Economic Research-Ekonomska Istraživanja

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rero20

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To cite this article: Tong Yang, Ziwei Yuan & Chen Xing (2023) Research on China's fiscal and taxation policy of new energy vehicle industry technological innovation, Economic Research-Ekonomska Istraživanja, 36:2, 2108100, DOI: 10.1080/1331677X.2022.2108100

To link to this article: https://doi.org/10.1080/1331677X.2022.2108100

Published online: 09 Aug 2022.

ECONOMIC RESEARCH-EKONOMSKA ISTRAŽIVANJA
2023, VOL. 36, NO. 2, 2108100
https://doi.org/10.1080/1331677X.2022.2108100

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Research on China's fiscal and taxation policy of new energy vehicle industry technological innovation

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ABSTRACT

Technological innovation in the new energy vehicle industry is conducive to the achievement of China's major strategic goal of 'carbon peak and carbon neutrality'. This research involved an empirical study on the relevant data of 14 listed new energy vehicle companies from 2012 to 2019. It used the entropy weight method to obtain the technological innovation index through the four indicators of research and development (R&D) investment, fixed asset investment, intangible assets, and patent application volume. Taking fiscal subsidies and tax burdens as independent variables, a fixed effect model was used to analyze the impact of fiscal and taxation policies on technological innovation in the new energy vehicle industry. The research results show that financial subsidies will encourage new energy vehicle companies to carry out technological innovation, the tax burden has no significant impact on the technological innovation of new energy vehicle enterprises, the scale and age of enterprises, as well as the proportion of R&D personnel to the total number of employees, will all encourage new energy vehicle companies to carry out technological innovation. Based on this, we put forward specific suggestions on further improving the fiscal subsidy and tax incentive policies.

ARTICLE HISTORY
Received 28 December 2021
Accepted 26 July 2022

KEYWORDS
Entropy weight method; fiscal policy; new energy vehicles; technological innovation

JEL CODES
H25; Q28; Q56

1. Introduction

The vigorous development of the new energy vehicle industry will help to realize the 'The Fourteenth Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of Long-term Goals for 2035', and it will broadly help to foster a green production lifestyle to achieve the 'carbon neutral' and 'carbon peak' goals. The automobile industry is one of the main industries in China, and new energy vehicles are an important aspect in the revitalization of the automobile industry and an area where various enterprises must compete. Moreover, new energy vehicles are a global cutting-edge scientific and technological field; they

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are also a key area for the future development of China's automobile manufacturing industry, and technological innovation in these vehicles is an important driving force in China's economic development. Technological innovation in new energy vehicle enterprises often encounters the 'double externalities' problem (Jaffe et al., 2005), the first of which is the positive externality of the technological innovation of new energy vehicle enterprises themselves. The key to technological innovation is the transformation of knowledge so that there is knowledge spillover. The spillover of knowledge often leads to a 'free-riding' behavior in some new energy vehicle companies when innovating. When the innovation results enter the market, other competing enterprises can imitate and copy technology (Arrow, 1962) so as to enjoy the innovation benefits brought about by the knowledge spillover. However, this also reduces the economic benefits that the innovative subjects themselves should obtain; in such a situation, there will be more and more technical replicators anticipating knowledge spillover in the market, and, more importantly, technology explorers who are willing to take the initiative to carry out independent research and development, which may lead to stagnation in terms of the level of technological innovation in society as a whole, which affects the economic development. The second is the positive externality of new energy vehicle technology innovation to protect the environment and save energy. New energy vehicles can reduce carbon emissions and reduce air pollution, reflecting their positive externalities to protect the environment. Moreover, the use of alternative power sources such as electricity and hydrogen in new energy vehicles can effectively reduce the use of non-renewable energy sources such as oil, which reflects its positive externality to saving resources. This positive externality is conducive to the development of China's economy in a green, low-carbon, and sustainable direction.

Since technological innovation in new energy vehicle enterprises is prone to the problem of 'double externalities', government support for new energy vehicle enterprises is indispensable (Ghisetti & Pontoni, 2015). In order to realize the innovative application of new energy vehicles, improve the rate at which new energy vehicles are used by in order to alleviate environmental pollution problems, and to have sufficient funds for enterprises to carry out technological innovation research and development, as well as enhancing China's technological innovation capabilities, the government has issued a number of fiscal and tax policies, such as research and development (R&D) subsidies, purchase subsidies, and tax incentives, but the new energy vehicle industry is still facing such difficulties as the 'long-term push' and technical bottlenecks that are difficult to break through, so research on the financial and tax support of industrial technology innovation is necessary. In the current situation of increasing downward pressure on China's economy, the fiscal and tax policies based on subsidies and preferential tax policies will be the main policies in promoting the long-term development of new energy vehicles in China, and whether the current specific tax policies can achieve policy objectives, continuously improve the competitiveness of new energy vehicle enterprises themselves, and promote the technological innovation and economic growth of enterprises is the main research content of this paper. Based on the current situation of the new energy vehicle industry, this study examined the existing relevant fiscal and tax policies in the industry, combined with the data of listed companies producing new energy vehicles, to explore whether fiscal and taxation policies can effectively stimulate new energy vehicle enterprises to carry out technological innovation, provide data support and a realistic basis for government policy formulation, and enable the Chinese government to adjust and optimize new energy vehicle subsidies in a targeted manner according to the actual innovation ability of new energy vehicles. Based on the empirical analysis results, the aim of the study was to put forward suggestions for policy improvement in order to promote the technological progress of new energy vehicle enterprises and promote the sustained and healthy development of the new energy vehicle industry.

2. Literature review

Although the development period of new energy vehicles has been relatively short, all countries attach great importance to the development of the industry and have formulated development plans suitable for their own countries. The specific development effects of the industry are attracting the attention of scholars. With regard to the necessity of developing new energy vehicles, Nakata (2003) studied whether the number of new energy vehicles would affect greenhouse gas emissions. His empirical analysis enabled him to conclude that the development of new energy vehicles could reduce greenhouse gas emissions, and he expounded the reasons for the feasibility of the development of the industry. Nichols et al. (2015) asserted that new energy vehicles will contribute to low-carbon development in the future and reduce energy consumption. Therefore, many countries have promoted new energy vehicles as national strategies with a view to changing the existing energy structure. Tan and Lin (2019) found that recognition of the role of new energy vehicles in improving urban air quality can increase sales of new energy vehicles, and people's willingness to buy new energy vehicles has also been increasing year by year (Christidis & Focas, 2019). In addition, the current status of new energy vehicles and the development of the industry are also attracting the attention of researchers. Rao (2020) quantitatively evaluated the development level of new energy vehicles. Liu et al. (2020) studied the support policies and patent applications of China's new energy vehicle industry, and pointed out that China's industrial policy has a significant influence on the number of patents. Meng and Jin (2019) established the new energy vehicle industry development capabilities based on an improved entropy method and mutation progression method. They pointed out that the new energy vehicle industry gap is large and lacks core technologies and independent innovation capabilities. Liu et al. (2021) pointed out that the policy combination composed of producer-oriented and consumer-oriented tools is synergistic and complementary, which can effectively promote the popularization of new energy vehicles. Zhou et al. (2019) outlined the dual-credit system (energy credit and green credit) and investigated its effects on green technology investments (GTI).

Scholars have also studied the fiscal and taxation policies related to new energy vehicles. Ma et al. (2017) pointed out that a series of tax incentives introduced by the Chinese government in recent years have played an important role in guiding the development of new energy vehicles. Li et al. (2020) used joint analysis methods to study the public's preferences for incentive policies and believe that consumers need to be more aware of them. Liu et al. (2018) pointed out that the key to promoting the rapid development of new energy companies lies in the degree of government incentives. Aerts and Czarnitzki (2004) study showed a strong positive correlation between financial subsidies and firms' innovative activities, and Hussinger (2008) also reached this conclusion in his study. Koga (2003) showed that for every 1% of tax revenues given up by the government, firms invested 0.68% more in R&D and innovation activities.

