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An empirical study on the impact of tax incentives on the development of new energy vehicles: Case of China

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ABSTRACT

As a substitute for traditional fuel vehicles, the new energy automobile industry has gradually come into the public's view in response to environmental protection requirements. China values the role of policy regulation in promoting the rapid growth of the new energy vehicle sector. This research uses data from A-share listed new energy automotive corporations from 2010 to 2022 and the two-way fixed effect model to investigate the influence of tax incentives on the development of new energy vehicles. The empirical results show that: (1) Tax incentives have a significant promotion effect on the performance of new energy automobile enterprises and have the most significant impact on their operational capacity; (2) Tax incentives can improve the performance of new energy automobile enterprises by alleviating financing constraints; (3) The incentive effect of tax incentives on the performance of new energy car firms is more substantial in the eastern region, but the effect on the central and western regions is unclear; (4) The tax incentives on the performance of new energy automobile enterprises. The promotion effect has long-term, sustained effects. Based on the foregoing conclusions, this paper gives policy recommendations on how to stimulate the development of new energy vehicles in terms of tax advantages.

1. Introduction

Currently, with increasing attention to environmental issues, countries are gradually reducing their dependence on traditional non-renewable and polluting energy sources and shifting to the development and use of renewable and clean energy sources such as solar, wind, and nuclear energy (Loiter and Norberg-Bohm, 1999; Corsatea, 2014). Tailpipe emissions from conventional automobiles, as the main source of exhaust pollutants, make the development of the automobile industry face resource and environmental constraints. In recent years, the market share of new energy vehicles has continued to grow (Musti and Kockelman, 2011), and its promotion and use can both alleviate energy constraints and reduce environmental pressure (Samaras and Meisterling, 2008; Sioshansi and Denholm, 2009; Nichols et al., 2015). In order to promote the realization of China's "dual-carbon" goal, accelerate the transformation and upgrading of the automobile industry, and realize the sustainable development of the automobile industry, the promotion of new energy vehicles is feasible.

Under the pressure of increasing environmental problems around the world, the rise of the new energy vehicle industry is regarded as an important measure to address climate change and reduce pollution. The development of new energy vehicles not only decreases reliance on fossil fuels but also brings significant positive externalities to society by reducing greenhouse gas emissions and air pollutants (Langbroek et al., 2016). Supportive measures in terms of policies, funding and infrastructure in various countries have become important drivers for the rapid development of the industry. The Chinese government attaches great importance to green eco-environmental protection, adheres to the road of green ecological, low-carbon and sustainable development, and lists the new energy vehicle industry as one of the strategic emerging industries. In promoting new energy vehicles, the Chinese government has adopted a two-way support policy at both the demand and supply levels.

At the consumer level, the Chinese government has lowered the purchase threshold of new energy vehicles through incentive policies to stimulate market demand. For example, the vehicle purchase tax exemption policy implemented in September 2014 has had a direct impact on the sales of new energy vehicles, providing consumers with tangible economic benefits when purchasing vehicles. However, while demand-side policies effectively boosted sales in the short term, their

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direct benefits to manufacturers were relatively limited (Sallee, 2008). This is especially true as subsidies are gradually reduced, making it difficult for demand-side policies alone to sustain incentives for enterprises to invest in core technology research and innovation.

At the supply level, policy support targeted at enterprises, such as tax incentives, has a more direct impact. The Enterprise Income Tax Law implemented in January 2008 in China stipulates that high-tech enterprises are subject to a reduced corporate income tax rate of 15% (lower than the standard rate of 25%). As a recognized high-tech industry by China, new energy vehicle enterprises can enjoy this tax reduction. In addition, to encourage increased R&D investment by automotive companies China implemented a policy of additional deduction for R&D expenses from 2018 to 2023. These producer-oriented tax incentives have a more intuitive impact on the development of new energy vehicle companies. China's strong support and active promotion of the new energy vehicle industry. These policies not only directly reduce the tax burden on enterprises, but also encourage them to increase their R&D efforts and motivation at a deeper level. Such policy orientations have undoubtedly injected significant momentum into the growth of this emerging industry. In recent years, the new energy automobile industry has achieved rapid growth under the dual drivers of policy guidance and market demand. In 2013, China's new energy vehicle sales were only18,000 units. By 2023, sales had surged to 9.495 million units, with an average annual growth rate exceeding 50%.

Low-carbon, emission reduction, green, environmental protection will achieve the world's new discourse, China's auto industry to take the road of energy saving and environmental protection, new energy vehicles have a future development of the power can't be ignored. Therefore, the purpose of this paper is to select the data of new energy vehicle enterprises in A-share listed companies from 2010 to 2022, construct a two-way fixed model to analyze the substantive effect of tax preferences for new energy vehicle industry, and analyze the mediating effect thereof through the mechanism, test the effect of the policy in each region by using the analysis of heterogeneity and analyze the policy effect of tax preferences for the long-term development of new energy automobile enterprises through the dynamic panel model. The results show that: (1) tax incentives have a significant promotion effect on the performance of new energy vehicle enterprises and have the most significant impact on their operational capacity; (2) tax incentives can improve the performance of new energy vehicle enterprises by alleviating the financing constraints; (3) tax incentives in the eastern region have a stronger motivation for the improvement of the performance of new energy vehicle enterprises, but it is not obvious in the central and western regions; (4) tax incentives are effective in promoting the performance of new energy vehicle enterprises and there is a long-term sustained effect.

The innovations of this study are as follows. (1) Studying the impact of tax policy support from the supply perspective and quantitatively analyzing the implementation effect of tax incentives for new energy vehicle enterprises, which helps to improve the understanding of how tax incentives promote the development of new energy automobiles. (2) Utilizing the intermediary mechanism to analyze the impact of tax preferences on new energy vehicle enterprises from the perspective of financing constraints. (3) Consider a dynamic panel to consider the sustained effect of tax preferences on new energy vehicle enterprises from a long-term perspective.

The rest of the article is structured as follows: Section 2 reviews the relevant literature. Section 3 presents the corresponding research hypotheses based on the theoretical analysis. Section 4 is the research design, which introduces the data sources and research methods of this article. Section 5 presents the empirical results, including benchmark regression, mediation mechanisms, etc., and analyzes the results. Section 6 is the conclusions and recommendations, which presents the conclusions, policy recommendations and limitations.

2. Literature review

With the current emphasis on the environment and energy issues, new energy vehicles, as a general trend in the development of the automobile industry, have an unignorable driving force and have received extensive attention from various countries. In order to explore the impact of tax incentives on the development of new energy vehicles, this study combs through the relevant literature in accordance with the following three parts: (1) Tax incentives; (2) New energy vehicle industry development; (3) The effect of tax incentives on new energy vehicle enterprises.

2.1. Tax incentives

Tax incentives, as an indirect policy incentive, mainly include direct tax reductions, tax exemptions, increased tax credits, partial tax credits and other forms. It does not directly provide subsidies to enterprises, but rather reduces the taxable amount of enterprises, alleviates the tax burden of enterprises by means of indirect preferences, reduces the costs of enterprises to a certain extent, and promotes the cash flow turnaround of enterprises.

