

Research on the Influence Mechanism of dual-credit Policy on Green Innovation Level of Automobile Enterprises: Moderating Effect Based on Internationalization Depth and Internationalization Breadth

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ABSTRACT

The “dual-credit” policy is a key strategy implemented by the state to promote green mobility, aiming to encourage automakers to make progress in fuel efficiency and new energy technologies through quantitative management of corporate average fuel consumption points and new energy vehicle points. In this paper, we take Chinese listed automobile enterprises as the experimental group, and match the control group from non-automobile enterprises by propensity score matching method, and use double-difference model to test the incentive effect of the dual-credit policy on the improvement of green innovation level of automobile enterprises. The study finds that the “dual-credit” policy significantly improves the green innovation level of automobile enterprises; the internationalization depth and internationalization breadth of enterprises negatively and positively regulate the incentive effect of the “dual-credit” policy on the improvement of the green innovation level of automobile enterprises, respectively; and the analysis of heterogeneity shows that the “dual-credit” policy has a significant impact on the improvement of the green innovation level of automobile enterprises. “Heterogeneity analysis shows that the dual-credit policy has a more significant positive effect on SOEs than on non-SOEs. Based on the empirical analysis of the policy, targeted suggestions for policy improvement are made.

KEYWORDS

“Dual-credit” policy; Automobile company; Green Innovation

1. INTRODUCTION

In September 2017, China's Ministry of Industry and Information Technology (MIIT) issued a transition policy for the new energy vehicle industry, stipulating that the “Measures for the Parallel Management of Average Fuel Consumption and New Energy Vehicle Points for Passenger Vehicle Enterprises” (the “dual-credit” policy) will be implemented as of April 1, 2018, which indicates that China's new energy vehicle industry policy is changing from the early selective industrial policy of fiscal and tax subsidies to functional industrial policy such as the “dual-credit” policy. This shows that China's new energy vehicle industrial policy is shifting from the early selective industrial policy of fiscal and tax subsidies to the functional industrial policy such as the dual-credit policy, which aims to build a market mechanism to promote technological innovation and high-quality development of the industry. 2021, China explicitly puts forward the “3060 target In 2021, China explicitly put forward the “3060 Goal”, which is to strive to reach the peak of carbon dioxide emissions by 2030, and strive to achieve carbon neutrality by 2060. The energy-saving and environmental protection industry, as an important force to ensure green development, is bound to play a key role in China's

efforts to realize the “dual-carbon” goal. Cultivating the energy-saving and environmental protection industry has been elevated to the level of a national strategy, and the key to improving the competitiveness and service quality of the industry lies in improving the green technology innovation capability of enterprises and designing suitable environmental service models.

“The dual-credit policy, as a policy established with reference to the zero-emission policy of the U.S. and the emission trading system of the European Union, will have a significant impact on the green development of China's entire automobile industry and even society as a whole, as it will affect both traditional fuel vehicles and new energy vehicles through the points for the average fuel consumption and points for new energy vehicles of enterprises at the same time. This will have a significant impact on the green development of China's automobile industry and society as a whole.

However, the existing research on the dual-credit policy still has some limitations, which are mainly reflected in the following four aspects: firstly, the research in this field focuses on the impact on new energy automobile enterprises, and the research object has some limitations, and seldom focuses on the impact on the whole automobile industry, and the universality of the research conclusions is weak. Therefore, as a representative policy in the “post-subsidy” era, there are still many uncertainties in the existing research on how the dual-credit policy will affect all automobile enterprises. Second, existing studies focus on the impact of the dual-credit policy on the level of technological innovation of enterprises, but seldom pay attention to its impact on green innovation, a special form of technological innovation, and pay insufficient attention to environmental protection and sustainability. Third, in recent years, “new energy” and “export” have gradually become the two highlights of China's auto market development, and Chinese auto brands are accelerating the layout of the global market, so the importance of the internationalization of automobile enterprises is becoming more and more prominent, but the existing research pays less attention to this issue! However, existing research has paid less attention to this issue, leaving a gap.

In order to clarify the above issues, this study takes Chinese listed automobile enterprises as the experimental group, and matches the control group from non-automobile manufacturing enterprises by propensity score matching method, and empirically examines the incentive effect of the dual-credit policy on the improvement of green innovation level of automobile enterprises by using the double-difference model, and at the same time, based on the perspective of internationalization of enterprises, we select the internationalization depth, internationalization depth, internationalization depth, internationalization depth, internationalization depth, internationalization depth, internationalization depth, internationalization depth, internationalization depth and internationalization depth. Meanwhile, based on the perspective of enterprise internationalization, this study selects internationalization depth and internationalization breadth as moderating variables to study their moderating effects on the main effect, connecting domestic and international, and improving the related research according to the changes of the industry situation. In addition, the study also analyzes the heterogeneity based on enterprise scale, so as to present a more complete picture of the influence mechanism of the dual-credit policy on the green innovation level of automobile enterprises.

2. LITERATURE REVIEW

For the dual-credit policy, the research of domestic scholars mainly focuses on the impact of the policy on the production and operation of new energy automobile enterprises.

Zhang Qi [1] and other scholars show that the dual-credit policy can effectively promote the development of new energy automobile enterprises, but it will also have a negative impact on the production and profit of traditional automobile enterprises. Cheng Yongwei and Mu Dong [2] study the decision-making problem of automobile manufacturers under the dual-credit policy and show that the shareholding ratio affects the formation of internal agreements. Lu Chao [3, 4] and others found that increasing the proportion of new energy vehicle points can inhibit the production of fuel vehicles,

while the dual-credit policy can reduce the price of new energy vehicles, increase profits, and promote the active emission reduction of fuel vehicles. Chai Qiangfei [5] and others believe that the dual-credit policy will increase the price of traditional fuel vehicles, reduce the production of traditional fuel vehicles and reduce the profit of new energy vehicle enterprises. Zan Xin and Ou Guoli [6] believe that active participation of consumers will become an important support to ensure the stable development of the new energy vehicle industry and market in the context of subsidy regression.

