The Effects of the US-China Trade War on Corporate R&D of Chinese New Energy Vehicle Companies

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Abstract. Chinese new energy vehicle companies have recently had trade frictions with the EU and the US, which can draw inspiration from the US-China trade war that began in 2017. This paper uses a difference-in-difference model to study the impact of the exogenous impact of the trade war on corporate R&D, and uses text mining to identify research samples. Empirical results show that the trade war promotes the R&D of Chinese new energy vehicle companies. The results remained robust after the parallel trend test and robustness test. The research results reveal that the trade war forces companies to innovate, and companies will increase strategic investments in an uncertain environment to gain advantages in future markets. In the face of new trade frictions, Chinese new energy vehicle companies should continue to increase their R&D investment. This paper enriches the industry perspective in the study of the relationship between trade war and corporate innovation and puts forward suggestions for Chinese new energy vehicle companies.

Keywords: US-China trade war; new energy vehicles; corporate R&D; difference-in-difference model; text mining.

1. Introduction

In October 2023, the EU launched an anti-subsidy investigation into China's new energy vehicles. On June 12, 2024, the European Commission announced that it would impose a temporary tariff of up to 38.1% on new energy vehicles imported from China from July 4. On May 14, 2024, the White House announced that it would increase tariffs on Chinese electric vehicles from 25% to 100%, and impose an additional 2.5% special tariff, bringing the total tariff to 102.5%. Chinese new energy vehicle companies are facing uncertainties brought about by a new round of trade frictions following the US-China trade war that began in 2017. Therefore, the impact of the last round of trade war on the innovation of China's new energy vehicle companies has important implications. The Biden administration's continuation of the trade war and the increasing trade restrictions in the high-tech sector indicate that the main battlefield of the trade war is technological competition [1].

In the US-China trade war, the US government adopted a variety of trade restriction measures, such as punitive tariffs, to reduce the trade deficit [2]. Starting from March 2018, the Trump administration has gradually launched a list of high tariffs on goods worth about US$250 billion. At the same time, Trump included 44 Chinese high-tech companies in the Entity List, intending to cut off commercial channels for China and foreign countries to communicate and develop advanced technologies through investment restrictions, export controls and technological blockades. In response to this situation, the academic community has made it clear that in a complex and changing external environment, the foundation for the high-quality development of Chinese enterprises is innovation capability [3], and independent innovation is an important way to break through the technological restrictions of the trade war [4]. At the micro level, how firms are affected by the trade war in terms of employment and capital markets has been extensively discussed in previous literature [5, 6]. At the macro level, the stability of financial markets will also be undermined [7]. There are inconsistent research results on how corporate innovation is affected in the traditional trade friction model centered on anti-dumping and anti-subsidy [4, 8].

In the study of the causal relationship between corporate innovation and trade war, the focus is on determining whether companies recognize the uncertainty brought about by trade frictions. There are two main methods in existing research, namely, counting the number of trade friction events at the

industry level [8] and text mining to determine whether a company is affected [9,10]. However, unlike the traditional trade friction model, in this trade war, the United States used a series of measures such as tariffs, entity lists, and export reviews to suppress China, which broke through the traditional anti-dumping framework in the WTO system [11]. There are significant individual differences in the relationship between trade environment uncertainty and corporate behavior [12]. Using text mining to determine whether companies recognize the impact of trade frictions is more suitable for studying this trade war.

Previous studies have shown that the US-China trade war has a significant reverse effect on Chinese companies' R&D investment [13, 14]. To study the characteristics of the new energy vehicle industry and corporate micro factors, this paper takes 2017 as the impact year, uses the data of listed companies within the scope of China's new energy vehicle concept stocks from 2013 to 2022, and studies the impact of the trade war on the R&D investment of China's new energy vehicle companies through a difference-in-difference model. The author processed corporate annual reports through corpus recognition and semantic analysis methods and used companies that were identified to be affected by trade frictions as the experimental group, and those that were not as the control group. The empirical results show that the trade war has a significant forced effect on the innovative behavior of new energy vehicle companies, which has greatly promoted the companies' willingness to increase research and development investment. This result has passed the robustness test.