In terms of the impact of fiscal and tax policies on new energy vehicles, Masiero et al. (2016) discussed the incentives offered by the Chinese government (national and local governments) for electric vehicles. Shao et al. (2021) pointed out that government policies can improve the financial performance of enterprises and help them develop in a balanced way. Liu et al. (2018) stated that incentives offered as direct purchase rebates imposed by the government could increase the market acceptance of electric vehicles. Li et al. (2020) investigated public preferences for various incentive policies by using the conjoint analysis method. They found that, for consumers, the relative importance of different policy categories is ranked as follows: charging incentive policies, driving incentive policies, vehicle registering incentive policies, and purchasing incentive policies. Wu et al. (2020), based on a unique set of panel data from 127 listed companies in the Chinese automotive industry, pointed out that government subsidies can improve the technological innovation output of new energy vehicle enterprises. Cin et al. (2017) took Korean small and medium-sized manufacturing enterprises as a sample and found that government subsidies have a positive impact on enterprises' R&D expenditure through a two-stage dynamic panel data model approach. Wang et al. (2021) stated that government subsidies have a significant negative effect on the financial performance of new energy companies.

Our review and analysis of the existing literature shows that scholars have conducted a lot of research on the development of the new energy vehicle industry and related policies, especially the insufficiency of the fiscal and taxation policies in the industry, and put forward relevant suggestions; these provide a rich theoretical basis for follow-up practical research. In addition, scholars have enriched the research on the policy effects of the new energy vehicle industry. They have carried out theoretical research, demonstrated these with detailed data models, and conducted an in-depth analysis of the specific measures of financial subsidies and tax incentives. However, there is still a lack of research on the impact of fiscal and taxation policies on technological innovation in the new energy vehicle industry. Most of this research has been on the impact of fiscal and taxation policies on the R&D investment of new energy vehicle enterprises. Because the data on the new energy vehicle industry are relatively scarce, most scholars tend to use game theory and numerical simulation methods to analyze the government fiscal and taxation policies and the technological innovation behavior of enterprises. As a result, there are relatively few empirical studies on the impact of fiscal and taxation policies on the technological innovation of new energy vehicle enterprises. In addition, most research has focused on the incentive effect of fiscal and taxation policies on the technological innovation of enterprises, mainly studying the impact of fiscal and taxation policies on a specific type of enterprise such as high-tech enterprises or small and micro enterprises, or in a certain province, and research and analysis are rarely conducted on a specific industry. Moreover, at present, the focus of China's government subsidies is strategic emerging industries, and other scholars have also focused their research on this area while less independently analyzing the new energy vehicle industry as a research object. In order to better stimulate the new energy vehicle industry to carry out technological innovation and then promote the development of the new energy vehicle industry, it is necessary to carry out an in-depth study on the impact of fiscal and taxation policies on the technological innovation of new energy vehicle enterprises.

3. Relevant policies for the new energy vehicle industry

In a broad sense, the new energy vehicle industry refers to the collection of all producers and consumers in the new energy vehicle industry chain, from raw materials to components, complete vehicles, and supporting infrastructure, forming an upstream and downstream interconnected industrial chain. In this article, the term 'new energy vehicle' refers to a new type of car that entirely or partly uses unconventional energy sources, and leads in terms of drive system, body structure, vehicle function, and so forth. In addition, its key is the use of light-pollution or even zero-pollution energy as its driving force. In recent years, non-renewable resources such as oil have gradually become scarce, the ecological environment has been slowly destroyed in the process of economic development, and the rise of the new energy vehicle industry can effectively save resources and protect the environment (Nakata, 2003; Pradhan et al., 2006). In order to promote the take-up of new energy vehicles, the national government has issued a number of policies to promote the development of the industry. By the end of 2020, these laws and regulations resulted in the development of detailed plans for the industrial objectives, technological development path, infrastructure construction, and financial support of the new energy vehicle industry. They also introduced numerous incentives and support measures, such as R&D subsidies, purchase subsidies, and tax incentives (Wang et al., 2017). This study mainly examined the effects of the fiscal and taxation policies in the central regulations. Therefore, the relevant policies are divided into three categories: fiscal subsidies, tax innovations, and other categories.

3.1. Financial subsidies

As China has determined the new energy vehicle industry to be a strategic emerging industry, it has promulgated a series of policies aimed at ensuring the sustained and healthy development of the industry. In the early stage of the development of new energy vehicles, the state promulgated a number of policies to support industrial development. As the acceptance of new energy vehicles in the market gradually increased, the government gradually raised the threshold of financial subsidies and implemented a subsidy retreat policy to reduce the need for enterprises to respond to these policies. The government is relying more on market competition to induce producers to continuously improve their own technical level and product quality and to produce new energy vehicles to meet consumer demand, which should promote the sustained and healthy development of new energy vehicle enterprises. In this study, the fiscal policies at the national level were selected, as shown in Table 1.

Table 1. Summary of fiscal subsidy policies at the national level.

Release time	Text number	Regulation category	Policy content
January 2009	Caijian [2009] No. 6	Comprehensive Energy Regulations	Demonstration and promotion will be carried out in 13 cities, and purchase subsidies will be given to units purchasing new energy vehicles.
May 2010	Caijian [2010] No. 227	Comprehensive Financial Regulations	Seven new pilot cities were added, and five cities were selected to give individual purchase subsidies.
May 2010	Caijian [2010] No. 230	Comprehensive Energy Regulations, Comprehensive Financial Regulations	Determine the specific subsidy amount for different types of new energy vehicles, and clearly pay the subsidy funds to the production enterprises.
September 2012	Caijian [2012] No. 780	Comprehensive Energy Regulations	Set up R&D subsidies to encourage new energy vehicle companies to carry out technological innovation.
September 2013	Caijian [2013] No. 551	Comprehensive Environmental Protection Regulations	Adjust the purchase subsidy standards for new energy vehicles and begin to implement a decline mechanism.
January 2014	Caijian [2014] No. 11	Comprehensive Energy Regulations, Comprehensive Environmental Protection Regulations	Continue to adjust the purchase subsidy standards for new energy vehicles and reduce the subsidy funds for bicycles in proportion.
November 2014	Caijian [2014] No. 692	Rewards and Punishments	Reward for the construction of charging facilities.
April 2015	Caijian [2015] No. 134	Comprehensive Energy Regulations	Expand the scope of subsidies to the whole country and increase the rate of decline of purchase subsidies.
May 2015	Caijian [2015] No. 159	Petroleum Products Market	Reduce operating subsidies for traditional cars and provide operating subsidies for new energy buses.
January 2016	Caijian [2016] No. 7	Comprehensive Energy Regulations	Comprehensive awards and subsidies will be given to areas with relatively complete construction of supporting infrastructure, such as charging facilities, and large-scale promotion and application of new energy vehicles.
December 2016	Caijian [2016] No. 958	Comprehensive Financial Regulations	Adjust the new energy vehicle purchase subsidy standard, set the subsidy ceiling, and continue to implement the subsidy decline.
February 2018	Caijian [2018] No. 18	Comprehensive Energy Regulations	Improve the subsidy standards for new energy vehicles and raise the technical threshold requirements
March 2019	Caijian [2019] No. 138	Comprehensive Energy Regulations	Set the transition period subsidy standard; after the transition period, no purchase subsidy will be set.
April 2020	Caijian [2020] No. 86	Comprehensive Energy Regulations, Comprehensive Environmental Protection Regulations	Extend the purchase subsidy period and smooth the pace of subsidy decline.
December 2020	Caijian [2020] No.593	Comprehensive Energy Regulations, Comprehensive Environmental Protection Regulations	Adjust the purchase subsidy standard

Source: Authors' collection.The data comes from the Peking University Center for Legal Information, and its URL is http://www.pkulaw.cn/.