In recent years, many countries have proposed a series of policy incentives to increase the attractiveness of new energy vehicles. Policy incentives can attract consumers to choose and purchase new energy vehicles, thus increasing new energy vehicle sales (Langbroek et al., 2016). Although policy incentives can promote new energy vehicle sales to a certain extent, most tax incentives benefit consumers rather than producers in terms of the individuals who benefit from the tax incentives (Sallee, 2008). Policy incentives are also needed to alleviate the cost of enterprises. Diamond (2009), using data from various states in the U.S., found that there is a large gap between the life cycle cost of hybrid-electric vehicles and that of gasoline vehicles, and that the government needs to change the status quo through the corresponding monetary policies and tax incentives.

The Chinese government has been improving its tax incentives in recent years to promote the popularization of new energy vehicles. In terms of income tax, China has reduced the enterprise income tax at a rate of 15 percent for high-tech enterprises in need of key support, and high-tech enterprises are applicable to new energy vehicle enterprises. A sales-based reduction and exemption system is adopted for value-added tax (VAT), for example, VAT is levied at a reduced rate of 9% on the sales of new energy batteries, photovoltaic modules and other key components. Tax incentives are effective in promoting the development of the new energy automobile industry, and the tax exemption policy has the strongest long-term promotion effect (Ma et al., 2017). Li et al. (2016) evaluated China's new energy vehicle policy incentives from the perspective of consumers through a questionnaire survey using a four-paradigm model, and the results of the study showed that the new energy vehicle macro-policy was considered to be of great significance and high satisfaction, which proved the feasibility of the tax incentive policy.

2.2. New energy vehicle industry development

The new energy vehicle industry has developed so far, mainly including hybrid electric vehicles (HEVs), battery electric vehicles (BEVs), fuel cell electric vehicles (FCEVs) and so on. The development of new energy vehicles is influenced by technological breakthroughs, energy environment, policy support and other factors (Liu et al., 2018).

In order to reduce air pollution as well as energy consumption, the development of new energy vehicles is very necessary. It has been shown that an increase in the market share of electric vehicles contributes to the reduction of greenhouse gas emissions, improves air quality (Nakata, 2003; Åhman, 2006; Egnér and Trosvik, 2018), and can improve most countries' energy security (Samaras and Meisterling, 2008; Nichols et al., 2015). Thomas (2009), by comparing different power types of vehicles, found that all-electric vehicles not only achieve a reduction in greenhouse gas emissions, but also reducing the country's dependence on imported oil. In the long run, new energy vehicles can make a significant contribution to the realization of social goals.

New energy vehicles (NEVs), as an innovative technology, lead the way in sustainable urban mobility (Wang et al., 2019), promote the sustainable development of smart cities (Lopez-Carreiro and Monzon, 2018). The technological change of new energy vehicles can drive the common development of neighboring industries, an advantage that traditional vehicles cannot match. New energy vehicles need to be promoted by the government in terms of development paths and benefits, while policy support needs to maintain technological development without losing focus (Åhman, 2006). In a cost simulation scenario of a rapid shift to electric vehicles in Australia, the shift to new energy vehicles has cost-effectiveness and climate mitigation advantages, and policymakers should adopt strong policies to support the transition to new energy vehicles (Riesz et al., 2016). Overall, the direction of development of new energy vehicles is positive and favorable.

2.3. The effect of tax incentives on new energy vehicle enterprises

Financial subsidies, tax incentives and other policy incentives can, to a certain extent, help the new energy vehicle industry to maintain economic growth and promote the development of the new energy vehicle industry (Yuan et al., 2015). Tax incentives have a promotional effect on the new energy vehicle market (Sierzchula et al., 2014), direct tax reductions are more effective than deferred tax rebates and tax credits (Diamond, 2009).

Tax incentives have been shown to be effective, with high-tech firms receiving extensive financial and informational support from the policy incentives (Storey and Tether, 1998). Tax incentives, such as tax rebates, for new energy vehicle enterprises can significantly increase the market share occupied by new energy vehicles (De Haan et al., 2007; Chandra et al., 2010). Jenn et al. (2013) found that the U.S. federal government incentivizes consumers to purchase new energy vehicles through the tax credit policy, and when the amount of the policy incentive is large enough, the more sales of new energy vehicles will increase, thus improving the ability of new energy vehicle enterprises to develop. Gallagher and Muehlegger (2011) further analyzed that, compared with the income tax reduction policy, the sales tax reduction policy is more significant in promoting the sales growth of new energy vehicles. vehicle sales growth than the income tax reduction policy.

Tax incentives can reduce the tax burden of new energy vehicle enterprises, indirectly reduce the cost of enterprises, and promote the long-term development of enterprises. Among the new energy vehicle policy incentives implemented in various countries, countries such as the Netherlands and Norway have taken incentives to promote the development of the new energy vehicle industry, while Germany and other mature countries mainly provide policy support for new energy vehicles in research and development, emphasizing the supply side to reduce the burden on enterprises and achieve longer-term development (Wesseling, 2016). Gass et al. (2014) analyze the policy of new energy vehicle industry in Austria by analyzing the Austrian regional policy preferences for the new energy vehicle industry, it shows that tax preferences can increase sales by reducing enterprise tax costs. Yan (2018), based on sales calculations of the total cost of ownership of electric vehicles in Europe, finds that for every 10% increase in tax preferences, the sales of battery electric vehicle will increase by 3%, the tax preferences from a certain degree of mitigates business costs. Tax incentives can be used as a long-term policy tool to break down market barriers and promote the technology.

2.4. Summary of literature

By analyzing the existing literature, it can be seen that new energy vehicles can effectively respond to environmental protection and energy requirements, and their development is necessary. Scholars have found from the study that the impact of tax policy on the development of new energy vehicles is positive. The tax incentives introduced by the government have better improved the production and research and development enthusiasm of new energy vehicle enterprises and achieved the purpose of promoting the development of new energy vehicle industry. However, most of the literature discusses that tax incentives have a greater impact on consumers and drive the sales of new energy vehicles, thus promoting the development of new energy vehicles. The direct impact of tax incentives on producers is debatable, and there are relatively few quantitative analyses of the development of new energy vehicle enterprises. This study seeks to discuss the impact of tax incentives on the development of new energy enterprises from the producer's perspective, providing key evidence to further promote the development of the new energy vehicle industry.

3. Theoretical analysis and research hypotheses

3.1. Neoclassical investment model (NIM)

Through the above theoretical analysis of the impact of tax preferences on new energy automobile enterprises, Jorgenson's (1963) neoclassical investment model is introduced for specific analysis. Without considering the corporate income tax, the user cost of capital goods includes financing cost and depreciation cost, and the enterprise capital use cost can be expressed as:

$$C = q(r + \delta) \tag{1}$$

where C denotes the user cost of capital, q denotes the price of capital goods, r denotes the market interest rate, and δ denotes depreciation.

When the government levies an income tax on firms (disregarding tax incentives), and assuming an income tax rate of U, the firm's cost of capital use can be expressed as:

$$C = \frac{q(r + \delta)}{(1 - U)} \tag{2}$$

Comparison of formula (1) and formula (2) shows that the imposition of income tax on enterprises makes the cost of capital utilization of enterprises become 1/(1-U) times of the original. It can be seen that the government taxing behavior will increase the cost of capital use of enterprises, thus inhibiting the level of capital investment in enterprises. When the government gives certain tax incentives to enterprises, the smaller the income tax rate U is, the smaller the cost of capital utilization of enterprises is, which makes the expected return increase and promotes the investment level of enterprises, thus making the performance of enterprises improve accordingly.