The marginal contributions of this article may be in the following aspects: Firstly, this paper provides a new perspective based on the combination of existing research methods in academia. Secondly, this paper provides new evidence on the role of trade war in promoting corporate innovation from an industry perspective, which enriches the relevant literature on the relationship between trade frictions and corporate innovation behavior. Finally, most of the existing research on the relationship between uncertainty and corporate innovation focuses on economic policies. From the perspective of uncertainty research, this paper provides new results on the impact of exogenous shocks from an industry perspective.

2. Literature Review and Research Hypothesis

2.1. US-China Trade War and Corporate Innovation

Scholars believe that the political and economic conflicts revealed in the US-China trade war are the trade frictions that have had the greatest impact on globalization since 2018 [15,16]. The impact of the United States tariffs and technological blockades on Chinese companies' production and investment is profound. The trade war not only disrupts the international trade order, but also greatly increases the uncertainty of the trade environment [1, 7, and 10]. The fundamental purpose of the United States' series of trade friction measures is to restrict China's economic development and block its technological progress [2]. As the US continues to escalate its tactics, Chinese companies are paying more attention to increasing R&D investment, strengthening independent innovation capabilities, and enhancing resistance to technological blockades. The academic community has paid much attention to this issue, and many recent studies have drawn rich conclusions: Lang and Li found that the increased uncertainty in the trade environment caused by the trade war will force companies to innovate [17]. Zhou et al. pointed out that the path for enterprises to learn advanced technologies is blocked by the trade war, which will undoubtedly reduce the technological development level of affected enterprises [1]; Chen et al. conducted research from the perspective of the information and communication industry and found that the innovation capabilities of Chinese high-tech enterprises had a significant negative impact in the trade friction [18]. Xie et al. and Cai et al. both found that the trade friction has a reverse effect on Chinese companies, promoting their R&D investment [13, 14]. In summary, the academic community has not yet reached a consensus on the relationship between corporate innovation and the trade war. There are still many limitations in the research methods and perspectives, which indicates that a new perspective is needed to understand the impact of trade frictions on corporate innovation.

2.2. Real Options Theory and Strategic Growth Options Theory

Real Options Theory provides a systematic theoretical analysis framework for enterprises' investment choices in an environment of high uncertainty. This theory holds that under the premise of investment irreversibility, investment has asymmetric and nonlinear adjustment costs. High adjustment costs force firms to delay investment to preserve options when business conditions improve in the future. Different from the flexibility of financial options, the value of real options depends entirely on future performance and market fluctuations due to their specific investment projects [19, 20]. R&D investment is different from other investment projects. The uniqueness of its investment cycle and potential returns, as well as the flexibility of multi-stage investment, enable enterprises to better adapt to market changes and conform to the characteristics of real options under conditions of economic uncertainty [21]. For this reason, the real option attributes of corporate R&D investment are prominent, and the present value of cash flow brought by multi-stage investment is its underlying asset [22]. Czarnitzki et al. found that companies reduced their R&D investment due to the uncertainty of the economic environment [23]. Khan et al. also supported the real options theory based on data from Chinese listed companies [24].

The new trade friction measures used by the US government have greatly increased the uncertainty of the economic environment faced by Chinese companies. Therefore, according to the real options theory, when faced with high adjustment costs and future uncertainties in R&D investment, companies will choose to reduce R&D investment in exchange for options. Based on the above analysis, this paper proposes the following hypotheses:

H1a: The US-China trade war has hindered the innovation of new energy vehicle companies and reduced their R&D investment.