3.2. Tax incentives

In order to promote the production and use of new energy vehicles, the state has provided a large number of preferential tax policies and government subsidies. Starting with taxes, we discuss below the preferential tax policies for the new energy vehicle industry.

3.2.1. Preferential tax policies for value-added tax

In order to support the development of new energy vehicles, the state has set up certain financial subsidies, and the relevant tax laws and regulations clearly stipulate that the central financial subsidies are not subject to value-added tax; that is, there is no value-added tax levied on the government subsidies obtained by new energy vehicle enterprises. In addition, if new energy vehicle enterprises can independently develop energy-saving and environmental protection products, they can enjoy the preferential policy of refunding the value-added tax immediately or after collection.

3.2.2. Preferential tax policies for consumption tax

At present, China's cars are subject to the levy of a consumption tax. The basis for the collection of this tax on passenger cars and medium and light commercial buses is the cylinder capacity; that is, the lower the displacement of the vehicle, the lower the corresponding consumption tax rate will be. The power source of new energy vehicles is new energy, and compared with traditional cars, their displacement is lower, so the applicable consumption tax rate is also lower. In addition, the batteries required for new energy vehicles are mainly lithium-ion batteries (Li et al., 2017), and these are exempt from consumption tax. This reduces the production costs for battery companies that produce new energy vehicles to a certain extent. At the same time, the relevant policies provide that refined oil products are subject to consumption tax, and as new energy vehicles generally do not use these products or they use less than traditional cars, it reduces the tax burden on consumers.

3.2.3. Preferential tax policies for corporate income tax

China has always encouraged the development of high-tech industries. As an emerging industry, new energy vehicles face many technical problems and need to continue to break through and innovate, especially in the field of battery R&D and in respect of some key parts and components. The enterprise income tax policy stipulates that eligible high-tech enterprises shall be taxed at a preferential rate of 15%. In addition, in order to encourage technological innovation, the state has set up a preferential income tax policy that provides for a 75% deduction for R&D expenditure for development and design with respect to new products and technologies. This policy is a direct tax reduction that reduces the tax base of enterprises.

3.2.4. Preferential tax policies for other taxes

In addition to the above three taxes in the new energy vehicle industry, there are other tax incentives. Some small taxes have been set up with preferential policies, such as the vehicle purchase tax, customs duties, and vehicle and vessel taxes. Under the vehicle purchase tax policy, new energy vehicles are effectively exempt. The tax burden is ultimately borne by consumers and is levied at 10% of the price excluding tax. This tax burden is substantial, and the exemption from this tax shows that the government hopes to promote the use of new energy vehicles and achieve the goals of energy saving, emission reduction, and green environmental protection. Regarding preferential tariff policies, energy-saving and environmental protection equipment associated with new energy vehicles can be exempted from tariffs at the import link, and tax refunds can be applied for at the export link. The vehicle and vessel tax policy provides for exemption from this tax on new energy vehicles.

3.3. Other categories

There are many other types of policies supporting the development of the new energy vehicle industry. Since this study has focused on the impact of fiscal and taxation policies on new energy vehicle industry technological innovation, all other policies are classified into other categories. Among these policies, the impact is mainly to encourage the construction of new energy vehicle facilities-related policies and dual-point policies (Li et al., 2020). The latest government work report proposes to speed up the construction of supporting facilities such as charging piles. It can be seen that the state attaches great importance to the construction of supporting facilities for new energy vehicles, because supporting facilities are energy supply stations for new energy vehicles and are related to the promotion of new energy vehicles. In the supporting facilities policy, detailed plans have been made for the development of charging facilities, technological breakthroughs, electricity prices, and operational efficiency. The main target of the dual-point policy is passenger car enterprises; the government uses points accounting to manage the target enterprises.

4. Research hypothesis and sample index selection

4.1. Research hypothesis

After categorizing the relevant literature, we found that in terms of the mechanism of fiscal and taxation policies, most scholars have studied their impact on the new energy vehicle industry from two aspects: fiscal subsidies and tax incentives. The new energy vehicles referred to in this article are vehicles that are different from traditional fuel vehicles and use other forms of fuels. These include hybrid vehicles, pure electric vehicles, and hydrogen energy vehicles. Specifically, the new energy vehicles listed in the Catalogue of New Energy Vehicle Models Exempted from Vehicle Purchase Tax are the focus of this article.

There have been many studies on the impact of financial subsidies on technological innovation. Some scholars have found that increasing government subsidies can obviously encourage enterprises to carry out technological innovation, and there is a positive correlation between financial subsidies and enterprise R&D investment. With the increase in financial subsidies, the capital invested by enterprises in innovation also increases. It has a positive effect on the innovation and development of enterprises, but when observing the innovation output, it has been found that the impact of fiscal subsidies on it is not significant. Some scholars believe that financial subsidies have a positive impact on the number of patents granted by enterprises, and they have found that financial subsidies can effectively increase the number of patent applications by enterprises.

In the initial stage of the development of the new energy vehicle industry, companies will face problems that affect their subsequent development, such as small scale, low capital, and backward technology. These problems will make it take more time for those companies to be accepted by consumers. The timely provision of financial subsidies by the government can enable enterprises to have more funds for R&D investment and thereby have more confidence in their technological innovation and improve the safety technology and other performance of new energy vehicles, which will open the market faster. In China, it is only when the new energy vehicle models developed and manufactured by new energy vehicle enterprises meet certain technical standards that new energy vehicle enterprises can obtain promotion subsidies. This is conducive to reducing the technical threshold for enterprises to enter the new energy vehicle industry, sharing the cost of technological innovation of enterprises, and improving the enthusiasm of enterprises for technological innovation. Therefore, promotion subsidies can stimulate technological innovation in new energy vehicle enterprises by creating high innovation returns for advanced technologies.

Therefore, this study proposed hypothesis 1:

> Hypothesis 1: Financial subsidies promote the technological innovation of listed new energy vehicle companies.

Scholars have found that the sensitivity between R&D investment and cash flow is positively correlated with the tax burden borne by enterprises; that is, the heavier the tax burden borne by enterprises, the stronger the sensitivity between them. Accordingly, the intensity of the R&D investment will increase. Moreover, the tax preference can significantly stimulate the technological innovation of enterprises. The greater is the tax preference, the more R&D investment by enterprises, and the lower is the tax burden of enterprises, the more R&D investment.

In general, tax incentives can have a positive effect on technological innovation in the new energy vehicle industry in terms of reducing the marginal cost of innovation, because they alleviate the corporate financing constraints and enhance the innovation risk compensation. On the one hand, the technological development of the new energy vehicle industry is not yet mature, and R&D innovation has a huge rigid demand for capital flow. Higher tax incentives can maintain a relatively sufficient level of profit for enterprises, and enterprises can reduce their expenditures with their receipt of these incentives. Production and operations are transferred to technology R&D. On the other hand, the tax preferential policies represented by R&D expenses plus deductions are conducive to enterprises themselves being able to enhance their innovation enthusiasm and expected benefits, and, to a certain extent, reduce the possibility of uncertainty caused by innovation activities. The potential negative effects of the new energy vehicle companies are offset by the necessary compensation and guarantee for their innovative R&D. To this end, this study used this combined theoretical analysis to propose hypothesis 2:

> Hypothesis 2: When the degree of tax incentives is higher, it is more conducive to the release of the technological innovation effects of new energy vehicle companies.

