategic emerging industries[J]. Macroeconomic Research, 2011(11): 63-69+11.