Strategic Growth Option Theory relaxes certain assumptions of Real Option Theory. The theory holds that from the perspective of competitive investment among enterprises, investment decisions not only bring potential benefits but also affect the behavior of competitors [25]. While high environmental uncertainty weakens the deferral option, it also highlights the advantages of strategic growth options in dealing with future market changes. This provides a theoretical analysis framework for enterprises' behavior of increasing investment projects with strategic growth option attributes under uncertain environments. As a strategic investment, an enterprise's R&D investment behavior can help the enterprise gain a first-mover advantage, influence the investment behavior of competitors and occupy a favorable position in the future market. Existing studies have shown that environmental uncertainty will force companies to increase their R&D investment [26]. Shen et al. studied the relationship between trade policy uncertainty indicators and the innovation of Chinese new energy vehicle companies and found that trade policy uncertainty has a positive impact on corporate innovation [27]. These studies all support the strategic growth option theory.

In response to the impact of the technological blockade in this round of trade war, the Chinese government has introduced a series of policies to support Chinese companies in high-tech and core industrial fields to break through the US technological blockade. The new development opportunities not only lie in the opportunities brought by the subsidy policy but also because this is an important opportunity for Chinese companies to gain the upper hand in the market through research and development and innovation. According to the strategic growth option theory analysis framework, companies will increase R&D investment to obtain future growth options under the encouragement of opportunities brought about by uncertainty. Therefore, this paper proposes an opposing hypothesis:

H1b: The US-China trade war has a forced effect on the innovation of Chinese new energy vehicle companies, significantly promoting their R&D investment.

2.3. The Causal Relationship Between Trade Friction and Corporate Behavior

The core issue in studying the relationship between trade frictions and corporate behavior is how to measure the extent to which companies are affected by shock events. Early studies mainly used the method of counting the number of specific trade friction events. For example, Wan et al. studied the US-China trade war based on the statistics of anti-dumping events [4], and Erbahar et al. analyzed

and studied American companies from the perspective of industry anti-dumping [28]. Further research confirmed the large heterogeneity of enterprises when they are affected by economic environmental uncertainty. Some scholars began to weigh and adjust enterprise variables to specifically study the extent to which enterprises are affected [8].

However, the series of combined measures taken by the US government in this round of trade frictions have broken through the traditional trade friction tools under the WTO framework [11]. The impact of non-trade measures is broader than the number of businesses that are directly affected [29]. Since traditional research methods make it difficult to accurately study the heterogeneity of enterprises affected by different means, academia has begun to widely use text mining technology to identify the extent to which enterprises are affected by economic environmental uncertainty. For example, Caldara et al. analyzed conference call reports and found that companies facing new tariffs in the trade war reduced their investments [9]. Benguria et al. used text mining to study the industry's perception of economic environmental uncertainty and pointed out that economic environmental uncertainty has a significant negative impact on corporate investment [10]. Therefore, existing academic research has proven that text mining has unique advantages in measuring the degree to which enterprises are affected by economic environmental uncertainty. Many literatures have demonstrated the maturity and wide range of applicability of text mining, which shows that text mining is one of the most appropriate research methods.

In summary, two theoretical analysis frameworks with different mechanisms of action have emerged in previous literature, and the empirical perspectives of various studies are not completely consistent. Considering the non-traditional characteristics of the trade friction tools in this round of trade war and recent literature research, this paper believes that the empirical research path based on text mining is more suitable for analyzing the impact of the US-China trade war on the R&D investment of new energy vehicle companies.

3. Study Design

3.1. Sample Selection and Data Sources

Based on the research of Cai et al. (2023) [14], this paper uses 2017 as the impact time, and the author uses 2018 as the proxy impact time for robustness testing. This paper selects listed companies with new energy vehicle concepts in the Chinese stock market from 2013 to 2022 as samples and undergoes the following processing: (1) excludes listed companies that have not released annual reports during the period; (2) excludes companies with abnormal operating conditions (ST); and (3) removes listed companies that have not disclosed the amount of R&D investment. Finally, a total of 212 listed companies' panel data were constructed. The annual reports for text mining are from Juchao Information Network, and the financial statement data are from the CSMAR database, Table 1 shows the variable definitions.