4.2. Selection of sample indicators

The sample of the empirical analysis part of this study came from listed companies whose main business is automobile manufacturing and sales. First of all, the use of stock trading software such as Flush finds the concept plate, classifies it according to the concept of the new energy vehicle industry, and selects all the enterprises in the concept plate as the initial sample company for research. It should be noted that the 'new energy vehicle enterprises' in this article refer to automobile enterprises that can develop and manufacture new energy vehicles. This article draws on the practice of Sung (2019) to determine whether the automobile company is a 'new energy vehicle enterprise' by querying whether the sales business of the enterprise on the official website of the automobile company contains new energy vehicles. If the official website of the automobile enterprise indicates that the sales business of the automobile enterprise includes new energy vehicle products, the automobile enterprise will be defined as a new energy vehicle enterprise. In addition, since China's new energy vehicle industry has only gradually developed since 2012, the time period of 2012–2019 was selected as the sample interval. We removed Special Treatment (ST) or Particular Transfer (PT) listed companies in the eight years from 2012 to 2019. When collecting the data required for empirical analysis, we found that the relevant data for some companies were incomplete. Therefore, we removed these companies and finally obtained valid data for 14 listed companies. The data used in the study came from the annual reports published by the sample companies and relevant information from the National Patent Office. Excel (Microsoft, Redmond) was used to calculate and summarize the required indicators, and Stata 15.0 was used to complete the empirical analysis of each indicator.

Based on the data of the 14 listed new energy vehicle companies over 8 years, we set up the index of the technological innovation, government subsidies, and tax burden and explored the influence of fiscal and taxation policies on the technological innovation of the new energy vehicle enterprises and, from this, we drew our conclusions.

4.2.1. Interpreted variables

The whole process of technological innovation activities can be divided into two stages of technological innovation: the input stage and technological innovation output stage. For the measurement of the technological innovation indicators, if only the input stage is considered, the results of the study cannot explain whether enterprises' investment in R&D will eventually bring technological innovation output. In addition, it is meaningless to ignore the input and only talk about the results. Therefore, the two stages need to be considered comprehensively. In this study, the investment stage of technological innovation was measured by the R&D input and fixed asset input, and the output stage was measured by the intangible assets and patent applications. The entropy weight method was introduced to summarize the four indicators in the two stages to obtain the technological innovation index. The specific data selection of the four indicators and the calculation process of the entropy method were performed as set out below.

1. Technological innovation index
   The notes to the financial statements of listed companies indicate the R&D expenses of the enterprise for the current year, and this category of expenses was

selected to represent the investment in R&D. Taking into account the risks and other factors, in general, larger enterprises have more investment in R&D, while smaller enterprises have less. In order to reduce the impact of the enterprise size on R&D investment, this study used the R&D investment intensity index to measure the R&D investment.

2. Fixed assets investment
   In this study, the net fixed asset account in the balance sheet was selected to measure the fixed asset input. The scale of the enterprise will have an impact on the level of the fixed asset investment. Large-scale enterprises have more investment in fixed assets, while small-scale enterprises have less. In order to reduce the impact of the enterprise scale on the investment in fixed assets, the capital expenditure rate was used to measure the fixed assets investment intensity, which was represented by the ratio of fixed assets to total assets.
3. Intangible assets
   To a certain extent, intangible assets reflect the technical level of enterprises. The amount of intangible assets stated on the balance sheet was used to measure intangible assets. Because the amount of intangible assets is usually large, in order to obtain a more stable result, it is treated in the evidence.
4. Patent application volume
   Scholars usually use the number of patent applications or patent authorizations in their research to measure patent indicators, but because the amount of patent grants is influenced by external factors, and it takes a certain amount of time from application to authorization, there is a time lag, so we selected the number of patent applications to measure the company's technology output in the current year.
5. Technology innovation index
   This study measured the technological innovation of enterprises by the index of technological innovation. Through the entropy weight method, the weight of the four indicators of R&D investment, fixed asset investment, intangible assets, and patent application volume were determined in the technological innovation activities, and the technological innovation index was summarized according to its corresponding value and weight calculation.

The calculation steps used for the entropy weight method were as follows.

1. Assimilation processing
   For the m sample companies, each company has n evaluation indicators, and Xij is used to represent the jth evaluation index of the ith company. The n evaluation indicators of the m sample companies form an original data matrix X = (Xij) m*n.

$$\mathrm{X} = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1n} \\ X_{21} & X_{22} & \cdots & X_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ X_{m1} & X_{m2} & \cdots & X_{mn} \end{bmatrix}$$

Since different evaluation indicators may have differences in direction, the original data need to be processed for convergence. Depending on the different directions, the evaluation indicators are mainly divided into two categories, positive and negative indicators, and the values of the positive and negative indicators represent different meanings. In general, the greater the absolute value of the indicator, the better the indicator is; therefore, different methods need to be used to standardize the positive and negative indicators.

Positive indicators:

$$Y_{ij} = \frac{X_{ij} - \min(X_{1j}, X_{2j}, \ldots, X_{mj})}{\max(X_{1j}, X_{2j}, \ldots, X_{mj}) - \min(X_{1j}, X_{2j}, \ldots, X_{mj}\Big)} \tag{4.1}$$

Reverse indicator:

$$Y_{ij} = \frac{\max(X_{1j}, X_{2j}, \ldots, X_{mj}) - X_{ij}}{\max(X_{1j}, X_{2j}, \ldots, X_{mj}) - \min(X_{1j}, X_{2j}, \ldots, X_{mj}\Big)} \tag{4.2}$$

2. Normalization processing

   Since there are different dimensions between indicators, formula (4.3) can be used to standardize the indicator data to ensure comparability between indicators that characterize different attributes.

$$P_{ij} = \frac{Y_{ij}}{\sum_{i=1}^{m} Y_{ij}} \tag{4.3}$$

Finally, the standardized matrix is obtained.

$$\mathrm{P} = \begin{bmatrix} P_{11} & P_{12} & \cdots & P_{1n} \\ P_{21} & P_{22} & \cdots & P_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ P_{m1} & X_{m2} & \cdots & P_{mn} \end{bmatrix}$$

3. Determine the weight of the evaluation index

   Apply formula (4.4) and formula (4.5) to calculate the entropy value Ej and entropy weight Wj of each index.

$$E_j = \frac{\sum_{i=1}^{m} P_{ij} ln P_{ij}}{lnm} \tag{4.4}$$

$$W_j = \frac{1-E_j}{\sum_{j=1}^{n} 1 - E_j} \tag{4.5}$$

4.2.2. Explaining variables

1. Financial subsidies

   In order to obtain complete financial subsidy data, it is necessary to understand the accounting treatment principles used by enterprises when they receive financial subsidies. When the financial subsidy is not related to the company's daily operating activities, it is included in the non-operating income; when it is related to the company's daily operating activities, it is included in the other income account. The empirically selected data are for 2012–2019. However, the accounting standards for government subsidies were revised in 2017. Prior to 2017, government subsidies were not accounted for separately, but after 2017 they were accounted for separately as described above. Therefore, the measurement of financial subsidies needs to take into account the 2017 demarcation point. Until 2017, the amount of government subsidy was recorded under the non-operating income account selected, and after 2017, the sum of the amount of government subsidy under the two expense categories was used. It should also be noted that for some enterprises in some years the amount of tax rebates was included in the government subsidies for accounting purposes, so the selection of data for those companies needed to take that into account. In order to get a stable result, the financial subsidy data needed to be re-counted.