New energy vehicle enterprises, as high-tech enterprises, enjoy 15% tax incentives. Policy support can significantly improve the performance of enterprises, and the greater the degree of support, the greater the sustainability of enterprise investment (Buzzacchi et al., 2013). New energy vehicle firms can reduce their tax burden through tax incentives, lowering the cost of capital employed by the firms, and the reduction in cost will, to some extent, lead to an increase in revenue. Policy support can also improve enterprise debt servicing capacity, promote the total fixed assets, etc. (Cannone and Ughetto, 2014), which can enhance the development ability of new energy vehicle enterprises and have a positive impact on the performance of new energy vehicle enterprises (Potoglou and Kanaroglou, 2007). Therefore, based on the above analysis, the following hypotheses are proposed.

Hypothesis 1. Tax incentives have a positive impact on the performance of new energy vehicle enterprises.

3.2. Mechanistic effect of tax incentives

Firms have financing constraints due to market failures (information asymmetry, etc.), the high-risk nature of R&D and the difficulty of using intangible assets as collateral (Brown et al., 2013). Financing constraints bind firms, whose investment behavior is affected not only by the demand for investment but also by the availability of their capital (Bilicka, 2020). For new energy vehicle firms, which have high investment and depend on external financial support for their production activities, easing financing constraints is crucial for this type of firm.

Tax incentives lead to a decrease in the effective tax rate, which will enhance firms' retained earnings and cash flows and reduce their cost of capital. The decrease in tax rates leads to a corresponding increase in firms' investment in fixed assets (Doyle and Van Wijnbergen, 1994), which leads to an increase in firm size and a corresponding increase in firms' financial performance (Auerbach, 1989). Tax policy reduces the degree of enterprise investment-cash flow sensitivity, which helps enterprises obtain more bank loans or private investment from the outside, increases the flow of funds, improves the solvency of enterprises, and effectively alleviates enterprise financing constraints (Colombo et al., 2012). The alleviation of financing constraints by tax incentives promotes, to a certain extent, the enhancement of the flow of capital and operational capacity of enterprises, which maximizes their performance (Baños-Caballero et al., 2014).

In addition, tax incentives, as a signal sent by the government, can convey favorable information and policy preferences of the enterprise to the outside world, alleviate the information asymmetry between the two sides (Bond and Samuelson, 1986), and help the enterprise to obtain other external resources to improve its performance (Jourdan and Kivleniece, 2017). The government's implementation of tax incentives for new energy and other high-tech enterprises indicates that the government recognizes the innovation and development capabilities that the enterprise has and encourages the development of the industry, which enables the enterprise to attract more external funds and achieve the purpose of alleviating financing constraints (Meuleman and De Maeseneire, 2012). When the degree of tax incentives is higher, i.e. the signal value is greater, allowing firm performance to exert greater value (Ozmel et al., 2013). The salience of government signals can improve firm performance by alleviating financing constraints that provide room for firms to optimize resource allocation. Therefore, the following hypothesis is formulated.

Hypothesis 2. Tax incentives enhance new energy vehicle enterprise performance by alleviating financing constraints.

4. Research design

4.1. Sample selection and data sources

In this study, we find the securities codes of new energy vehicle enterprises from the Oriental Fortune database, and find the corresponding sample data from the Cathay Security (CSMAR) database according to the securities codes. Among the selection criteria are as follows: (1) selecting enterprises with a high share in the new energy automobile industry; (2) deleting enterprises with large missing indicators in the enterprise data. According to the above criteria, this study finally selected 21 enterprises (Jiangling, Haima, Chang'an, FAW, Ankai, Zhongtong, BYD, Dongfeng, Yutong, SAIC, Foton, Yaxing, Shuguang, Hanma, JAC, Dima, Jinbei, Jinlong, GAC, the Great Wall, Lifan).

Considering that from 2009, China began to introduce a series of support for the development of new energy automobile industry related policies, the introduction of the policy to its impact on the market there is a certain lag. Secondly, before 2010, new energy vehicles are still in the initial stage, general business conditions and production and sales are low, so the data year from 2010 to analyze. In addition, because many companies have not yet published their annual reports for 2023, resulting in more missing values of the indicators for that year, this study selects 21 listed companies of new energy vehicles from 2010 to 2022 as the research sample. For further analysis, the sample data are processed as follows: (1) Excluding ST and *ST samples. (2) Excluding some samples with missing data. A total of 178 sample data from 2010 to 2022 are finally selected.

4.2. Variable selection and definition

4.2.1. Explained variable

This study adopts enterprise business performance to measure the comprehensive development capability of new energy vehicle enterprises. Financial indicators can better reflect the performance of enterprises, but there are many financial indicators, so it is very important to choose appropriate indicators to measure enterprise performance. In this study, the entropy value method is used to determine the weights of each indicator, and the comprehensive score of each sample enterprise's business performance is calculated according to these weights. As an objective weighting method, the entropy value method can avoid the influence of subjective factors and ensure that the final composite score of enterprise performance is more scientific, accurate and credible.

(1) Construction of Enterprise Performance Indicator System

The four major capabilities of an enterprise are profitability, development capability, solvency, and operational capability, each of which has its own specific measurement indicators, and a total of eight indicators have been selected to evaluate enterprise performance in this study. Table 1 lists the selected indicators and calculation formulas.

(2) Entropy value method

According to the principle of entropy value method, the degree of dispersion of a certain indicator can be measured by entropy value. The greater the degree of dispersion, the more significant the influence of the indicator in the comprehensive evaluation, so its weight should be increased accordingly. The entropy value method needs to be utilized to derive the weights in several steps.

The first step is to standardize the data of the above eight indicators. According to the attributes of each indicator, they are mainly divided into positive and negative indicators, among which the larger values of the six indicators of profitability, development ability and operation ability indicate that the enterprise's operation ability is better, which can be judged as positive indicators. However, the total gearing ratio and current ratio can't be so simple to belong to a certain category, neither the larger the better, nor the smaller the better, so it is judged as a moderate type of indicators. In general, the normal range of gearing ratio is 40%–60%, so take 50% as the reference value of x_0.The current ratio in the range of 1.5–2 can be regarded as a healthy enterprise, so 175% as the reference value of current ratio x_0. Positive indicators and moderate indicators are standardized using formula (3) and formula (4) respectively. The minimum and maximum values after standardization are 0 and 1, respectively, and in order to ensure that the subsequent processing of the data is effective, each standardized data is shifted, and the addition of 0.0001 is used here.

$$x'_{ij} = \frac{x_{ij} - x_{ijmin}}{x_{ij}\,max - x_{ij}\,min} \tag{3}$$

$$x'_{ij} = \begin{cases} \dfrac{x_{ij} - x_{ij}\,min}{x_0 - x_{ij}\,min}, & x_{ij} < x_0 \\ \dfrac{x_{ij}\,max - x_{ij}}{x_{ij}\,max - x_0}, & x_{ij} \geq x_0 \end{cases} \tag{4}$$

In the second step, the weight of the jth indicator of the ith sample data is calculated according to formula (5), and then the entropy value of the indicator is calculated according to formula (6).

Table 1
Enterprise performance evaluation index system.