Existing studies on the impact of the dual-credit policy on the innovation level of automobile enterprises have focused on its impact on the technological innovation of enterprises.

Regarding the heterogeneity of the impact of dual-credit policy on different types of innovation in automobile enterprises, Shi Dan [7] and others believe that dual-credit policy significantly incentivizes the “substantive” innovation behavior and “strategic” innovation behavior of new energy automobile enterprises. Yao Huize et al. [8] showed that the dual-credit policy has a facilitating effect on the technological innovation of upstream enterprises of new energy vehicles, and that the former has a greater impact on the former than the latter, between the “substantive” innovation and the “strategic” innovation. The former is more influential between “substantive” innovation and “strategic” innovation.

Regarding the study on the heterogeneity of the “dual-credit” policy affecting the level of technological innovation of enterprises in different links of the automobile industry chain, Rao Yibang et al. [9] concluded that the “dual-credit” policy has to a certain extent enhanced the R&D investment of enterprises and stimulated innovation, and that in the case of new energy vehicles, it has a significant impact on power battery, motor, motor and motor. In terms of new energy vehicles, the intensity of R&D investment in the field of power battery and motor electric control is significantly higher than that in the field of vehicle.

In addition, there are some evaluations on the negative impacts of the dual-credit policy in the academic circles. Guo Wen et al. [10] believe that the dual-credit policy can promote the support of fuel vehicle suppliers for new energy vehicles, and motivate them to continue to improve the level of technological innovation under the trend of subsidy contraction, but fuel vehicle enterprises may not take the initiative to promote technological innovation. Bai [11] believes that after the implementation of the “dual-credit” policy, a large number of joint-venture new energy vehicle enterprises have been established, which will change the organizational and technological path of industrial upgrading, increase the dependence of local enterprises on multinational corporations, and will not be conducive to the enhancement of the technological level of new energy vehicles.

3. THEORETICAL MECHANISMS AND RESEARCH HYPOTHESES

The “dual-credit” policy mainly consists of two kinds of points, one is used to improve the utilization rate of fuel vehicles CAFC points, and the other is used to increase the number of new energy vehicles NEV points, realizing the combination of traditional fuel policy and new energy vehicle production policy.

According to the classic S-C-P paradigm in the theory of industrial organization [12], the enterprise as the core organizational part of the industrial organization, the innovation behavior under the influence of industrial policy is the basis for the formation of the enterprise's innovation capability, the innovation capability to further transform the enterprise's existing innovation capital into actual performance, in order to cover all the links of the enterprise's innovation activities, to form a complete closed innovation value chain [13], and the innovation activities also Only then will the innovation activities have more practical significance.

Therefore, the research on enterprise innovation capability is crucial, which is mainly reflected in this study to explore the level of green innovation in automobile enterprises. Green innovation refers to the introduction of novel and environmentally friendly technologies or methods in products, processes,

services or business models, aiming to reduce resource consumption, reduce environmental pollution and enhance sustainability. It not only focuses on technological innovation, but also includes improvements in management, processes and systems, aiming to achieve a win-win situation in terms of economic and environmental benefits.

Among the existing studies, Sun [14] and others pointed out that the dual-credit policy restricts the proportion of fuel vehicles produced and the technological thresholds of all passenger car companies in order to promote the R&D and production of new energy vehicles. In addition, the policy also establishes a points trading system and tries to replace government subsidies with points revenue, reflecting an important shift from policy-driven to market-driven, and one of its main purposes is to promote the technological innovation of automobile enterprises and the optimization and upgrading of the entire automobile industry through the policy shift. According to the research of SHI Dan [7] and others, according to the theory of enterprise innovation and Schumpeter's growth theory, the environmental regulation policy will enhance the innovation level of enterprises while constraining the cost of production enhancement, and the dual-credit policy, as an environmental policy tool, is aimed at promoting the automobile industry to develop in the direction of more environmentally friendly and energy-saving. "Porter's Hypothesis" points out that although environmental regulation increases the technology cost of enterprises and raises the market entry threshold, enterprises can gain competitive advantages through technological innovation, thus realizing 'compensatory gains' that exceed the cost of environmental regulation.

To summarize, the impact of the dual-credit policy on the green innovation level of automobile enterprises has the following theoretical foundations:

First, the economic incentive mechanism, i.e., based on the special point trading attribute of the dual-credit policy, enterprises with strong R&D capability can trade their abundant NEV points. The most prominent incentive rule design of the "dual-credit" policy is to allow NEV points to be traded in the market, which means that the new energy vehicle products produced by automobile enterprises can not only gain revenue and profit, but also profit from the points trading, which is a "double profit" mechanism. The "double profit" inducement mechanism can promote automobile enterprises to incorporate vehicle manufacturing and technology development of new energy vehicles into the important position of innovation direction selection and innovation behavior decision-making. This economic incentive mechanism can encourage automobile enterprises to obtain more innovation resources, increase investment in green technology R&D, and improve their green innovation level.