2. Tax incentives

   Many scholars take the income tax preferential force as the index to measure the preferential tax, but since the income tax incentives only involve enterprise income tax, the breadth is relatively small, and the enterprise income tax rate of new energy vehicles differs for different projects, so the data obtained are not accurate. Therefore, this study used the ratio of the various taxes paid by the enterprise to the total profit as an indicator to refer to the tax incentives of the enterprise.

4.2.3. Control variables

The technological innovation of an enterprise is a relatively complex process. In addition to being affected by independent variables, it is also affected by many control variables and some other variables, which are often unpredictable. Therefore, when conducting the empirical research in this study, after taking into account factors such as the scale of the enterprise, the age of the enterprise, and the employee composition, the following data were selected as the control variables.

1. The scale of the enterprise

   The operating status of an enterprise and its R&D capabilities are inseparable from the size of the enterprise. The larger the enterprise scale, the more the enterprise will have sufficient funds and the ability to bear potential risks and conduct more R&D independently. Smaller companies, without strong financial support, have a higher risk of trial and error, which results in weaker R&D capabilities. There is a certain connection between the appropriate scale and the

Table 2. Model variables and symbol design.

Variable	Variable name	Variable symbol	Calculation formula
Interpreted variables	Technology innovation index	TII	Entropy weight method
	Investment in research and development	R&D	Investment in research and development/Operating income
	Capital expenditure rate	CE	Fixed assets/Total assets
	Intangible assets	IA	Ln (Intangible assets)
	Number of patent applications	PA	Ln (Number of patent applications)
Explaining variables	Financial subsidies	gov	Ln (government subsidy)
	Tax burden	tax	Various taxes and fees paid by enterprises/Total profit
Control variable	The scale of enterprises	size	Ln (Total assets)
	Asset turnover rate	zczz	Operating income/Total assets
	The age of the enterprise	age	Ln (the age of the enterprise)
	Proportion of R&D personnel	RS	Number of technicians/Total number of employees

Source: Authors' design.

technological innovation of enterprises. Therefore, we determined that the size of the enterprise would be one of the control variables and that it would be represented by the total assets in the balance sheet.

2. The asset turnover rate
The development of an enterprise can be judged from its sales ability and profitability. Companies with better sales and profitability tend to have faster asset turnover, which further reflects the company's management quality and asset utilization efficiency. Accordingly, we introduced the asset turnover rate to measure these factors and set it as a control variable to exclude the impact of the enterprise asset utilization on the empirical regression analysis.
3. The age of the enterprise
The technological innovation capability of an enterprise is related to its capital situation. The earlier a company is established, and the more market share it has accumulated, the stronger its ability will be to bear R&D risks and the more willing it will be to carry out technological innovation. Therefore, we selected the age of the enterprise as the control variable and denoted this as age.
4. Proportion of R&D personnel
The technological innovation activities of enterprises are mainly carried out by R&D personnel. The number of R&D personnel is directly related to the company's technological innovation output. Different companies have different employee scales. In order to eliminate the impact of enterprise scale, we selected the proportion of R&D personnel to measure R&D personnel, and we represented this by RS (research staff). The proportion of R&D personnel (RS) = the number of technical personnel/the number of total employees.
The specific conditions of the above variables are shown in Table 2.

5. Model construction and empirical analysis

5.1. Model construction

In the empirical part, this study selected the panel data of 14 companies for 8 years. If only cross-sectional data or time series data are used, a more comprehensive analysis result cannot be obtained. Therefore, we used the panel data model for our research.

We constructed the following model based on our research hypothesis and variable design:

$$\mathrm{TII} = \beta_0 + \beta_1\mathrm{gov} + \beta_2\mathrm{size} + \beta_3\mathrm{zczz} + \beta_4\mathrm{age} + \beta_5\mathrm{RS} + \mu \tag{I}$$

$$\mathrm{TII} = \beta_0 + \beta_1\mathrm{tax} + \beta_2\mathrm{size} + \beta_3\mathrm{zczz} + \beta_4\mathrm{age} + \beta_5\mathrm{RS} + \mu \tag{II}$$

Model (I) explores hypothesis 1: the relationship between financial subsidies and technological innovation of China's listed new energy vehicle companies. Model (II) explores hypothesis 2: the relationship between the tax burden and technological innovation of new energy vehicle listed companies. In these models, $\beta 0$ is the individual effect, gov is the independent variable government subsidy in model (I), tax is the independent variable tax burden in model (II), size is the control variable enterprise size, zczz is the control variable asset turnover rate, and age is the control variable. The variable is the age of the enterprise, RS is the control variable; the proportion of R&D personnel, and μ is a random variable, which refers to other variables that affect the explained variable.

5.2. Empirical analysis

5.2.1. Descriptive statistical analysis

We used Stata 15.0 software to do the descriptive statistical analysis on each variable set in the empirical analysis; the results are shown in Table 3.

It can be seen from Table 3 that the average value of the technological innovation index of China's listed new energy vehicle companies is 4.195, and the standard deviation is 0.419. Because the technological innovation index is determined by the entropy weight method based on the R&D investment, capital expenditure rate, intangible assets, and patent applications, it can be seen that the technological innovation of the new energy vehicle companies is not stable, and the gap between the maximum value and minimum value is large. The average value of financial subsidies is 638 million yuan and the standard deviation is 954 million yuan. It can be seen that for the new energy vehicle industry, the government provides relatively large financial subsidies, but for different enterprises, there is a large gap in financial subsidies. The average value of the tax burden is 1.755, and the standard deviation is 5.101, which indicates that the tax burdens of different enterprises are quite different, and the tax

Table 3. Descriptive statistics of variables.

Variable	Mean value	Standard deviation	Minimum value	Maximum value
TII	4.195	0.419	3.211	4.854
gov	6.38E + 08	9.54E + 08	727,100	4.72E + 09
tax	1.755	5.101	−4.18	38.386
size	24.163	1.565	20.613	27.468
zczz	0.774	0.298	0.223	1.511
age	32.786	36.702	5	157
RS	0.2021	0.1178	0.042	0.643

Source: Authors' calculations.

burdens borne by the enterprises are relatively large. The mean enterprise size is 24.163, and the standard deviation is 1.5655, which indicates that there is a certain gap in the scale of new energy vehicle companies. The average asset turnover rate is 0.774, and the variance is 0.298. This indicates that, overall, the asset utilization efficiency of the listed new energy vehicle companies is relatively high, but there is a large gap in utilization efficiency between different companies. The mean value of the age of the enterprise is 32.786, and the variance is 36.702, which indicates that the gap in the establishment of the enterprises is large. The average proportion of R&D personnel is 0.2021, and the variance is 0.1178. This indicates that, overall, the R&D personnel of the new energy vehicle companies account for 20% of the company's total employees, and there is a certain gap between different companies. The minimum value is 0.042 and the maximum value is 0.643, which indicates that different new energy vehicle companies place different degrees of emphasis on R&D.

5.2.2. Pre-inspection

First, we will conduct a unified correlation test on the variables appearing in this study. The results are shown in Table 4.

The Pearson correlation coefficient between the variables in Table 4 shows that there is a significant correlation between the technical innovation index, financial subsidies, tax burden, enterprise size, return on assets, employee compensation, and the proportion of R&D personnel, which indicates that these variables are interrelated and can be regressively analyzed.

Second, according to the general model of the panel data, a total of 112 sample data from the 14 sample listed companies were imported into the formula for the Hausman test, and it was found that the *P* values of model (I) and model (II) were much less than 0.05. Therefore, fixed effects models should be established for both models.

Model (I) and model (II) were then tested for multicollinearity. The variance expansion factors of the two models are shown in Tables 5 and 6.

It can be seen from the test results in the table that the variance expansion factors of the variables in the two models are between 1.03 and 4.67, which are far less than 10. This fully shows that neither model has multiple collinearity and will not have a significant impact on the least squares estimate, so the model selection is appropriate.