Classification	Index	Calculation method	Type	Weight
Enterprise Profitability	Operating margin	Operating profit/Operating income	Positive	1.65
	Return on assets	(Total profit + Finance costs)/Average total assets Where: Average total assets = (Total assets closing balance + Total assets closing balance of previous year)/2	Positive	6.06
Enterprise Development Capacity	Total asset growth rate	(Total assets for the current year - Total assets for the previous year)/Total assets for the previous year x 100%	Positive	10.61
	Net profit growth rate	(Current year's net profit - Previous year's net profit)/Previous year's net profit x 100 percent	Positive	3.23
Enterprise Solvency	Asset-liability ratio	Total liabilities/Total assets	Moderate	15.02
	Current ratio	Current assets/Current liabilities	Moderate	11.99
Enterprise Operational Capability	Total asset turnover	Operating income/Average total assets Where: Average total assets = (Total assets closing balance + Total assets prior year closing balance)/2	Positive	23.26
	Current asset turnover	Operating income/Average occupancy of current assets Where: Average occupancy of current assets = (Closing balance of current assets + Closing balance of current assets in the previous year)/2	Positive	28.18

Data Source: CSMAR database.

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{5}$$

$$e_i = -\frac{1}{\ln m}\left[\sum_{i=1}^{m} p_{ij} \ln p_{ij}\right] (j = 1, 2 \ldots, n) \tag{6}$$

In the third step, the entropy weight of each indicator is determined using formula (7). Finally, the weights of operating profit margin, return on assets, gearing ratio, current ratio, total asset turnover, current asset turnover, total asset growth rate, and net profit growth rate are derived from the data and the formula (included in Table 1).

$$w_i = \frac{(1 - e_j)}{\sum_{j=1}^{n} (1 - e_j)} \tag{7}$$

In the fourth step, the linear weighting method was utilized to derive a composite score of the business performance of each new energy vehicle enterprise for each year, and this composite score was identified as the explanatory variable (enterprise performance), and the variable was named EP.

4.2.2. Explanatory variable

Currently, China's tax incentives for new energy vehicle enterprises include enterprise income tax and value-added tax. Among them, income tax has the widest coverage and the greatest impact on enterprises (Lokshin and Mohnen, 2012). Therefore, this study chooses enterprise income tax preference as a proxy variable for tax incentives.

The tax incentive (TI) is obtained by taking the logarithm of formula (8) (Chu et al., 2016).

$$\textit{Tax Incentives}(TI) = TP \times (STR - ETR) \tag{8}$$

Where TP is the total profit, STR is the statutory tax rate and ETR is the effective tax rate. The effective tax rate refers to the generalized calculation method of Wu (2009), which is calculated by Equation (9), where EBIT is the earnings before interest and tax.

$$\textit{Effective tax rate} = \textit{income tax expense}/EBIT \tag{9}$$

4.2.3. Mediating variable

Currently, the main indicators for measuring financing constraints include the KZ index, WW index, and SA index. The KZ index, which relies on the Tobin's Q ratio, has some potential measurement errors that could affect its accuracy in assessing financing constraints. The SA index is constructed using only two variables, firm size and firm age. Although these two variables have some exogenous advantages. However, it is too simple to rely only on these two factors to measure financing constraints in an industry such as new energy vehicles, which have rapid technological and market change. In contrast, the WW index considers multiple dimensions of firm financial indicators, providing broader economic significance. It is particularly applicable to capital-intensive and technology-driven industries, making the WW index a better choice for measuring financing constraints in China's new energy vehicle enterprises. Therefore, referring to the study of Whited and Wu (2006), we construct the WW index to measure the financing constraints of firms. The specific calculation method for the WW index can be found in formula (10).

$$WW = -0.091CF_{i,t} - 0.062DIVPOS_{i,t} + 0.021TLTD_{i,t} - 0.044LNTA_{i,t} + 0.102ISG_{i,t} - 0.035SG_{i,t} \tag{10}$$

where CF is the ratio of cash flow to total assets; DIVPOS is a cash dividend payout dummy variable that is 1 if the firm pays cash dividends and 0 otherwise; TLTD is the long-term debt-to- total assets ratio; LNTA is the natural logarithm of total assets; ISG is the industry sales growth; and SG is corporate sales growth.

4.2.4. Control variable

Since enterprise performance not only receives the influence of external factors, but also constrained by internal factors. Therefore, this study chooses control variables.

(1) enterprise size (Size). Due to the large differences in size among different enterprises, the total enterprise assets are used to indicate the enterprise size.
(2) Enterprise age (Age). Firm age is obtained by subtracting the year of establishment from the current year and taking the logarithm. When both individual fixed effects and time fixed effects are controlled for, there is a covariance problem between firm age and fixed effects. To mitigate these problems, the natural logarithm is taken for firm age.
(3) Firm R&D level (RD). Firms' R&D level is expressed as the ratio of R&D investment to business investment.
(4) Shareholding Concentration (SC). Shareholding concentration is expressed as the proportion of shares held by the first largest

shareholder, and a higher proportion usually means that the shareholders have more say.

(5) Government grants (GS). The government subsidy data in the notes to the financial statements of the enterprise is used, and the natural logarithm is taken as a control variable for it.

(6) Business operating capacity (BC). Business operating capacity is expressed using the ratio of total profit to operating revenue. Operating capacity can assess the degree of fulfillment of an enterprise's profit plan, and at the same time, it can compare the level of business management among enterprises and over different periods of time.

The above variable definitions are counted in Table 2.

4.3. Model construction

This study establishes a two-way fixed-effects model to analyze the impact of tax incentives on new energy vehicle companies. The two-way fixed effects model can control for a number of observable individual and time characteristics, thereby improving the accuracy of the model estimation. With the control of time and individual effects, the immediate impact of tax incentives on the performance of new energy vehicle companies can be better observed. The basic econometric model is set as:

$$EP_{i,t} = \alpha_0 + \alpha_1 TI_{i,t} + \alpha_2 \sum Controls_{i,t} + \lambda_i + \gamma_t + \varepsilon_{it} \tag{11}$$

In formula (11), $EP_{i,t}$ denotes the enterprise performance of enterprise i in year t, which is the explanatory variable. $TI_{i,t}$ denotes the enterprise income tax benefits enjoyed by enterprise i in year t, which is the core explanatory variable. $Controls_{i,t}$ includes a series of control variables. λ_i is the individual fixed effect, γ_t is the time fixed effect, ε_{it} is the random error term. random error term.

In order to further test whether tax incentives positively promote firm performance by alleviating financing constraints, the following mediation effect test model is constructed:

$$WW_{i,t} = \beta_0 + \beta_1 TI_{i,t} + \beta_2 \sum Controls_{i,t} + \lambda_i + \gamma_t + \varepsilon_{it} \tag{12}$$

Formula (12) are used to test the mediating effect of financing constraints. Where, $WW_{i,t}$ denotes the financing constraint of firm i in year t and is the mediating variable. The rest of the variable settings are the same as in formula (11).

Table 2
Variable definitions.