Second, market demand-oriented, "dual-credit" policy directly affects the market demand for environmentally friendly cars. With the implementation of the policy, consumer demand for cars with high fuel efficiency and low emissions will increase, while the demand for traditional fuel vehicles may decline. In order to adapt to the changes in market demand, car companies are forced to accelerate the pace of innovation in green technology and launch more environmentally friendly products.

Thirdly, the dual-credit policy promotes technological innovation competition in the entire automobile industry. In order to meet or exceed the targets set by the policy, automobile companies have been competing fiercely with each other, constantly exploring new green technologies and innovative solutions. This competitive pressure has prompted automakers to continuously improve their green innovation level.

Overall, the dual-credit policy positively affects the green innovation level of automobile enterprises through economic incentives, market demand orientation, and technological innovation competition.

Based on the above discussion, the following hypotheses are proposed:

H1: The dual-credit policy can improve the green innovation level of listed automobile enterprises.

With the development of global economic integration, the competitive environment for automobile enterprises is no longer limited to the domestic market. As a result, many firms have to consider the

rules, standards and consumer demands of the international market when making strategic decisions. Introducing the degree of internationalization as a moderating variable allows for a more comprehensive understanding of the actual impact of policies and their association with the context of globalization. International markets, on the other hand, tend to have more stringent environmental requirements than domestic markets. For example, the European market has relatively stringent regulations on automobile emissions, while China's dual-credit policy is also being gradually strengthened, but there may be differences in implementation strength and market response. Introducing the degree of internationalization as a moderating variable helps to analyze how companies adjust their green innovation strategies in the face of different market standards.

From the theoretical level, the resource-based theory in internationalization theory emphasizes the importance of enterprises acquiring key resources through internationalization. In deepening the internationalization process, automobile enterprises can contact and absorb international advanced green technologies and innovation concepts, thus enhancing their green innovation level, which provides theoretical support for the introduction of the moderating variable of internationalization depth in this study. In short, the depth of internationalization may play a moderating role in the impact of the dual-credit policy on the green innovation level of listed automobile companies.

The depth of internationalization reflects the degree of resource investment in overseas markets, and based on the study of Wang Xin [15], this paper adopts the ratio of overseas revenue to total revenue to measure the depth of internationalization.

In existing studies, combining the transaction cost theory and the theory related to outsider disadvantage, some scholars believe that there is a negative relationship between internationalization and corporate innovation. In addition, some scholars argue that internationalization is not simply linearly related to firm innovation and further explore its industrial heterogeneity or influence mechanism. Liu Sukun [16] and other scholars combine the classical theories of internationalization of latecomer firms (including the LLL framework and springboard theory), and by analyzing the listed companies in China's strategic emerging industries from 2010 to 2020, they argue that there is a non-linear U-shaped relationship between the degree of internationalization and the efficiency of corporate innovation.

The depth of internationalization may play a negative moderating role in the impact of the dual-credit policy on the level of green innovation of automotive listed companies for the following reasons:

First, cost pressure. The increase of internationalization depth may lead to higher cost pressure on automobile enterprises, including the cost of raw materials, production costs, transportation costs, etc. This kind of cost pressure may reduce their R&D efforts. This cost pressure may reduce the funds and resources for R&D of green technologies, thus weakening the positive impact of the dual-credit policy on the level of green innovation of automobile enterprises;

Second, competitive pressure. The increase in the depth of internationalization may lead domestic automobile enterprises to face more intense international competition, forcing them to pay more attention to cost control and scale effect rather than green innovation, thus weakening the positive impact of the dual-credit policy on the level of green innovation of automobile enterprises;

Third, policy uncertainty. Third, policy uncertainty. Uncertainty in the international environment may reduce the willingness of automobile enterprises to invest in green innovation in the long term, because it is difficult to predict the changes in international policies and markets. This weakens the positive impact of the dual-credit policy on the level of green innovation of automobile enterprises.

Fourth, the marginal effect. Under high internationalization depth, enterprises may face higher technical requirements and market standards. At this time, the marginal benefit of investment in green innovation rises, because failure to meet green standards may lead to a decline in market share and additional costs.

Based on the above discussion, the following hypothesis is proposed:

H2: The depth of internationalization negatively moderates the incentive effect of the dual-credit policy on the green innovation level of automobile enterprises.

According to the internationalization stage theory and network theory, it is crucial for enterprises to gradually expand their international markets and establish extensive network relationships. Automobile enterprises operate in multiple international markets and face more diversified needs and challenges, thus stimulating more green innovations. At the same time, extensive international networks also provide automotive firms with more opportunities for cooperation, which helps to jointly develop and promote green technologies, which provides theoretical support for the introduction of the moderating variable of internationalization breadth in this study. In short, internationalization breadth may play a moderating role in the impact of the dual-credit policy on the green innovation level of listed automobile companies.

Breadth of internationalization is a measure of a firm's degree of internationalization from the perspective of geographic location, which refers to the degree of activity and coverage of a firm in the international market, i.e., the degree of expansion of its overseas operating markets. Qiu Chen and Yang Huixin [17] selected A-share listed companies in Shanghai and Shenzhen from 2009 to 2018 as the research sample, and the regression results show that enterprises can absorb and utilize diversified technological knowledge through the internationalization of R&D, and as the level of internationalization rises, the enterprises show a more positive learning effect and innovation effect. Based on the social network theory, Wu, Hang and Chen, Jin [18] constructed a moderated mediation model to explore the internal mechanism of internationalization affecting innovation performance, and found that the degree of internationalization positively affects the diversification of international innovation network partners, thus promoting the development of innovation.