In order to improve the accuracy of the regression results, annual dummy variables were defined for the two models to detect whether there is a time effect. The results of the test are shown in Table 7.

Table 4. Correlation analysis results.

Variable	tii	gov	tax	size	zczz	age	rs
tii	1.000						
gov	0.813***	1.000					
tax	0.210**	0.1089	1.000				
size	0.794***	0.863***	0.088	1.000			
zczz	0.167*	0.322***	0.104	0.286***	1.000		
age	0.223**	0.150	−0.012	0.207**	0.219**	1.000	
rs	0.284***	0.385***	−0.030	0.506***	0.460***	0.471***	1.000

Note: ***, **, and * are significant at the significance levels of 0.01, 0.05, and 0.1, respectively.
Source: Authors' calculations.

Table 5. Model (I) variance expansion factor table.

Variable	VIF	1/VIF
gov	4.19	0.238682
size	4.67	0.214272
zczz	1.34	0.746222
age	1.29	0.776510
rs	1.94	0.514711
mean value	2.69	

Source: Authors' calculations.

Table 6. Variance expansion factor table of model (II).

Variable	VIF	1/VIF
tax	1.03	0.969238
size	1.37	0.730392
zczz	1.30	0.771997
age	1.29	0.776534
rs	1.91	0.523533
mean value	1.38	

Source: Authors' calculations.

Table 7. Results of joint significance test of dummy variables.

Test items	Test value (*P* value)
Joint significance of dummy variables in model (I)	1.70 (0.1937)
Joint significance of dummy variables in model (II)	0.80 (0.6040)

Source: Authors' calculations.

Table 8. Empirical results of model (I).

	Model I				
Variables	(1)	(2)	(3)	(4)	(5)
gov	0.0450***	0.0229*	0.0224*	0.0302**	0.0303**
	(0.0130)	(0.0130)	(0.0133)	(0.0123)	(0.0119)
size	–	0.1630***	0.1626***	0.1087***	0.1266***
		(0.0379)	(0.0382)	(0.0373)	(0.0368)
zczz	–	–	0.0160	0.0054	0.0199
			(0.0812)	(0.0745)	(0.0725)
age	–	–	–	0.5843***	0.6037***
				(0.1391)	(0.1351)
RS	–	–	–	–	0.6722**
					(0.2631)
_cons	3.0540***	−0.3099	−0.3061	−1.3140*	−1.9583**
	(0.2310)	(0.8098)	(0.8145)	(0.7845)	(0.8014)
R○2	0.9381	0.9487	0.9487	0.9574	0.9604
N	112	112	112	112	112

Note: ***, **, and * are significant at the significance levels of 0.01, 0.05, and 0.1, respectively.
Source: Authors' calculations.

Model (I) and model (II) were examined, and it can be seen that the *p*-values were greater than 0.05, thus accepting the original hypothesis, so neither model (I) nor model (II) included the time effect.

5.2.3. Regression analysis

From the empirical results of Table 8, it can be seen that R^2 is 0.9604, which shows that the model equation is more reliable and can explain the hypothesis. Based on the results of the regression analysis, the following conclusions can be drawn.

The financial subsidy policy has a significant relationship with the technological innovation of listed new energy vehicle companies. The current financial subsidies and the technological innovation of the enterprises are significantly positively correlated, and this indicator has passed the t-test at a significant level of 5%. The coefficient of this indicator is 0.0303, which means that when the financial subsidy increases by one unit, the technical innovation index will increase by 0.0303 units. Hypothesis 1 passes validation. In terms of the entire new energy vehicle industry studied in this article, financial subsidies can promote the technological innovation of enterprises in the new energy vehicle industry. This is no different from the conclusions drawn by many scholars (Sun et al., 2019; Arqué-Castells, 2013; Duguet, 2003). This result is also in line with the basic theory of R&D subsidies. Government departments can guide the R&D behavior of enterprises to alleviate the problem of insufficient stimulation of the market economy for enterprises' R&D activities. Most of the government R&D subsidies in China's new energy vehicle industry take the form of special funding, which provides a certain guidance for the actual direction of a company's technological innovation, and the increase in the investment of enterprises in the R&D of key technology areas has resulted in a large number of patent applications and technological innovations. It can be seen that the hypothesis that financial subsidies promote technological innovation of listed new energy vehicle companies has been verified.

The scale of enterprises has a significant positive correlation with the technological innovation of listed new energy vehicle companies. The larger the size of the enterprise, the better the effect of technological innovation. This indicator passed the t test at the significant level of 1%. The coefficient of this indicator is 0.1266; that is, when the size of the enterprise increases, for each additional unit, the technological innovation index will increase by 0.1266 units. This is because larger companies are more financially powerful and can overcome the risks they encounter in their R&D activities. The accumulation of capital by enterprises over the years is positively related to the state of technological innovation. The earlier the establishment of the enterprise, the more of the market they can accumulate, and they are consequently more capable of bearing the risk of product research and development, resulting in a stronger willingness to carry out technological innovation. It can be seen that the scale of China's new energy vehicle listed companies has a certain impact on enterprise technology innovation.

There is a significant positive correlation between the age of the enterprise and the technological innovation of listed new energy vehicle companies. The older the company, the better the effect of technological innovation. This indicator passed the t-test at the significant level of 1%. The coefficient of this indicator is 0.6037; that is, when the age of the company increases by one unit, the technological innovation index will increase by 0.6037 units. The longer the enterprise has been in operation, the lower the additional resource constraints there are in terms of assets and lending capacity, which is conducive to the investment risk of the enterprise in technological innovation. Moreover, the longer the business life, the higher the levels of business management ability and experience are, which will also affect the technological innovation of the enterprise (Plank & Doblinger, 2018). It can be seen that the age of China's

Table 9. Empirical results of model (II).

	Model II				
Variables	(1)	(2)	(3)	(4)	(5)
tax	−0.0005	−0.0016	−0.0016	−0.0024	−0.0025
	(0.0033)	(0.0023)	(0.0023)	(0.0022)	(0.0022)
size	–	0.1947***	0.1961***	0.1129***	0.1184***
		(0.0186)	(0.0192)	(0.0306)	(0.0302)
zczz	–	–	0.0245	0.0682	0.0913
			(0.0744)	(0.0718)	(0.0716)
age	–	–	–	0.3875***	0.3698***
				(0.1143)	(0.1128)
RS	–	–	–	–	0.4790**
					(0.2371)
_cons	4.1961***	−0.5057	−0.5595	−0.2075*	−0.0154**
	(0.0154)	(0.4501)	(0.4808)	(0.5092)	(0.5100)
R○2	0.1928	0.6357	0.6330	0.5937	0.6012
N	112	112	112	112	112

Note: ***, **, and * are significant at the significance levels of 0.01, 0.05, and 0.1, respectively.
Source: Authors' calculations.

listed new energy vehicle companies has a great influence on their technological innovation.

The proportion of the number of R&D personnel to the total number of employees is positively correlated with the technological innovation of the listed new energy vehicle companies. This indicator passed the t-test at the significant level of 5%. The coefficient of this indicator is 0.6722; that is, when the number of R&D personnel in the total number of employees increases by one unit, the technological innovation index will increase by 0.6722 units. When an enterprise has more R&D personnel, the R&D success rate is higher, and it is easier to achieve technological innovation. At the same time, more R & D personnel also means that enterprises are more capable of engaging in technological innovation activities and are more inclined to increase technological innovation. This shows that the proportion of R&D personnel of listed new energy vehicle companies in China to the total number of employees has a great influence on technological innovation.