3.2. Variable Definition

Table 1. Variable definitions.

Variable Symbols		Variable Definition
Explained variable	R1	R&D investment/total assets
	R2	R&D investment/operating income
	R3	R&D investment plus 1 and take the natural logarithm
Explanatory variables	DID	Treated ∗ Post
Control variables	Total Assets	Add 1 to the total assets and take the natural logarithm
	Asset Liability Ratio	Total Liabilities/Total Assets
	Income Growth Rate	Income Growth Rate
	ROA	Return on Total Assets
	Current Assets Ratio	Current Assets Ratio
	Operating Assets Ratio	Operating Assets Ratio
	TobinQ	TobinQ

3.2.1. Dependent variable: enterprise R&D investment

This paper uses the ratio of R&D investment to total assets (R1) as the explained variable in the empirical analysis. The ratio of R&D investment to operating income (R2) and the natural logarithm of R&D investment plus 1 (R3) are used as proxy variables in the robustness test.

3.2.2. Independent variables: treated and post

Due to the requirement of the difference-in-difference (DID) model to accurately select the experimental group and the control group, this paper refers to the identification method of the relationship between trade war and corporate investment behavior in academic circles [9,10], as well as the research of academic circles in recent years on identifying managers' perception of uncertainty [30,31]. Due to the requirement of the difference-in-difference (DID) model to accurately select the experimental group and the control group, this paper refers to the identification method of the relationship between trade war and corporate investment behavior in academic circles [9, 10], as well as the research of academic circles in recent years on identifying managers' perception of uncertainty [30, 31], and uses the text mining and semantic analysis methods of Chinese corpus. The experimental groups were selected in the following way:

First, the author use Python to crawl the annual reports of Chinese new energy vehicle concept listed companies from 2017 to 2022 and uses the Jieba word segmentation module for word segmentation. Secondly, the author separately counted the keywords that represent the US-China trade war (such as US-China trade war, US-China trade frictions, US-China trade disputes, etc.) and the keywords that represent the impact of company identification (such as impact, weakening, enhancement, etc.). Finally, the author constrains the two keywords to be in the same sentence to construct an indicator of listed companies' perception of the trade war. This paper collects data from listed companies with new energy vehicle concepts from 2017 to 2022. Companies that have been aware of the trade war for at least three years are considered the experimental group, and the Treated variable is assigned a value of 1; otherwise, they are considered the control group.

The Post variable selects 2017 as the impact time and assigns a value of 1 in 2017 and later, otherwise, it is assigned a value of 0. In addition, the author selects 2018 as the proxy impact time in the robustness test.

3.2.3. Other variables

Referring to the variable selection of R&D investment research in existing studies, this paper also controls variables such as total assets and total liabilities, while controlling individual fixed effects and clustering effects of enterprises.

3.3. Model Settings

Since the US-China trade war is an exogenous shock [32], this paper uses the DID model for empirical research:

$$RD_{it} = \alpha_0 + \beta DID_{it} + \lambda_i X_{it} + \gamma_t + \varepsilon_{it} \quad (1)$$

$$DID_{it} = Treated_{it} \times Post_{it} \quad (2)$$

In the above model, RD_{it} is the explained variable; DID_{it} is the core explanatory variable; X_{it} is the control variable group; γ_t is the enterprise effect; ε_{it} is the residual term. The model uses robust standard errors clustered by firm. If the DID_{it} regression coefficient β is negative and the result is significant, it means that the trade war has reduced corporate R&D investment, supporting hypothesis H1a; conversely, if the regression coefficient is significantly positive, it indicates that the trade war has a promoting effect on corporate R&D investment, verifying hypothesis H1b.

4. Empirical Analysis

4.1. Descriptive Statistics

Table 2. Descriptive statistics.