Category	Notation	Variable Name	Description
Explained Variable	EP	Enterprise performance	Calculated by the entropy method
Explanatory variable	TI	Tax Incentives	Total profit*(Statutory tax rate - Effective tax rate)
Mediating Variable	WW	Financing constraints	−0.091CF-0.062DIVPOS+0.021TLTD-0.044LNTA+0.102ISG-0.035SG
Control variable	Size	Enterprise size	Total assets
	Age	Age of the business	Current year minus the year of establishment of the enterprise and take the logarithmic value
	RD	Research and development level	R&D investment/revenue*100%
	SC	Shareholding concentration	Shareholding ratio of the largest shareholder (%)
	GS	Government subsidy	Government grants take the natural logarithm
	BC	Business capacity	Total profit/operating income*100%

Table 3
Descriptive statistics of variables.

Variable	Observations	Mean	Std. Dev	Min	Max
EP	178	4.029	1.072	1.942	7.490
TI	178	23.194	2.024	18.099	27.365
WW	178	−0.296	0.080	−0.471	−0.094
Size	178	8.662	17.291	0.118	99.011
Age	178	2.964	0.248	2.197	3.526
RD	178	3.891	2.018	0.073	8.869
SC	178	39.160	16.987	10.370	74.300
GS	178	18.966	1.758	12.623	22.275
BC	178	5.101	4.335	−6.459	17.469

4.4. Descriptive statistics of key variables

Table 3 reports the descriptive statistics of the main variables. The statistics show that the standard deviation of enterprise performance (EP) is 1.072, indicating a more pronounced gap in the performance of different enterprises. The mean value of tax incentives (TI) is 23.194, indicating that firms as a whole have enjoyed more adequate tax reduction dividends, but its standard deviation is 2.024, indicating that the strength of incentives varies widely across firms. The small standard deviation of financing constraints (WW) indicates that the selected sample is more consistently subject to financing constraints in general. Overall, the data is evenly distributed.

In order to determine the existence of multicollinearity between the benchmark model variables, the test of VIF was conducted. Table 4 reports the results of the multicollinearity test. The test results show that the variance inflation factor VIF of each variable does not exceed 5, the mean value does not exceed 3, and 1/VIF is greater than 0.1. Therefore, through the test of multicollinearity, it can be determined that there is no multicollinearity problem in the explanatory variables.

5. Results analysis

5.1. Baseline regression results

A Bidirectional fixed model with individuals and time is used for the analysis, and robust standard errors are included to control for the effect of heteroskedasticity on the regression results. Table 5 reports the results of the benchmark regression of tax incentives and new energy firm performance. In the benchmark regression results, columns (1) and (2) are the results of whether or not two-way fixation is performed when no control variables are added. Columns (3) and (4) are the results of whether or not two-way fixing is performed when control variables are included. The results show that the coefficient on tax incentives is significantly positive at the 1% level, regardless of whether control variables are included. When including control variables, two-way fixed effects are applied to the model, and the model fits better, at which time the coefficient of tax incentives on the performance of new energy vehicle enterprises is 0.208. The results show that tax incentives have a significant promotion effect on the performance of new energy vehicle enterprises. Therefore, hypothesis 1 is verified, that is, tax incentives have a positive impact on the performance of new energy vehicle

Table 4
Multicollinearity test results.

Variable	VIF	1/VIF
TI	3.94	0.254
Size	2.42	0.413
Age	1.12	0.894
RD	1.44	0.694
SC	1.51	0.664
GS	2.60	0.385
BC	1.93	0.518
Mean VIF	2.14	

Table 5
Baseline regression results.

Variable	EP			
	(1)	(2)	(3)	(4)
TI	0.233***	0.265***	0.333***	0.208***
	(0.028)	(0.071)	(0.056)	(0.054)
Size			−0.022***	−0.010*
			(0.004)	(0.006)
Age			−0.922***	−3.079*
			(0.305)	(1.808)
RD			−0.176***	−0.144***
			(0.038)	(0.033)
SC			0.006	−0.012
			(0.004)	(0.009)
GS			0.042	−0.047
			(0.068)	(0.057)
BC			−0.026	0.041**
			(0.021)	(0.016)
Constant	−1.364**	−2.127	−0.985	10.144**
	(0.654)	(1.660)	(1.431)	(5.069)
N	178	178	178	178
R^2	0.193	0.780	0.392	0.836
Control variables	NO	NO	YES	YES
ID fixed	NO	YES	NO	YES
Year fixed	NO	YES	NO	YES

Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

enterprises.

This finding has similarities with results obtained in some previous studies. In an analysis of the European market, Yan (2018) found that a 10% increase in tax incentives leads to an average 3% increase in the market share of battery electric vehicles. This result indicates that tax incentives can directly boost the market share of new energy vehicles, thereby indirectly enhancing the market performance and financial outcomes of related enterprises. Similarly, Sierzchula et al. (2014) found a significant positive relationship between financial incentives and electric vehicle market share through an analysis of data from 30 countries. Bjerkan et al. (2016) pointed out that incentive policies significantly increased the market penetration rate of electric vehicles, contributing to higher market shares. These conclusions show that financial incentives such as tax incentives can not only enhance market penetration and competitiveness of new energy vehicles, but also create greater market opportunities for enterprises, thereby promoting the improvement of enterprise performance. These studies have verified from different perspectives and regions that tax incentives are an important means to promote the development of the new energy vehicle industry and improve enterprise performance.

After regressing enterprise performance using a composite indicator and obtaining significant results, we further conducted regressions on the four components of performance of new energy vehicle enterprises: profitability, development, solvency, and operational capability according to Table 1. Table 6 reports the regression results of tax incentives on different indicators of new energy vehicle enterprises. A separate study of each dimension was able to provide more detailed and nuanced results, allowing for a more in-depth analysis of the impact of policies. We aimed to discover the specific areas where tax incentives have had the most significant effects and to identify potential differences in the level and direction of impact between these performance dimensions. This analysis contributes to a more comprehensive understanding of the multifaceted effects of the policy on corporate performance.

Columns (1) and (2) in Table 6 show that in terms of profitability, the coefficient of the impact of tax incentives on the return on assets is 0.012, which is significantly positive at the 5% level. This result indicates that tax incentives can effectively improve the utilization efficiency of assets of new energy automobile enterprises. Tax incentives reduce the tax burden pressure of enterprises and release more funds for investment and operation, which improves the return ability of assets and increases the utilization rate of assets (Na et al., 2021). The effect of tax incentives on the Operating margin of new energy vehicle enterprises did not reach a significant level. This may be due to the limited direct adjustment effect of tax incentives on the operating income and cost structure of enterprises. New energy vehicle enterprises may be more inclined to use tax relief for expanding production scale, strengthening R&D investment, and enhancing market share, which may not necessarily change the structure of operating profit immediately.

According to the results from columns (3) to (6), tax incentives do not have a particularly significant impact on the development ability and solvency of new energy vehicle enterprises. Although this result is not significant, it still has some explanatory value. The reason for this result may be that the gearing ratio, total assets growth rate, net assets

Table 6
Baseline regression results(separately).