From the empirical results of Table 9, it can be seen that R^2 is 0.6012, which shows that the equation is relatively reliable, can explain the hypothesis, and, according to the regression analysis results, the correlation coefficient of tax incentives is estimated to be −0.0025, but the regression results are not significant; that is, the relationship between the tax burden and the technological innovation of listed companies with new energy vehicles is not significant, which shows that the tax incentives have no significant impact on the substantial innovation output of the new energy vehicle industry. The reasons for this result may come from the following aspects: first, the policy dependence leads to a blunting of R&D enthusiasm. Tax incentives alleviate the financial pressures of enterprises, and it is easy for enterprises to form policy dependence, which leads to this blunting in enterprises. The second aspect is the lack of further government oversight. After the provision of tax incentives, the government does not further track the use of subsidy funds and innovation output, and also lacks the performance evaluation of government policies, which encourages the research and development inertia of enterprises and leads to a gradual invalidation of preferential tax policies. The third aspect is the lack of novelty requirements for technological innovation. The preferential tax policies of the new energy vehicle industry do not mention the novelty requirements of innovation; that is, domestic or international leadership, which will adversely affect the quality of innovation and, to a certain extent, also causes a waste of preferential tax funds. The fourth aspect is an insufficient protection of intellectual property rights. The lack of intellectual property protection will lead to low infringement costs, reduce the incentive for enterprises to carry out in-depth innovation, and ultimately lead to a decline in the quality of innovation output. In addition, the scale of the enterprise, the age of the enterprise, and the number of R&D personnel in the total number of employees showed a significant positive correlation with the technological innovation index, which is consistent with the empirical conclusions of model (I). In summary, hypothesis 1 passes the test while hypothesis 2 fails the test.

New energy vehicles are products that are both high tech and protect the environment, and their R&D and production will inevitably produce positive externalities. Furthermore, there is a certain overflow, making the net income of enterprises smaller than the net benefits that society can obtain. Also, due to the high level of investment in the new energy vehicle industry and the long R&D cycle, the industry has the characteristics of high risk and uncertain returns, and the government needs to guide enterprises through fiscal and taxation means. At the same time, in order to compensate for the 'double externality' of technological innovation in new energy vehicle enterprises, the government can incentivize new energy vehicle enterprises to carry out technological innovations through subsidies so as to achieve the optimal level of innovation in society. In order to encourage new energy vehicle enterprises to increase their level of R&D investment and continuously carry out technological innovation, the government will promote financial subsidies while providing tax incentives for enterprises, and promote the output of the technological innovations of enterprises in a two-pronged manner. In order to investigate the relationship between financial subsidies and tax incentives on the technological innovation activities of enterprises, this paper adds the interaction term between financial subsidies and tax incentives to the explanatory variables, and constructs a model (III) to conduct empirical research.

$$\mathrm{TII} = \beta_0 + \beta_1 \mathrm{gov} * \mathrm{tax} + \beta_2 \mathrm{size} + \beta_3 \mathrm{zczz} + \beta_4 \mathrm{age} + \beta_5 \mathrm{RS} + \mu \tag{III}$$

Table 10 reports the results from empirical studies based on model (III). The data show that the regression coefficient of the interaction between financial subsidies and tax incentives on the technological innovation of new energy vehicle enterprises is 0.0007, which fails the significance level test. From Tables 8 and 9, it can be seen that financial subsidies have a significant positive effect on technological innovations in enterprises and are significant at the level of 1%, while tax incentives do not have a significant relationship with technological innovation. In summary, it can be seen that financial subsidies have a greater incentive effect on the technological innovation of new energy enterprises, and the implementation of tax incentives has not significantly enhanced the positive impact of financial subsidies on the technological innovation of enterprises, indicating that China's current preferential tax policies cannot better cooperate with the financial subsidy policy to guide enterprises to carry out

Table 10. Empirical results of model (III).

	Model III				
Variables	(1)	(2)	(3)	(4)	(5)
gov	0.0702***	0.0174	0.0172	−0.0227*	0.0218*
	(0.0143)	(0.1269)	(0.0130)	(0.0123)	(0.0121)
tax	0.0098	−0.0152	−0.0157	−0.0141	−0.0151
	(0.0787)	(0.0603)	(0.0609)	(0.0572)	(0.0563)
gov*tax	−0.0005	0.0007	0.0007	0.0006	0.0007
	(0.0041)	(0.0031)	(0.0031)	(0.0030)	(0.0029)
size	–	0.1785***	0.1791***	0.10847**	0.0911***
		(0.0217)	(0.0227)	(0.0336)	(0.0332)
zczz	–	–	0.0070	0.0479	0.0710
			(0.0758)	(0.0722)	(0.0720)
age	–	–	–	0.4153***	0.3972***
				(0.1140)	(0.1126)
RS	–	–	–	–	0.4627**
					(0.2350)
_cons	2.7130***	−0.5725	−0.5886	−0.0774	−0.2523
	(0.2617)	(0.4461)	(0.4813)	(0.4737)	(0.4748)
R○2	0.2128	0.5432	0.5432	0.6008	0.6171
N	112	112	112	112	112

Note: ***, **, and * are significant at the significance levels of 0.01, 0.05, and 0.1, respectively.
Source: Authors' calculations.

technological innovation activities and promote the accelerated and healthy development of the new energy vehicle industry. China also needs to strengthen its tax incentives (more specifically, tax incentives for enterprises with high technological output), and strengthen the novelty requirements for technological innovation of enterprises so as to enhance the synergy between tax incentives and fiscal policies, and jointly promote China's new energy vehicle enterprises to become global leaders.

6. Research conclusions and policy recommendations

6.1. Research conclusions

On the basis of our relevant theoretical analysis, we selected the new energy vehicle-related companies listed on the main board in 2012–2019 as the research object to explore the impact of fiscal and taxation policies on the technological innovation of enterprises. Through regression analysis of the sample data, the following conclusions can be drawn.

First, financial subsidies will encourage new energy vehicle enterprises to carry out technological innovation. The high investment and high-risk characteristics of R&D activities make many enterprises lack the intrinsic innovation motivation. At the same time, the inability of external investors to obtain access to all the relevant and valid information can also lead to difficulties in financing innovative projects. The R&D subsidy, which is part of the financial subsidy, can become a source of funds for enterprises and thereby directly solve some R&D funds gaps. Financial subsidies can also effectively transmit the signal that enterprises are regulated and in good standing with the government, which can help to reduce the adverse effects of information asymmetry, broaden the source of funds for innovative projects, and raise more funds for R&D activities. This can promote the smooth development of financing, lay the foundation for technological innovation in new energy vehicle enterprises, and enhance the core competitiveness of these enterprises. As an integral part of financial subsidies, the purchase subsidy can create and expand the new energy vehicle market, compensate for the 'dual externalities' of technological innovation of new energy vehicle enterprises, and support new energy vehicle enterprises to carry out technological innovation.

Second, the tax incentives have no significant impact on the technological innovation of new energy vehicle enterprises, and the technological innovation index is obtained by summarizing the R&D investment, fixed asset investment, intangible assets, and patent application volume through the entropy law, and the preferential tax policy does not have a significant incentive effect, which may be due to the formation of policy dependence, the lack of government supervision, the lack of novelty requirements for innovative achievements, or the failure of innovative achievements to obtain effective intellectual property protection. Moreover, the tax incentives have not played a significant role in promoting financial subsidies; the government's simultaneous implementation of financial subsidies and tax incentives has not achieved its expected goals, and the preferential tax policies need to be further deepened and strengthened so that they can better coordinate financial subsidies to jointly promote the development of China's new energy vehicle industry.