Variable	Obs	Mean	SD	Min	Max
Treated	2,120	0.589	0.492	0	1
R1	2,080	0.029	0.015	0.001	0.124
R2	2,080	0.051	0.042	0.001	0.950
R3	2,115	18.804	1.504	12.440	23.761
Total Assets	2,083	22.526	1.290	19.732	27.621
Asset Liability Ratio	2,082	0.449	0.174	0.009	1.461
Income Growth Rate	2,070	0.774	23.020	-3.095	1044.9
ROA	2,120	0.033	0.069	-1.127	0.322
Current Assets Ratio	2,120	0.598	0.133	0.142	0.966
Operating Assets Ratio	2,120	0.216	0.189	-0.859	0.862
TobinQ	2,025	1.921	1.003	0.738	11.512

The descriptive statistics of the main variables are shown in Table 2. From Table 2, it can see that the mean value of the variable Treated is 0.589, indicating that the proportion of enterprises in the experimental group to the total sample is 58.9%. The minimum value of the variable R1 is 0.001 and the maximum value is 0.124, indicating that the minimum ratio of R&D investment to total assets is 0.1% and the maximum is 12.4%. There are large differences in R&D investment between samples.

4.2. Benchmark Regression

This paper analyzes the impact of the US-China trade war on R&D investment based on model (1). The explained variable (R1) is the ratio of enterprise R&D investment to total assets. The regression controls individual fixed effects and clustering effects. The results are shown in Table 3. From the results, in the two regression results without introducing control variables and with introducing control variables, the regression coefficient of the DID variable is significantly positive at the 0.1% level. This reveals the forced effect of the trade war on the innovation of new energy vehicle companies, prompting companies to increase R&D investment, supporting the competitive hypothesis H1b.

Table 3. The effect of US-China trade war on R&D investment.

	VARIABLES	
	(1)	(2)
DID	4.90***	4.02***
	(0.000)	(0.000)
Constant	104.92***	6.21***
	(0.000)	(0.000)
Firm Fe	Yes	Yes
Controls	No	Yes
Observations	2,080	2,022
R-squared	0.7586	0.7721

The regression results support the strategic growth option theory. Against the backdrop of US-China political conflict and technological competition, Chinese companies realize that only by strengthening their independent innovation capabilities and improving their technological level can they avoid being affected by the US technology blockade. Only by increasing R&D investment, which is a strategic investment in line with the growth option, can Chinese companies gain an advantage in corporate competition and gain a dominant position in the future market.

The empirical results of this paper are consistent with the results pointed out by Xie et al. and Cai et al. that the trade war has a reverse effect on the innovation of Chinese enterprises and promotes the R&D investment of enterprises [13, 14]. However, the results are inconsistent with the results of Caldara et al. that the trade war will reduce the physical investment of Chinese enterprises [9]. The reason may be the difference in adjustment costs caused by the difference in R&D investment and physical investment. The adjustment cost of physical investment belongs to the stock type adjustment, while the adjustment cost of R&D investment belongs to the flow type adjustment and has strategic investment attributes in an uncertain environment [33].

4.3. Parallel Trend Test

The baseline regression results illustrate the forced and promoted effects of the US-China trade war on R&D investment of new energy vehicle companies. However, the DID model requires a parallel trend test to ensure that the experimental group and the control group have the same trend before the impact time. Figure 1 shows that the experimental group and the control group had the same trend before 2017, but there were significantly different trends after 2017. The results of this article passed the parallel trend test.

The author found that the coefficient for the current period in 2017 was negative. The possible reason is that the far-reaching macro-exogenous shock of the trade war had a certain lag effect on the decision-making of corporate managers, causing companies to choose conservative option strategies to shrink R&D investment in a short period of time. After a year of shock, corporate managers gradually realized the importance of strategic investment and increased R&D investment.