Variable	Profitability		Development		Solvency		Operational	
	Pro_margin	Pro_return	Dev_asset	Dev_profit	Sol_asset	Sol_current	Ope_total	Ope_current
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TI	0.003	0.012**	0.001	3.433	−0.007	0.001	0.136***	0.094***
	(0.002)	(0.005)	(0.021)	(3.803)	(0.022)	(0.007)	(0.036)	(0.018)
Size	−0.001***	0.000	0.005**	−0.041	−0.003**	0.001**	−0.004	−0.002
	(0.000)	(0.000)	(0.002)	(0.116)	(0.002)	(0.001)	(0.004)	(0.002)
Age	0.060	0.113**	0.567	−72.825	0.672	0.295	−2.599***	0.123
	(0.043)	(0.053)	(0.667)	(98.701)	(0.584)	(0.182)	(0.963)	(0.628)
RD	−0.001	0.001	−0.018	−2.594	−0.022	0.003	−0.080***	−0.052***
	(0.001)	(0.002)	(0.014)	(2.502)	(0.021)	(0.006)	(0.023)	(0.013)
SC	−0.000	0.000	−0.000	0.145	−0.007*	0.004***	−0.006	−0.003
	(0.000)	(0.000)	(0.004)	(0.214)	(0.004)	(0.001)	(0.005)	(0.003)
GS	−0.003	−0.017***	0.029	0.013	0.019	−0.000	−0.083**	−0.042*
	(0.002)	(0.005)	(0.026)	(1.365)	(0.023)	(0.006)	(0.037)	(0.023)
BC	0.009***	0.008***	0.009	0.156	0.019**	−0.007***	−0.010	0.002
	(0.001)	(0.001)	(0.007)	(0.647)	(0.008)	(0.002)	(0.010)	(0.006)
Constant	−0.177	−0.297*	−2.100	142.956	−0.726	−0.432	8.303***	−0.506
	(0.126)	(0.167)	(1.724)	(242.127)	(1.664)	(0.523)	(2.806)	(1.800)
N	178	178	178	178	178	178	178	178
R^2	0.917	0.851	0.412	0.196	0.655	0.858	0.851	0.842
Control variables	YES	YES	YES	YES	YES	YES	YES	YES
ID fixed	YES	YES	YES	YES	YES	YES	YES	YES
Year fixed	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

growth rate and current ratio are indicators of the financial status of enterprises. Although these results are not statistically significant, they still offer some explanatory value. The reason for this outcome may be that indicators like the total asset growth rate, net profit growth rate, asset-liability ratio and current ratio are indicators of the financial status of enterprises. Tax incentives may require some time to improve the financial status of new energy vehicle enterprises, especially since improvements in development ability and solvency are typically long-term effects that are not immediately apparent. It may take some time for the tax incentives to improve the financial position of new energy automobile enterprises, especially the improvement of development ability and solvency is usually a long-term effect, which is difficult to see in the short term.

The regression results in columns (7) and (8) indicate that tax incentives have a significant positive impact on the operational capability of new energy vehicle enterprises. The coefficient of tax incentives on total asset turnover is 0.136 and is positively significant at the 1% level. This is consistent with our expectation. The coefficient of effect of tax incentives on current asset turnover is also significantly positive at 1% level. The significant improvement in total assets and current assets turnover ratio indicates that the enterprises have achieved more efficient resource utilization in production, sales and capital operation. These two indicators are closely related to operating income, indirectly reflecting the promotion effect of tax incentives on the market competitiveness of new energy vehicle enterprises.

Through the above analysis, we found that tax incentives have different degrees of impact on the secondary indicators of new energy vehicle enterprise performance. Specifically, tax incentives have the most significant impact on the operational capacity of new energy automobile enterprises. Tax incentives also have a relatively significant effect on the return on assets under profitability. Although tax incentives do not have a particularly significant impact on the development ability and solvency of new energy vehicle enterprises in the short term, this does not mean that tax incentives have no potential effects on these indicators in the long term. As enterprises gradually adapt to policy changes, tax incentives may bring sustained operational benefits and enhanced competitiveness over time. The impact of tax incentives is not only reflected in the short term but may also have a profound effect on the overall development of the enterprise through long-term accumulation effects.

5.2. Mechanism analysis

Table 7 reports the results of the regression of the mediating effect of financing constraints on tax incentives affecting the performance of new energy vehicle enterprises. Column (1) presents the baseline regression results of model (11). The regression results in column (2) further explore the impact of tax incentives on firms' financing constraints. By analyzing the regression coefficient of tax incentives on the WW index (agent variable for financing constraints), it is found that the coefficient is negative and significant at the 1% statistical level. This indicates that there is a negative relationship between tax incentives and corporate financing constraints. This result suggests that tax incentives can significantly reduce the financing constraints faced by new energy vehicle enterprises.

Fazzari et al. (1988) pointed out that capital-intensive enterprises tend to be more vulnerable to financing constraints due to their large capital requirements and limited external financing. As a capital-intensive and technology-driven industry, the production activities of new energy automobile enterprises rely on external financial support. When enterprises face financing constraints, the prioritization of investments is often restricted. Tax incentives alleviate the financing constraints of enterprises to a certain extent by directly reducing their tax burden and improving their internal cash flow levels. When financing constraints are mitigated, new energy vehicle enterprises are more likely to invest in technological research and development, long-term value, and expand their investment scale, thereby optimizing resource allocation and enhancing corporate performance. Furthermore, the reduction of financing constraints enables new energy automobile enterprises to access external funds at a lower cost and reduce financial pressure. With reduced financial burdens, these enterprises can expand production capacity or enter new markets, thereby increasing their market share and overall profitability in the new energy vehicle sector. Overall, the improvement of financing constraints through tax incentives has a particularly significant positive feedback effect on the performance of new energy vehicle enterprises. Therefore, Hypothesis 2 is verified that tax preferences enhance new energy automobile enterprise performance by alleviating financing constraints.

5.3. Heterogeneity analysis

In China, there is regional heterogeneity due to differences in

Table 7
Intermediary mechanism results.

Variable	EP	WW
	(1)	(2)
TI	0.208***	−0.006**
	(0.054)	(0.003)
Size	−0.010*	−0.001***
	(0.006)	(0.000)
Age	−3.079*	−0.244***
	(1.808)	(0.066)
RD	−0.144***	−0.003**
	(0.033)	(0.002)
SC	−0.012	−0.001**
	(0.009)	(0.000)
GS	−0.047	−0.009***
	(0.057)	(0.002)
BC	0.041**	−0.000
	(0.016)	(0.001)
Constant	10.144**	0.788***
	(5.069)	(0.184)
N	178	178
R^2	0.836	0.947
Control variables	YES	YES
ID fixed	YES	YES
Year fixed	YES	YES

Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 8
Heterogeneity analysis results.

Variable	Full sample	Eastern	Non-Eastern
	(1)	(2)	(3)
TI	0.208***	0.222**	0.064
	(0.054)	(0.074)	(0.099)
Size	−0.010*	−0.022***	0.052
	(0.006)	(0.007)	(0.074)
Age	−3.079*	−1.512	−9.090
	(1.808)	(1.849)	(5.561)
RD	−0.144***	−0.153**	−0.109**
	(0.033)	(0.051)	(0.045)
SC	−0.012	−0.007	−0.031**
	(0.009)	(0.019)	(0.010)
GS	−0.047	0.037	−0.026
	(0.057)	(0.135)	(0.079)
BC	0.041**	0.056*	0.058
	(0.016)	(0.026)	(0.033)
Constant	10.144**	2.960	29.557*
	(5.069)	(6.265)	(15.294)
N	178	98	80
R^2	0.836	0.636	0.804
Control variables	YES	YES	YES
ID fixed	YES	YES	YES
Year fixed	YES	YES	YES

Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

geographic location, natural foundation, economic development and other factors among different regions. The sample is categorized into three major regions: east, central, and west according to the place of establishment of the firms, and the central and western regions are merged into the non-eastern region because of the relatively small sample sizes in the central and western regions. Table 8 reports the results of the heterogeneity analysis. The results show that in the eastern region sample, the regression coefficient is 0.222 and is significant at the 1% level, indicating that tax incentives have a significant contribution to the performance of new energy vehicle firms. In contrast, the coefficient in the central and western regions is not significant, and the tax preference effect is not obvious. This may be due to the fact that the eastern region has better resource advantages, economic development level and institutional environment advantages than the central and western regions. The eastern region has better policy dividends and more obvious economic development advantages, so it has stronger motivation to improve the performance of new energy automobile enterprises. In contrast, the economic development advantages of the central and western regions are not prominent, and the government pays more attention to economic development and provides less financial support to new energy vehicle enterprises.