There are several reasons why the breadth of internationalization may play a positive moderating role in the impact of the dual-credit policy on the level of green innovation of listed automotive companies:

First, technology exchange and cooperation. Automobile enterprises with high internationalization breadth usually have richer international partners and technological resources. Such international cooperation can promote cross-border technology exchange and sharing, and help automobile companies to acquire and apply the world's leading green innovation technologies more quickly. By jointly developing green technologies with international partners, automakers can better meet the requirements of the dual-credit policy and improve their green innovation level, which strengthens the positive impact of the dual-credit policy on the green innovation level of automakers;

Second, market diversification reduces risks. Vehicle enterprises with high internationalization breadth usually have market shares in multiple countries or regions, and have better market diversification. This kind of market diversification reduces the uncertainty of automobile enterprises in the face of policy changes, disperses the risk, and makes them more confident to invest in green innovation, i.e., strengthens the positive impact of the dual-credit policy on the level of green innovation of automobile enterprises;

Third, global resource integration and optimization. Vehicle enterprises with a high degree of internationalization are able to better integrate global resources, including talents, technologies and funds. Through the layout of R&D centers and production bases in different countries or regions, automobile enterprises can make more flexible use of global resources to optimize the R&D and application process of green innovation. This kind of global resource integration and optimization can help improve the level of green innovation of automobile enterprises and make them more competitive, which strengthens the positive impact of the dual-credit policy on the level of green innovation of automobile enterprises;

Fourthly, international competition incentives. Vehicle enterprises with high internationalization are facing competitive pressure from the world, not only need to meet the domestic policy requirements, but also need to pay attention to the latest development trend of global green innovation. This

international competition motivates automobile enterprises to increase their investment in green innovation and improve their green innovation level, which strengthens the positive impact of the dual-credit policy on the green innovation level of automobile enterprises.

In summary, internationalization provides a broader development space for automobile enterprises by promoting technical exchanges and cooperation, reducing market risks, integrating global resources, and stimulating international competition, and promotes their achievements in green innovation, which positively moderates the influence mechanism of the “dual-credit” policy on the level of green innovation of automobile enterprises.

Based on the above discussion, the following hypotheses are proposed:

H3: The internationalization breadth positively regulates the incentive effect of “dual-credit” policy on the improvement of green innovation level of automobile enterprises.

4. INDICATOR DESCRIPTION AND MEASUREMENT MODEL

4.1. Indicator Description and Data Source

Considering that the subsidy rollback program has been gradually implemented since 2014, and the dual-credit policy was also conceived during this period and had an impact during the gestation period, the data window of this study is defined as 2014-2022, and drawing on the research methodology of Li Xu and Xiong Yongqing [19], the year 2017 is used as the cut-off point for testing the effect of the policy. cut-off point for the test. According to the National Economic Industry Classification Standard (GB/T 4754-2017), C36 refers to the automobile manufacturing industry, which is a general category of automobile-related industries covering the manufacturing of complete vehicles as well as the production of parts and accessories of automobiles, including the manufacturing of complete automobiles (C361), the manufacturing of automobile bodies and trailers (C362), and the manufacturing of automobile parts and accessories (C363). Therefore, this study selected the corresponding experimental group based on the automobile manufacturing industry classification of C36, including 175 A-share listed automobile companies between 2014 and 2022.

In addition, this study also matches to obtain a control group sample from A-share non-automotive manufacturing companies through the PSM method. This is done as follows: for the experimental group of automobile firms, the control variables are used as matching covariates, and the 1:5 nearest-neighbor matching method is used to match each automobile firm to five firms with similar characteristics, which ultimately results in 5,232 valid samples.

Some of the missing values are filled in by interpolation, and to minimize the effect of extreme data, all data are shaded at the 1% and 99% percentiles. The samples of firms in the “special treatment” (ST) category and PT firms were also excluded.

(1) Explained Variables

Currently, there are two main methods to assess enterprise innovation: one is to consider technology and human input, and the other is to focus on the number of innovation patents [20]. Enterprises' green patents include green invention patents and green utility model patents, and this indicator can better represent the enthusiasm as well as the results of enterprises' green innovation, thus most of the previous studies use the number of enterprises' green patent applications to measure the level of enterprises' green innovation [21]. In this paper, the sum of green invention patents and green utility model patents obtained by enterprises in the same year is chosen to measure the level of green innovation of enterprises.

(2) Explanatory variables

Referring to the existing studies, this paper uses the interaction term of the policy time dummy variable and the policy treatment variable as the explanatory variables [7]. The “dual-credit” policy was released in 2017, so 2017 is taken as the policy cut-off point for the test of the incentive effect of the “dual-credit” policy, i.e., the value of the policy time dummy variable *Post* is taken as 0 before 2017, and the value of the policy treatment variable *TPost* is taken as 1 in 2017 and thereafter. The policy treatment variable *Treat* indicates whether automobile listed enterprises are affected by the “dual-credit” policy, and its value of 1 indicates that the enterprises are affected by the policy, i.e., the enterprises listed in the experimental group; and its value of 0 indicates that the enterprises are not affected by the policy, i.e., the non-automobile manufacturing enterprises in the control group.

(3) Moderating Variables

This study introduces the degree of internationalization as a moderating variable and measures it in two dimensions: depth of internationalization and breadth of internationalization. Considering the availability of data, the proportion of the enterprise's overseas business revenue to operating revenue is used to measure the depth of internationalization, and the total number of the enterprise's overseas subsidiaries is used to measure the breadth of internationalization.