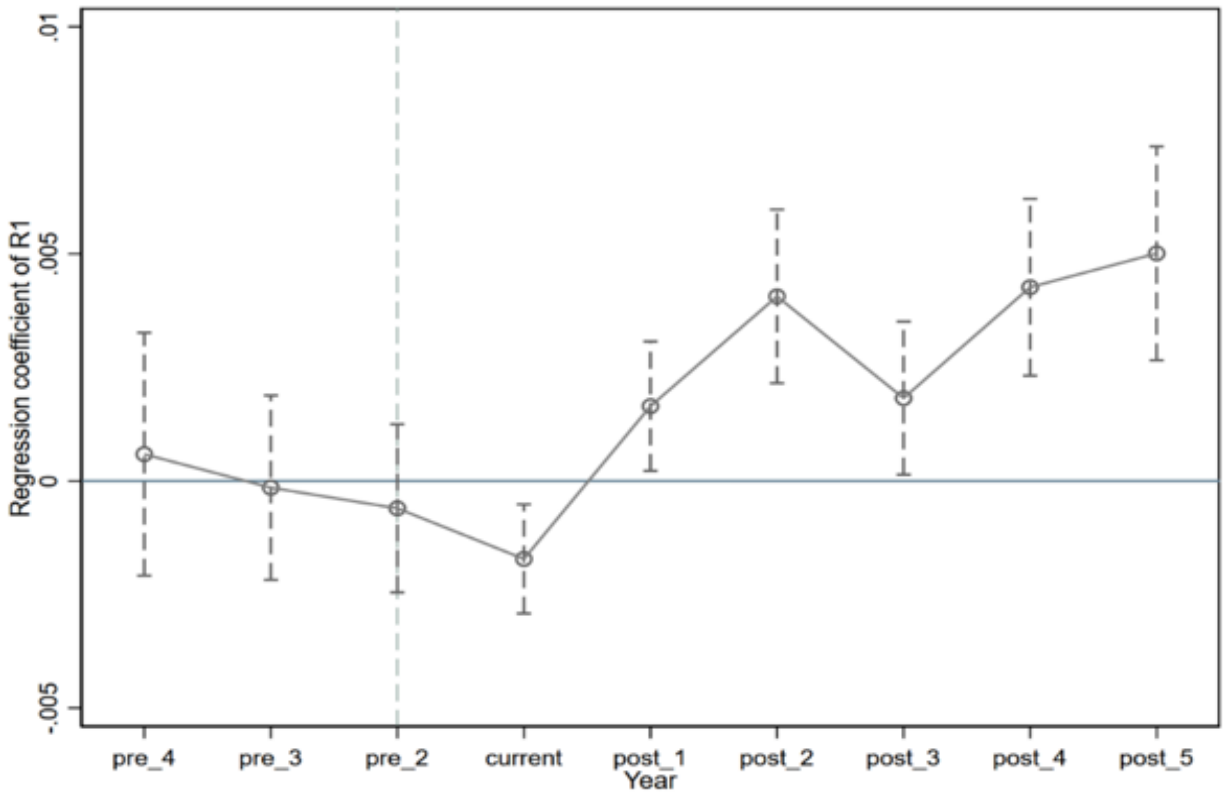

Fig 1. Parallel trend test of DID.

4.4. Robustness Test

Table 4. The result of robustness test.

	Replace the explained variable		
	(1)	(2)	(3)
VARIABLES	R1	R2	R3
DID 1	4.02***	5.49***	11.10***
	(0.000)	(0.000)	(0.000)
Constant 1	6.21***	11.77***	55.15***
	(0.000)	(0.000)	(0.000)
DID 2	5.33***	6.12***	11.80***
(Delayed impact year)	(0.000)	(0.000)	(0.000)
Constant 2	6.35***	11.92***	56.84***
	(0.000)	(0.000)	(0.000)
Firm FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations 1	2,022	2,022	2,022
R-squared 1	0.7721	0.7327	0.8514
Observations 2	2,022	2,022	2,022
R-squared 2	0.7772	0.7351	0.854

This paper adopts the method of replacing the explained variables and delaying the impact year to conduct a robustness test. The specific results are shown in Table 4. After replacing the explained variables, the regression results show that the regression coefficient of DID1 is significantly positive at the 0.1% level. After delaying the impact year by one year, the DID2 regression coefficient in the regression results of each explained variable is still significantly positive at the 0.1% level. The regression results of the robustness test and the benchmark regression results are significantly positive. The regression results of this paper pass the robustness test. The test results show the robustness of the trade wars forced effect on innovation and its promoting effect on R&D investment of Chinese new energy vehicle companies.