The specific reasons behind the observed regional differences may be as follows. On the one hand, the eastern regions of China have more developed infrastructure and markets, making them more attractive to business investments and policy support. These regions typically possess greater resources, such as capital, talent, and technology, providing new energy vehicle enterprises with more significant growth potential. In contrast, the central and western regions often face geographical remoteness and lower levels of transportation and market development. This limits their access to policy support and economic opportunities. The scarcity of resources may constrain the growth and development of new energy vehicle enterprises in these regions, thereby diminishing the effectiveness of tax incentives.

On the other hand, the eastern regions hold a leading position in China's economic development and has more high-tech industries and innovation resources. With higher economic development levels, governments in these regions have more fiscal capacity and policy tools to support measures for the new energy vehicle industry. As a result, the impact of tax incentives is more significant. In contrast, the central and western regions have a relatively weak economic foundation. Although the government has increased its support for the central and western regions in recent years, their overall economic growth remains slower, and enterprises have more limited growth opportunities. The governments in the central and western regions tend to focus more on the macro level of economic development and the advancement of traditional industries. The government's support for the new energy vehicle industry is weaker than that of the eastern region and often remains in the early stages of policy implementation. This also contributes to the difficulty for new energy vehicle enterprises in these regions to fully leverage the advantages brought by tax incentive policies.

5.4. Dynamic panel test

Since the two-way fixed effects model assumes that the impact of tax incentives on the performance of new energy vehicle enterprises is immediate, it may not adequately capture the time lag required for the policy's effects to materialize. Therefore, this study uses a dynamic panel model, which is used to capture the lagged effect of tax incentives. In empirical research, dynamic panel models are often employed to examine firms' target adjustment behaviors (Galán et al., 2015; Cave et al., 2023). These models include lagged explanatory variables as independent variables in the baseline regression model to evaluate the degree of persistence of firm performance. In this study, the one period lagged of firm performance is added to the baseline regression model, and the dynamic panel model setup is shown in formula (13). Where $EP_{i,t-1}$ denotes the firm performance of firm i in period t-1, and the rest of the variables are set up in the same way as formula (11).

$$EP_{i,t} = \varphi_0 + \varphi_1 EP_{i,t-1} + \varphi_2 TI_{i,t} + \varphi_3 \sum Controls_{i,t} + \lambda_i + \varepsilon_{it} \tag{13}$$

To estimate the persistence of tax incentives, we use a fixed effects model, the two-step generalized method of moments Estimator for first-differenced models (DIFF-GMM) proposed by Arellano and Bond (1991), and the two-step system estimator (SYS-GMM) proposed by Blundell and Bond (1998) for our study. Table 9 reports dynamic panel regression results. Although both FE and GMM regression coefficients are statistically significant at the 1% level, the estimated coefficients of the two methods differ significantly. The reason for this difference is the significant endogeneity of the FE model. While the FE estimator may have a downward bias when estimating the regression results of a dynamic model, its findings can serve as a benchmark and complement to the GMM results (Nickell, 1981).

In the GMM regression hypotheses, we consider lagged second and higher order dependent and independent variables as instruments for endogeneity. Meanwhile, firm size and age are used as exogenous instrumental variables. The regression coefficients and significance levels of DIFF-GMM and SYS-GMM are basically the same. In both estimator tests, the p-value of the autocorrelation test AR(2) is greater than 0.2, indicating that there is no significant second-order autocorrelation of the differenced residuals. The high p-value of Hansen's test (both at 0.814) suggests that the selected instrumental variables are valid and there is no serious over-identification problem.

In the regression results of DIFF-GMM and SYS-GMM, we find that the regression coefficients of tax incentives on the performance of new energy vehicle firms in the lagged period are positively significant at the 1% level. This significance indicates that the continuous effect of tax incentives may have an impact in the lag period. In other words, tax incentives have a significant effect on the future value of firm performance at the current moment. This effect is not limited to the short term but continues to unfold over time through lagged effects, reflecting the persistence of tax incentives. This result reflects the persistent effect of tax incentives, the impact of policy implementation is not immediately apparent, but rather gradually through the passage of time. It is possible that this effect is due to the fact that the inflow of funds provided by the tax incentives, or the alleviation of tax pressure can improve the financial situation of enterprises, thus enhancing their performance in various aspects of productivity, investment capacity, and technological

Table 9
Dynamic panel results.

Variable	EP		
	FE	DIFF-GMM	SYS-GMM
L.EP	0.500***	0.374***	0.375***
	(0.083)	(0.106)	(0.109)
TI	0.130*	−0.079	−0.079
	(0.072)	(0.171)	(0.184)
Size	−0.012**	0.014	0.015
	(0.005)	(0.026)	(0.027)
Age	0.281	−0.551	−0.545
	(0.504)	(1.054)	(1.061)
RD	−0.086*	−0.100	−0.100
	(0.047)	(0.120)	(0.123)
SC	−0.012	−0.014	−0.014
	(0.007)	(0.037)	(0.035)
GS	−0.200***	−0.060	−0.062
	(0.059)	(0.193)	(0.201)
BC	0.026**	0.062	0.062
	(0.010)	(0.047)	(0.050)
Constant	2.765*	7.660	7.670
	(1.487)	(9.059)	(9.765)
N	134	134	134
R^2	0.732		
AR (2) test(p-value)		0.210	0.219
Hansen test(p-value)		0.814	0.814

Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

innovation in the subsequent period, which in turn improves the performance of enterprises. Overall, the sustained effect of tax incentives suggests that the policy not only has an impact in the present, but also has a long-term, progressive impact on the future performance of new energy vehicle enterprises through certain lagged effects.

5.5. Robustness test

In order to obtain more robust results, two methods, sample remeasurement and sample selection bias, are used for robustness testing. Sample remeasurement is to use return on equity (ROE) as a proxy variable for the explanatory variables to measure the performance of new energy vehicle firms. Columns (1) and (2) of Table 10 report the results of the proxy variable tests. The coefficients on tax incentives are positively significant at the 1% level regardless of whether individuals and time are fixed, proving that the findings are robust. Sample selection bias is the result of shrinking the data before and after 1% to control for the effect of extreme values on the findings. Columns (3) and (4) of Table 10 report the results after the shrinkage treatment, and the coefficients of tax incentives on the performance of new energy vehicle firms are also significant at the 1% level after removing outliers, again verifying the robustness of the benchmark regression results.