(4) Control Variables

With reference to previous studies, this paper selects the following important control variables that affect the level of green innovation of enterprises: enterprise age, enterprise size, return on total assets, proportion of largest shareholders, gearing ratio, cash flow ratio, proportion of independent directors, two jobs, enterprise value, nature of property rights, growth rate of operating revenues, turnover rate of total assets, proportion of accounts receivable, proportion of fixed assets, and policy subsidies.

4.2. Measurement Model

The formula is shown in (4-1):

$$Green_{it} = \beta_0 + \beta_1 Post_t \times Treat_i + \beta_2 Post_t + \beta_3 Treat_i + \sum \beta_j Controls_{it} + \gamma + \lambda + \varepsilon_{it} \quad (4-1)$$

$Green_{it}$: Level of green innovation of automobile companies under the “dual-credit” policy, i.e., the number of green inventions independently obtained in the year

β_0 : constant term

β_1 : DID cross terms, treatment effects of DID, and the impact of dual-credit policy on the level of green innovation of automobile listed firms

$Post_t \times Treat_i$: Policy effects of the experimental group after the implementation of the “dual-credit” policy

$Controls_{it}$: control variable

γ, λ : Province fixed effects, year fixed effects

ε_{it} : random error term

Table 4.1. Descriptive Statistics

Variable	N	Mean	SD	Min	Median	Max
Gre	5232	9.345	26.805	0.000	1.000	194.000
Did	5232	0.153	0.360	0.000	0.000	1.000
RD	5232	18.449	1.434	14.869	18.323	22.572
Size	5232	22.339	1.251	20.090	22.191	26.054
ROA	5232	0.039	0.064	-0.232	0.040	0.203
Top1	5232	0.357	0.147	0.098	0.340	0.749
Lev	5232	0.439	0.187	0.078	0.438	0.899
Cashflow	5232	0.051	0.061	-0.128	0.050	0.220
Indep	5232	0.372	0.050	0.333	0.333	0.571
Dual	5232	0.309	0.462	0.000	0.000	1.000
TobinQ	5232	1.794	0.941	0.000	1.524	5.997
SOE	5232	0.263	0.441	0.000	0.000	1.000
FirmAge	5232	2.985	0.279	2.197	2.996	3.584
Growth	5232	0.257	3.976	-0.952	0.101	263.271
ATO	5232	0.682	0.377	0.000	0.615	7.788
REC	5232	0.150	0.100	0.000	0.135	0.780
FIXED	5232	0.224	0.128	0.001	0.205	0.872
Subsidy	5232	16.783	1.712	0.000	16.725	22.420

The initial sample of this study contains 32,641 observations, which are screened using the propensity score matching method. A control sample with similar characteristics to the experimental group is selected from A-share non-automotive manufacturing firms, and five firms with similar characteristics are matched for each automotive firm using the 1:5 nearest-neighbor matching method with the control variable as the matching covariate. Finally, 5232 valid samples are obtained through matching, and the observation period of the samples is 2014-2022. The subsequent empirical analysis is conducted based on the matched 5232 sample data.

The descriptive statistics of each variable are shown in Table 4-1, the sample is more informative, and the rest of the variables are in a reasonable value interval. Among them, the maximum value of the explanatory variable green innovation level is 194, the minimum value is 0, and the standard deviation is 26.805, which indicates that there is a large gap in green innovation level among automobile enterprises.

Among the control variables, the difference between the minimum value and the maximum value of the operating income growth rate is 264.223, which indicates that the operating income growth rate of each sample data has great variability, and a part of the automobile enterprises have poorer growth ability. In terms of corporate financial capability, the median asset-liability ratio is 0.438, indicating that the asset-liability ratio of China's A-share automobile listed enterprises is generally high.

5. EMPIRICAL RESULTS AND ANALYSIS

5.1. Benchmark Regression

Table 5.1. Benchmark regression results

	(1)	(2)	(3)
	h1	h2	h3
VARIABLES	Gre	Gre	Gre
Did	4.104***	3.740***	4.196***
	(1.100)	(1.120)	(1.132)
Size	10.788***	10.836***	10.786***
	(0.897)	(0.895)	(0.895)
ROA	-7.648	-7.808	-8.934*
	(5.128)	(5.153)	(5.194)
Top1	-5.959**	-5.778**	-4.780*
	(2.629)	(2.629)	(2.612)
Lev	-3.263	-3.246	-2.889
	(2.054)	(2.048)	(2.057)
Cashflow	14.647**	14.049**	13.056*
	(6.831)	(7.084)	(7.057)
Indep	25.088***	24.842***	23.438***
	(7.309)	(7.338)	(7.410)
Dual	3.257***	3.326***	3.078***
	(0.755)	(0.757)	(0.740)
TobinQ	1.288***	1.311***	1.307***
	(0.317)	(0.329)	(0.333)
SOE	2.697***	2.743***	3.339***
	(0.967)	(0.979)	(1.059)
FirmAge	-3.114**	-3.146**	-2.931**
	(1.245)	(1.337)	(1.320)
Growth	0.005	0.000	-0.015
	(0.043)	(0.043)	(0.045)
ATO	-2.996***	-3.008***	-3.407***
	(0.910)	(0.911)	(0.932)
REC	29.762***	29.809***	26.546***
	(5.483)	(5.481)	(5.520)
FIXED	-20.131***	-19.656***	-19.243***
	(2.909)	(2.872)	(2.918)
Subsidy	0.559	0.527	0.521
	(0.652)	(0.651)	(0.655)
Constant	-240.532***	-241.724***	-265.680***
	(14.411)	(14.427)	(16.204)
Observations	5,232	5,232	5,232
R-squared	0.263	0.266	0.278
Year fixed	NO	YES	YES
Province fixed	NO	NO	YES

(Note: *** p<0.01, ** p<0.05, * p<0.1; robust standard errors in parentheses. Same below.)