5. Conclusion and Recommendations

Based on the perspective of the relationship between economic environment uncertainty and corporate innovation behavior, this paper studies the relationship between R&D investment of Chinese new energy vehicle industry companies and the US-China trade war. The author takes the trade friction at the beginning of 2017 as an exogenous shock. The text mining method is used to identify whether listed companies in the new energy vehicle concept of the Chinese stock market perceive the impact of the trade war from the enterprise level, and divide the experimental group and the control group according to the results. This paper uses the DID model to analyze the impact of the trade war on the R&D investment of Chinese new energy vehicle companies. The research results show that:

The trade war has had a significant impact on the innovation and R&D investment of Chinese new energy vehicle companies. In an uncertain economic environment where risks and opportunities coexist, companies will increase their strategic investment in R&D to pursue competitive advantages and potential future market returns. The parallel trend test shows that there is a certain lag effect from the transmission of economic environment uncertainty from enterprises' recognition to their specific investment behavior. When exogenous shocks occur, enterprises will choose conservative option strategies. The robustness tests including replacement variables and delayed impact years further validate the findings of this paper.

Based on the research results of this article, reviewing the impact of the trade war on the R&D investment of Chinese new energy vehicle companies has important implications for the recent trade

frictions in which Chinese new energy vehicle companies have been subject to additional tariffs imposed by Europe and the United States when going overseas. First, the uncertainty in the economic environment brought about by trade frictions is both a risk and an opportunity for enterprises. The government should play the role of market leverage and guidance, support independent innovation of new energy vehicles through policy means, give full play to the role of enterprises as innovation subjects, and obtain greater growth potential and better core competitiveness based on flexibility. Secondly, new energy vehicle companies should also focus on strategic investment based on the strategic growth option theory and think about how to gain first-mover advantage and industry standard status in the future market. Finally, the government should play a guiding and coordinating role, coordinate the improvement of innovation capabilities in new energy vehicle-related industrial chains such as batteries, automotive smart chips, and automotive parts from the perspective of the industrial chain, and drive more companies to transform economic environment uncertainties into strategic growth opportunities.

To date, China's new energy vehicles have achieved milestone development. In 2023, China's automobile exports surpassed Japan for the first time to become the world's number one, and it has ranked first in the world in production and sales for nine consecutive years since 2015. The development of China's new energy vehicle industry is inseparable from market competition and innovation incentives. This is not only based on its emerging industry nature driven by disruptive technologies but also benefits from industrial development policies and excellent domestic market conditions. Among the top 15 global automakers in sales in 2022, 6 are Chinese automakers, and BYD ranks first in the world with 1.858 million vehicles. Strategic investment in R&D and the determination to enhance innovation capabilities are the keys to Chinese automakers leading the world. As of June 2021, BYD ranked first in the country with 9,426 patents, exceeding the second and third places combined. It is the leading innovation capability and efficient transformation capability of scientific research results that have enabled China's new energy vehicle industry to achieve remarkable development achievements that have attracted worldwide attention.

In 2024, facing anti-subsidy investigations and additional tariffs, China's new energy vehicle industry is no longer afraid of technological blockades. It is foreseeable that in the future, the independent innovation capabilities of enterprises will play an increasingly important role. Chinese new energy vehicle companies will also continue to increase their R&D investment in the face of trade frictions, build technological barriers, and widen the gap between themselves and other automakers. In the future, the author will continue to focus on corporate innovation mechanisms and influencing factors and contribute to this type of research from a new perspective.

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