5.6. Endogeneity test

Although the dynamic panel model can alleviate endogeneity issues to some extent, in order to obtain more robust estimation results, this study further employs the instrumental variable method. Specifically, we choose the local government's fiscal revenue to expenditure ratio (RE) as an instrumental variable. The higher the fiscal revenue-expenditure ratio, the more likely local governments are to implement active tax incentives. Conversely, the lower the fiscal revenue-expenditure ratio, the more cautious local governments are in implementing tax incentives, and the policy intensity may be limited. There is no direct relationship between the local fiscal balance ratio and the performance of new energy vehicle enterprises, which can satisfy the validity conditions of instrumental variable better.

Table 11 reports the regression results of the endogeneity test. Column (1) shows the results from the two-stage least squares (2SLS) regression using instrumental variable. After using the fiscal revenue-expenditure ratio as the instrument, the coefficient of the tax incentive on the performance of new energy vehicle enterprises remains significantly positive. This suggests that tax incentives play an important role in improving enterprise performance, confirming the robustness of the research conclusions. Column (2) adds the instrumental variables directly into the baseline model (formula 11) to test the exclusivity condition of the instrumental variable. The results show that after controlling tax incentives, the fiscal revenue-expenditure ratio has no significant effect on the performance of new energy vehicle enterprises. This indicates that the instrumental variable selected is not significantly correlated with the unobservable factors in the model and satisfy the exclusivity requirement of instrumental variable. It can be seen that after considering endogeneity, the results of the baseline regression still hold.

Table 10
Robustness test results.

Variable	ROE		Winsor (1%)	
	(1)	(2)	(3)	(4)
TI	0.017***	0.021***	0.321***	0.200***
	(0.004)	(0.005)	(0.055)	(0.056)
Size	−0.000	−0.001**	−0.023***	−0.009
	(0.000)	(0.000)	(0.004)	(0.006)
Age	0.038	−0.015	−0.911***	−4.317**
	(0.023)	(0.120)	(0.306)	(2.064)
RD	−0.016***	−0.006*	−0.181***	−0.159***
	(0.003)	(0.003)	(0.038)	(0.031)
SC	−0.001**	0.001	0.006	−0.012
	(0.000)	(0.001)	(0.004)	(0.009)
GS	−0.009*	−0.008*	0.071	−0.018
	(0.005)	(0.004)	(0.062)	(0.057)
BC	0.013***	0.018***	−0.025	0.043**
	(0.002)	(0.001)	(0.022)	(0.017)
Constant	−0.182*	−0.262	−1.282	13.488**
	(0.110)	(0.304)	(1.421)	(5.769)
N	178	178	178	178
R^2	0.661	0.906	0.397	0.836
Control variables	YES	YES	YES	YES
ID fixed	NO	YES	NO	YES
Year fixed	NO	YES	NO	YES

Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 11
Endogeneity test results.

Variable	EP	
	(1)	(2)
TI	0.994*	0.197***
	(0.571)	(0.056)
RE		−2.274
		(1.636)
Size	−0.015	−0.008
	(0.012)	(0.006)
Age	−3.637	−2.790
	(3.308)	(1.735)
RD	−0.119***	−0.139***
	(0.040)	(0.033)
SC	−0.025	−0.011
	(0.016)	(0.009)
GS	−0.172	−0.042
	(0.100)	(0.059)
BC	−0.079	0.036**
	(0.091)	(0.016)
Constant	−3.007	10.709**
	(14.232)	(4.805)
N	178	178
R^2	0.825	0.840
Control variables	YES	YES
ID fixed	YES	YES
Year fixed	YES	YES

Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

6. Conclusion and policy implications

6.1. Conclusion

This study empirically explores the relationship between tax incentives and the performance of new energy vehicle enterprises from the perspective of policy evaluation of environmental protection effects. Based on the data of A-share listed companies of new energy automobile enterprises from 2010 to 2022, this study establishes a two-way fixed effect model, and utilizes mechanism test and dynamic analysis to study the impact of tax incentives on the performance of new energy automobile enterprises, so as to explore the impact of tax incentives on the development of new energy automobiles. The main conclusions are as follows.

First, the baseline regression results show that tax incentives can significantly promote the performance of new energy vehicle enterprises, thus promoting the development of new energy vehicles. Furthermore, after regressing the secondary indicators of new energy vehicle enterprise performance, it was found that tax incentives have the most significant impact on the operational capacity of these enterprises. However, the incentive effect on their development capacity and solvency is not significant;

Second, Mechanism test results show that tax preferences can enhance new energy automobile enterprise performance by alleviating financing constraints;

Third, Heterogeneity results show that the incentive effect of tax preferences on new energy automobile enterprise performance is more significant in the eastern region, but the incentive effect on the central and western regions is not obvious;

Fourth, Dynamic panel results show that there is a long-term sustained effect of tax incentives on the performance of new energy automobile enterprises. In other words, the policy not only has an impact in the present, but also exerts a long-term effect on the future performance of new energy vehicle enterprises through a certain lag effect.

6.2. Policy implications

6.2.1. Implement differentiated tax incentives

If we want to improve the competitive advantage of vehicle enterprises, we need to strengthen cooperation with the supply side in R&D and production, and only by mastering the core resources and technologies can we stand firm in the market. The R&D investment of new energy vehicle enterprises is crucial at this stage, and enterprises that overcome technical difficulties can enhance market competitiveness faster and better. Therefore, the government can give lower corporate income tax incentives to enterprises with higher R&D expenses, and can formulate a program of excessive progressivity to make the incentives hierarchical and targeted, so that they can better support new energy vehicle enterprises to carry out R&D activities.

6.2.2. Expanding the coverage of preferential policies

The production of new energy vehicles requires a large number of raw materials and parts, etc. However, China's tax incentives lack preferential policies for enterprises that produce parts or provide related resources. Tax incentives should be further guided to favor the supply side of the new energy vehicle industry, and the focus of tax incentives should be shifted from the purchasing stage to the R&D support stage, so as to reduce the cost of relevant enterprises to invest in the research and development of new technologies. In addition, the recycling of new energy vehicles and their components can play a role in reducing environmental pollution. Improving the waste utilization rate of new energy vehicles and their parts can form a complete industrial chain and promote the virtuous cycle of the whole industry.

6.2.3. Tax incentives precision needs to be improved

In terms of value-added tax, consumption tax and enterprise income tax, China has not yet formulated special preferential policies for new energy automobile enterprises, and can only apply general policies that meet the conditions. For example, the VAT rate paid by enterprises in the sales segment is 13%, which is also the case for new energy vehicles, so there is no greater preference. The government can appropriately introduce VAT preferential policies for the sales segment of new energy vehicles, such as the use of VAT first levy and then return or immediate refund, which can greatly reduce the production costs of new energy vehicle enterprises. The government can give lower corporate income tax incentives to enterprises with higher R&D expenses, and can formulate a program of excessive progressivity to make the incentives hierarchical and targeted, which can better support the R&D activities of new energy automobile enterprises.

6.3. Limitations

A potential limitation of this study is its reliance on publicly available data. While public data enhances the transparency and reproducibility of the research, its depth and generalizability may be limited. Public data might lack certain details and fail to adequately reflect specific groups or more granular areas. Future research could address this limitation by utilizing more comprehensive private data and integrating various data sources to further validate these findings.

CRediT authorship contribution statement

Shaolong Zeng: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Man Ji:** Writing – review & editing, Writing – original draft, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Xinye Huang:** Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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