The empirical analysis is carried out by using the double difference model, and the results are shown in Table 5-1. Column (1) shows the regression results of the impact of “dual-credit” policy on the level of green innovation of enterprises without fixing the year and province, and the coefficient of the explanatory variable DID is 4.104, which is significantly positive at 1% significance level; column (2) shows the regression results of the impact of “dual-credit” policy on the level of green innovation of enterprises without fixing the year and province, and the coefficient of the explanatory variable DID is 3.740, which is significantly positive at 1% significance level. Column (2) shows the regression results of the impact of the “dual-credit” policy on the level of green innovation of enterprises for a fixed year, the coefficient of the explanatory variable DID is 3.740, which is significantly positive at the 1% significance level; column (3) shows the regression results of the impact of the “dual-credit” policy on the level of green innovation of enterprises for a fixed year and province, the coefficient of the explanatory variable DID is 4.740, which is significantly positive at the 1% significance level. The coefficient of the explanatory variable DID is 4.196, which is significantly positive at 1% significance level.

Thus, it can be confirmed that the implementation of “dual-credit” policy significantly improves the green innovation level of listed automobile enterprises, and hypothesis H1 is verified.

5.2. Propensity Score Matching Balance Test

In this paper, the method of propensity score matching is used to obtain the control group samples, and the reliability of the PSM matching results is verified by the balance test, which is shown in Figure 5-1.

This balance test table shows the statistics such as mean, standard deviation, standard deviation drop, t-test of the covariates before and after matching. The absolute values of standardized deviation of the control variables after matching are all greatly reduced and all are less than 10%, which indicates that the matching of the control group samples is more effective, and that the two groups have smaller differences in covariates and higher balance. And the difference tests of each control variable are not significant, indicating that there is no significant difference between the two samples on the control variables, and the difference is only whether they are affected by the policy or not. Therefore, if there is a significant difference in the explanatory variables between the two groups, it can be attributed to the effect of the dual-credit policy.

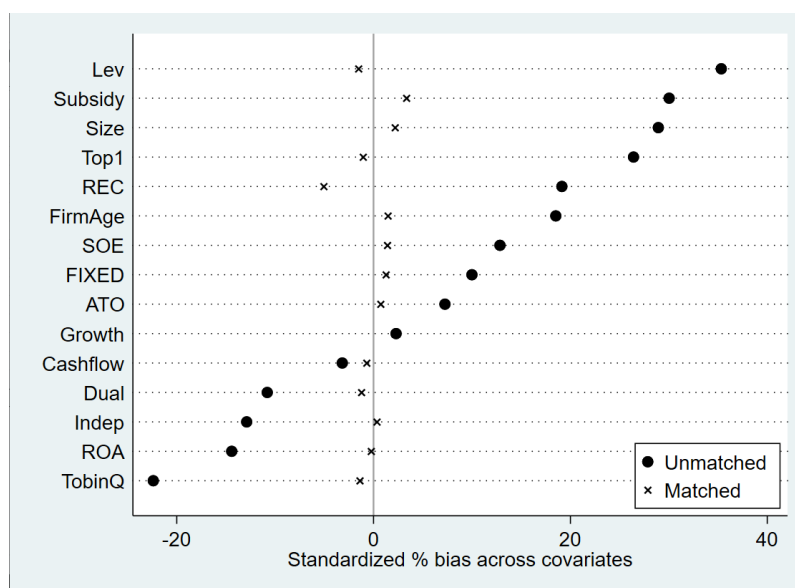


Figure 5.1. Graph of Balance Test Results

5.3. Robustness Test

In order to explore the lagged impact of the dual-credit policy on the green innovation level of automobile enterprises and to enhance the robustness of the regression results of the baseline model, this paper refers to the analytical method of Xu Yuan and Deng Huyan[22], and includes the lagged one-period explanatory variables into the regression model for testing, and the results are as shown in column (1) of Table 5-2, the estimated coefficient of the double-difference interaction term (DID) is 0.116 for one period, and it is positive at the 1% significance level, which indicates that the “dual-credit” policy promotes the green innovation level of auto enterprises. As shown in column (1) of Table 5-2, the estimated coefficient of the dual-credit interaction term (DID) with one period lag is 0.116, and it is positive at 1% significance level, indicating that the promotion effect of the dual-credit policy on the level of green innovation of automobile enterprises is still significant in the lagged period.

This result suggests that the policy effect is gradually visible from the initial implementation to the full implementation of the policy. Considering that the implementation of the policy usually takes a certain amount of time to accumulate, there may be a significant time lag in its impact on firms' behavior. This lagged effect further proves the durability and robustness of the dual-credit policy in promoting green innovation. Therefore, the regression treatment with one period of lag can more comprehensively capture the real impact of the policy on the level of green innovation of enterprises, so as to enhance the explanatory power and robustness of the empirical results.

Figure 5.2. Robustness test results

VARIABLES	(1) L.GreInvig	(2) Gre
Did	0.116*** (0.037)	3.529*** (0.977)
Constant	-8.457*** (0.455)	-224.801*** (8.973)
Observations	1,832	4,491
R-squared	0.392	0.253
control variable	YES	YES
year	YES	YES
province	YES	YES

5.4. Heterogeneity Analysis

In order to investigate whether the nature of different enterprises affects the relationship between the dual-credit policy and the level of green innovation of automobile enterprises, this study conducts a group test on state-owned enterprises and non-state-owned enterprises, and the test passes the test of inter-group variability, so that the results of the two groups can be effectively compared with each other, and the test results are shown in Table 5-3.