Third, the scale of enterprises, the age of enterprises, and the proportion of the number of R&D personnel to the total number of employees will all promote technological innovation by new energy vehicle companies. The difference in enterprise size reflects the difference in the resources owned by enterprises to some extent. Compared with small-scale enterprises, large-scale enterprises can use their more substantial capital to purchase advanced equipment and machinery, introduce technology, provide resources for technological innovation activities, and thereby improve their innovation ability. In addition, a long-standing enterprise, can rely on its wealth and technology accumulation to enhance its technological innovation ability. R&D personnel are the main force of technological innovation, as the number and quality of R&D personnel directly affect the pace and substance of the technological innovation. A high proportion of R&D personnel indicates that enterprises have a large number of technical innovation personnel and strong innovation vitality, which helps to improve the technology of the enterprise.

This study used the entropy weight method to obtain the technological innovation index through the four indicators of R&D investment, fixed asset investment, intangible assets, and patent application volume. The method was used to measure the technological innovation of new energy vehicle companies. However, there are other indicators that can be used to measure the technological innovation of enterprises. China's new energy vehicle industry started late. Even if the technological innovation situation of the industry has improved, there are still many key technologies that have not broken through the bottleneck. Therefore, there are still some improvements that can be made in the relevant fiscal and taxation policies.

6.2. Policy recommendations

The empirical research conducted using the model set up in this study shows that when the government's fiscal and taxation policies are tilted towards the new energy vehicle industry (Gass et al., 2014), the technological innovation of these enterprises will be significantly improved. This incentive effect is closely related to all aspects of the enterprise and is affected by many factors. Based on the above analysis, the following policy recommendations are put forward.

6.2.1. Improve financial subsidy policies

First, implement differentiated financial subsidy policies. When the government studies a subsidy project, it needs to make a comprehensive inspection of the enterprise and must first consider the innovation efficiency of the project, so that the R&D subsidy provided by it can play its full role and promote the development of the innovation project. In order to maximize the effectiveness of its R&D subsidies, the government should publish the corresponding enterprise catalogue and the research progress of the enterprise's subsidy projects in a timely manner. Technological innovation cannot be achieved overnight, so long-term innovation support systems need to be established. The government needs to provide various policy measures to promote technological innovation. The results show that the scale and age of enterprises and the proportion of R&D personnel of enterprises will promote the technological innovation of new energy vehicle enterprises. Therefore, if financial subsidies are provided to larger enterprises that have been established for some time and have the number of R&D personnel accounting for a large proportion of total employees, this will usually produce better technological innovation results.

Second, implement diversified financial subsidy policies. These policies should be developed in multiple directions. For example, a national new energy vehicle industry investment fund could be established to coordinate resources from all parties, initiate a process to tackle key core technologies in the industry, and master core technologies as soon as possible to occupy a dominant position in the field of new energy vehicles. In this regard, at present, BYD Automobile Company in China has better results in the continuous development of their own technologies, and their efforts have also led to the overall development of the domestic new energy vehicle industry. In addition, when the government provides product R&D subsidies, they should be linked to the company's total number of patents and product quality to increase the enthusiasm of enterprises for technological innovation. At the same time, it is still necessary to strengthen the awareness of intellectual property protection, improve the layout of intellectual property rights, form a good competitive environment, and continuously improve the status of China's new energy vehicle industry.

6.2.2. Improving preferential tax policies

The pertinence of substantive innovation at the level of tax incentive design should be improved. First of all, when the government designs preferential tax policies to promote technological innovation in new energy vehicle enterprises, it should be guided by substantive innovation, increase support and precision for projects with high scientific and technological content, and try its best to clear obstacles for the substantive innovation of enterprises. For projects with low scientific and technological content, the support should be appropriately reduced. Second, the novelty requirements of preferential tax policies for innovative output should be improved.

Novelty requirements represent in-depth substantive innovation, but China's preferential tax policies do not require novelty, which is not conducive to the development of high-quality innovation. Therefore, it is necessary to incorporate the novelty requirement into the threshold of preferential tax policies to enhance the purpose and effectiveness of the policy.

Next, a performance evaluation system for preferential tax policies should be established and the technological innovation of new energy vehicle enterprises should be supported effectively. Although China's tax incentives for new energy vehicle enterprises are relatively large and patent applications show a rapid growth trend, there is still a status quo in which the impact of preferential tax policies on the technological innovation of enterprises is not significant, and technological innovation with high-tech content is one of the core purposes of government tax preferential policy support, which shows that the government's preferential tax policy has not played its most important role. Therefore, the establishment of a performance evaluation system for preferential tax policies and the substantial innovation output as one of the core indicators of policy performance evaluation is a strong guarantee for the government and market players to cooperate with each other and reach technological innovations in new energy vehicle enterprises more rapidly.

Furthermore, the degree of tax incentives for small-scale new energy vehicle enterprises needs to be deepened. The results of our empirical analysis show that the control variable of enterprise scale has a significant impact on the technological innovation of new energy vehicle companies. Therefore, the degree of tax reductions and exemptions provided for small-scale new energy enterprises can be deepened to reduce the tax burden of these enterprises. Small-scale enterprises do not have strong financial support, so their R&D risks are relatively high, and their R&D capabilities are relatively weak. At present, for small micro-enterprises, China has formulated specific applicable income tax preferential policies, which shows that the government has paid attention to this aspect, and it is proposed to further increase the tax relief for small-scale new energy vehicle enterprises to allow them to have more funds for technological innovation. It is also possible to separately set up preferential investment and financing policies for innovative small-scale enterprises to encourage them to expand the scale of their enterprises.

Also, relax the requirements for new energy vehicle companies to be recognized as high-tech companies. In terms of corporate income tax, new energy vehicle manufacturers must be recognized as high-tech enterprises in order to enjoy low tax rates. In the 'High-tech Fields Supported by the State', there is a special list of 'Automobile Industry-related Technologies'. If an enterprise is recognized as a high-tech enterprise, it can enjoy preferential corporate income tax treatment and thereby further reduce its tax burden and, as a result, promote its scientific and technological innovation. The increase in the market share of new energy vehicles can effectively reduce carbon emissions, and the large-scale promotion of the use of new energy vehicles can help achieve China's 'dual-carbon' strategic objectives. However, many enterprises have not yet broken through the bottleneck period, which has hindered the development process of new energy vehicle enterprises, so it is still necessary to increase R&D efforts to enable these new energy vehicle enterprises to gradually mature and improve. At this time, incentives for the industry are particularly important. Therefore, it is recommended to relax the conditions for enterprises to be recognized as high-tech enterprises, so that more new energy vehicle enterprises can enjoy corporate income tax preferential treatment.

Finally, increase the deduction ratio for corporate R&D. R&D is the only way to achieve technological innovation, and R&D has certain risks for enterprises. In order to avoid risks, in general, enterprises are unwilling to invest much in R&D. Technology R&D is the lifeblood of new energy vehicle companies. Companies should attach importance to R&D investment and increase their support for technological innovation to enhance their vitality, and more deduction policy support will encourage companies to increase their R&D investment. Therefore, the government should consider increasing the deduction for new energy vehicle on the basis of a 100% deduction for R&D expenses to encourage enterprises to carry out technological R&D.

Acknowledgments

The authors are grateful to the editors and anonymous referees for their comments and acknowledge the support from the National Natural Science Foundation of China (Grant No. 72003002), Philosophy and Social Science planning project of Anhui Province (AHSKQ2020D60), Outstanding Young Talents Support Program in Colleges and Universities of Anhui Universities (General) (No. gxyq2020156), the Research Project of Anhui University of Finance and Economics (No. ACKYB20006), and from the Research and Innovation Project on Postgraduate of Anhui University of Finance and Economics (Grant No. ACYC2019012).

Disclosure statement

No potential conflict of interest was reported by the authors.

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