The regression results show that the Did regression coefficient of the sample of non-state-owned enterprises is 1.543, which is significant at 10% level, and the Did regression coefficient of the sample of state-owned enterprises is 13.749, which is significant at 1% level, that is to say, the significance of state-owned enterprises is stronger than that of non-state-owned enterprises, and therefore it can be known that the state-owned enterprises are more important than non-state-owned enterprises under the influence of the dual-credit policy. Therefore, it can be learned that state-owned enterprises can improve their green innovation level more effectively than non-state-owned enterprises under the influence of the “double points” policy.

Figure 5.3. Regression results of the test for heterogeneity of firms' ownership structure

	State-owned enterprises	Non-state enterprise
Variable	Gre	Gre
Did	13.749*** (5.14)	1.543* (1.71)
Size	12.734*** (12.04)	9.006*** (21.70)
ROA	-50.481** (-2.48)	-3.637 (-0.56)
Top1	-4.664 (-0.78)	-2.791 (-1.21)
Lev	-15.352** (-2.46)	1.243 (0.51)
Cashflow	-4.574 (-0.28)	18.328*** (2.96)
Indep	33.150** (2.00)	22.157*** (3.40)
Dual	8.386*** (2.81)	2.062*** (3.13)
TobinQ	1.821* (1.78)	1.406*** (3.88)
SOE	8.957** (2.00)	68.876*** (8.50)
FirmAge	-8.261** (-2.06)	-1.532 (-1.29)
Growth	-0.478 (-0.56)	0.014 (0.22)
ATO	-1.032 (-0.45)	-2.801*** (-2.88)
REC	45.062*** (5.07)	22.778*** (5.91)
FIXED	-27.032*** (-3.89)	-9.332*** (-3.20)
Subsidy	1.925*** (3.21)	-0.237 (-0.96)
Constant	-298.822*** (-12.58)	-195.862*** (-21.98)
Observations	1,344	3,315
Adjusted R-squared	0.334	0.240
province	YES	YES
year	YES	YES

The internal governance characteristics of enterprises with different equity structures are different, resulting in differences in resource allocation and efficiency, which significantly affects the incentive effect of innovation [23]. State-owned enterprises (SOEs) are the pillars of the national economy, spread across important strategic industries and monopoly industries, and are more likely to obtain policy tilts and financial support due to their close ties with the government. Compared with SOEs, non-SOEs face serious “financial discrimination” and administrative control disadvantages. Institutionally, SOEs are more innovative, while NSOEs are more R&D-intensive and

technologically efficient. At the same time, the state-owned enterprises themselves have the credibility of the government's endorsement, with less production and operation risks, and can more quickly correspond to the adjustment of industrial policy, i.e., the different nature of the enterprise determines the difference in its sensitivity to the policy.

To summarize, there are differences in the role of enterprise ownership structure on the influence of “dual-credit” policy on the level of green innovation of automobile enterprises.

5.5. Regulatory Mechanism Test

In order to explore the impact of the dual-credit policy on the green innovation level of automobile enterprises in different internationalization contexts, this study introduces internationalization breadth and internationalization depth as moderating variables to test the moderating effect, so as to analyze the degree of enterprises' participation in the global market and its moderating effect on the policy effect in a more refined way, thus improving the understanding of the impact mechanism of the policy. This will improve the understanding of the policy impact mechanism. The moderating models are shown in (5-1) and (5-2).

$$Green_{it} = \alpha_0 + \alpha_1 DID + \alpha_2 ID + \alpha_3 tj_2 + \sum \alpha_j Controls_{it} + \gamma + \lambda + \varepsilon_{it} \quad (5-1)$$

$$Green_{it} = \gamma_0 + \gamma_1 DID + \gamma_2 IB + \gamma_3 tj_1 + \sum \gamma_j Controls_{it} + \gamma + \lambda + \varepsilon_{it} \quad (5-2)$$

The results of regression analysis are shown in Table 5-4. Firstly, after the introduction of internationalization depth as a moderator variable, the regression coefficient of the interaction term tj_2 (ID * DID) is -13.54, and it is significantly negative at 1% significance level, which indicates that internationalization depth plays a significant negative effect on the relationship between “dual-credit” policy and the level of green innovation of enterprises. This indicates that the depth of internationalization plays a significant negative role in the relationship between the “double points” policy and the level of green innovation. That is, the higher the internationalization depth, the weaker the incentive effect of green innovation of enterprises responding to the dual-credit policy. This may be due to the fact that the complexity between technological resources, market adaptability and global environmental standards of firms with higher internationalization depth increases the difficulty of internal resource allocation and management, thus weakening the green innovation incentive of the dual-credit policy. The results are consistent with Hypothesis H4, which further supports that firms may face internal and external pressures when the depth of internationalization is high, resulting in their inability to fully utilize the policy incentives to enhance green innovation.

Second, when internationalization breadth is introduced as a moderator variable, the regression coefficient of the interaction term tj_1 (IB * DID) is 3.701 and is significantly positive at 1% significance level. This suggests that internationalization breadth has a significant positive moderating effect on the relationship between dual-credit policy and firms' green innovation level. The wider the internationalization, the better the enterprises can absorb and utilize external green technology resources in the wider international market, and the competitive pressure in the global market also encourages the enterprises to respond to the domestic green policy more actively. Wider international market layout helps enterprises to acquire advanced green technology and management experience through knowledge spillover effect, thus enhancing their green innovation level. This result verifies hypothesis H5, that is, the positive incentive effect of internationalization breadth on firms' green innovation is further confirmed.

Table 5.4. Moderated Effects Regression Results

VARIABLES	(1) Gre	(2) Gre
Did	-5.585** (2.493)	6.677*** (1.139)
t_{j1}	3.701*** (0.927)	
IB	-3.082*** (0.461)	
Size	11.98*** (0.456)	10.84*** (0.407)
ROA	-13.54** (6.727)	-9.708 (6.877)
Top1	-5.999*** (2.290)	-5.707** (2.292)
Lev	-2.272 (2.416)	-3.190 (2.440)
Cashflow	14.97** (6.204)	12.80** (6.308)
Indep	24.16*** (6.401)	25.93*** (6.432)
Dual	2.973*** (0.728)	3.467*** (0.734)
TobinQ	1.332*** (0.375)	1.228*** (0.379)
SOE	2.455*** (0.888)	3.576*** (0.881)
FirmAge	-2.629** (1.252)	-3.875*** (1.269)
Growth	-0.0333 (0.0797)	-0.0139 (0.0793)
ATO	-3.248*** (0.931)	-3.329*** (0.937)
REC	26.19*** (3.694)	27.68*** (3.731)
FIXED	-21.17*** (2.842)	-20.50*** (2.835)
Subsidy	0.652*** (0.244)	0.491** (0.247)
t_{j2}		-13.54*** (3.754)
ID		1.621 (1.579)
Constant	-260.9*** (9.381)	-238.4*** (8.552)
Observations	5,232	5,113
R-squared	0.285	0.290
R-squared	0.290	0.290
province	YES	YES
year	YES	YES
N	5113	5113
F	101.2	101.2

In summary, internationalization breadth and internationalization depth have different moderating effects on the incentive effect of dual-credit policy on green innovation. This finding suggests that firms' responses to policy incentives are not consistent across different dimensions of internationalization. While the breadth of internationalization enhances green innovation by facilitating technology absorption and market expansion, the depth of internationalization may weaken the incentive effect of the policy due to the complexity of internal management and difficulties in resource allocation. This provides important insights for policymakers to take into account the differences in firms' internationalization strategies in the process of promoting green innovation, and to design complementary policies that maximize the incentive effects of policies according to local conditions.

6. CONCLUSIONS AND RECOMMENDATIONS

This paper takes 175 A-share automobile listed enterprises as the experimental group from 2014 to 2022, and matches the control group from A-share non-automobile manufacturing enterprises by PSM (propensity score matching) method, and empirically analyzes the impact of the dual-credit policy on the level of green innovation of automobile listed enterprises by using the double-difference model. A double-difference model is used to analyze the impact of the “double integral” policy on the green innovation level of listed automotive companies, and the path of the policy is further explored by using internationalization depth and internationalization breadth as moderating variables. Based on the empirical results, the following main conclusions are drawn:

- (1) The dual-credit policy significantly improves the green innovation level of automobile enterprises, which verifies the important role of the policy in promoting the technological progress and green transformation of enterprises.
- (2) The depth of internationalization has a significant negative moderating effect on the incentive effect of the dual-credit policy. Firms with higher internationalization depth, despite their rich global resources, have a complex global operating environment that limits their quick response to domestic policy requirements, thus weakening the incentive effect of the policy on green innovation.
- (3) In contrast, internationalization breadth positively moderates the incentive effect of the dual-credit policy. Firms with greater breadth of internationalization are able to access more external green technology resources and experiences in a wider international market, which enhances the policy's effect on promoting green innovation. Breadth of internationalization reinforces the positive impact of policies by facilitating firms' global technology absorption and knowledge spillovers.
- (4) Heterogeneity analysis also shows that under the effect of the dual-credit policy, SOEs' green innovation level is significantly better than that of non-SOEs, because they are more favorable in terms of policy support and access to resources, and they are able to better utilize the policy orientation to promote green innovation, especially in the process of policy implementation.

In summary, this study comprehensively examines the implementation effect of the dual-credit policy from the perspective of microenterprises, especially in promoting green innovation and transformation and upgrading of the automobile industry. By introducing moderating variables, the study further enriches the exploration of the impact mechanism of the policy on enterprises' green innovation and provides solid empirical support. This study provides theoretical basis and empirical data for the optimization and adjustment of policies in China's automotive industry, highlighting the differences in the response of different types of firms to policies as well as the importance of internationalization strategies in the process of policy implementation.

The policy insights and recommendations of this paper are:

First, based on the positive moderating effect of the internationalization breadth of enterprises on the incentive effect of the dual-credit policy on the improvement of green innovation level of automobile

enterprises, the state should support enterprises to expand into the international market, and provide policy support, such as export subsidies or market access preferences, to green innovative products entering the international market in order to enhance the breadth of internationalization; enterprises should actively formulate and implement policies that keep pace with the times; and enterprises should actively formulate policies that keep pace with the times. Enterprises should actively formulate internationalization strategies that keep pace with the times, optimize international resource allocation, and improve their green technology innovation capabilities globally, as well as strengthen international standard docking, promote their innovation and R&D processes to closely comply with international green standards, and enhance their competitiveness and influence in the international market. This provides important insights for policy makers, that is, in the process of promoting enterprises' green innovation, they should take into full consideration the differences in enterprises' internationalization strategies, design supporting policies according to local conditions, and maximize the incentive effect of policies.

Second, based on the fact that SOEs are more effective in enhancing green innovation than non-SOEs under the influence of the dual-credit policy, the state should encourage SOEs to share their successful experiences and best practices in green innovation with all enterprises, so as to promote the green innovation level of the whole industry.

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