Micro effect of green credit policy on enterprise innovation

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Abstract. Since the reform and opening up, China's rapid economic development, has made remarkable achievements in the economy, but also brought a heavy burden on the environment, there have been many ecological problems, caused great social harm, destroyed the natural ecological environment, so the country vigorously promote the green credit system, It is of great significance to restrain the development of "two, one and one remaining".In this paper, the background of green credit policy and its research significance are systematically summarized, and relevant hypotheses are put forward by using relevant theories of green credit and industrial transformation and innovation.This paper further analyzes the influence mechanism of green credit on enterprise innovation, draws conclusions and puts forward relevant optimization suggestions.

Keywords: green credit;Industrial innovation;Path mechanism;

1. Research background and significance

The fourth and Fifth Plenary sessions of the 19th Central Committee put forward the development of green ecological economy. Green ecological economy is not only an effective supplement to China's traditional environmental management policy, but also an important exploration of applying market-oriented means such as financial regulation to the field of environmental protection. On July 12, 2007, China Environmental Protection Administration, People's Bank of China and China Banking Regulatory Commission jointly issued the "Opinions on Implementing Environmental Policies and Regulations to Prevent CREDIT Risks". Chinese companies rely heavily on bank loans for external financing. China's highly polluting industries have always been an important part of credit resources. The unbalanced distribution of green ecological economic resources objectively promotes the development of industries with high energy consumption and high pollution, and to some extent aggravates environmental pollution and environmental costs[1].

At present, innovation has become the primary driving force for China's social development. In the new era of accelerating the construction of an innovation-oriented country, technological breakthroughs and innovative output of enterprises are particularly important.Breakthrough innovation emphasizes to subvert the original technological achievements and market strategies, meet the needs of existing consumer groups and open up new markets by improving product performance, change industry rules and competition conditions, and even reshuffle the original industry[2].

Green ecological economy is an important financial tool to adjust the allocation of credit resources of high pollution enterprises.In theory, green credit policy can influence capital investment, technological innovation decision and resource redistribution among enterprises by setting up the dual constraint mechanism of environmental access threshold and credit quota control[3].

The majority of research findings indicate that green credit policy is successful from the standpoint of implementation effect. For instance, green credit is crucial in fostering the micro-effect of ground-breaking innovation in environmental protection businesses (He Lingyun et al.,2019) ［4］, significantly reduced the new loans to enterprises with high pollution and high energy consumption (CAI Haijing et al., 2019［5］;Bonorapl.influence, 2019［6］), and cities hit hard by the policy have achieved good environmental protection results.Green credit has adjusted the structure of heavy polluting industries to a certain extent, and heavy polluting enterprises constrained by bank credit and commercial credit have significantly increased their investment in

environmental governance (Chen Xingxing et al., 2019). ［7］.However, some scholars believe that green credit has not achieved the desired effect and may even have a negative impact.For instance, green credit falls short of its goals of altering loan terms and amounts as well as assisting high-polluting businesses with industrial reorganization and technological change (Wang et al.,2019).［8］, the development of green finance leads to the decline in the investment efficiency of renewable energy enterprises (He et al., 2019)［9］, the green credit policy has not been fully implemented (Zhang et al., 2011)［10］.To sum up, existing studies have elaborated the punitive effect of green credit on the financing of heavy polluting enterprises and the supporting effect of green credit on green enterprises. However, due to different research methods, perspectives and time ranges, there are also some disputes and differences, and some problems still need to be further studied.Based on this, studying the relationship between the green credit mechanism and industrial transformation and innovation is extremely important, whether one is trying to encourage the use of green credit to encourage industrial transformation and innovation or the further expansion of the green credit scale.

2.   Basic theoryand hypothesis

2.1 Basic theory

Ecological economics refers to the financing behavior of environmental pollution industries, which restricts their financing channels, and then has a certain restriction effect on their R&D input, innovation output, etc., and then has a certain restriction effect on the micro effect of their breakthrough innovation.Implementation of the green credit scheme largely involves the following two elements: First, as opposed to the previous credit system, the efficiency of the green credit program is determined by the company's environmental performance. Therefore, the business can improve its environmental performance by requesting more loans, which will motivate it to pursue environmental reform more vigorously.Voluntarily disclosing their own environmental information can reduce the financial costs of enterprises, while enterprises with high pollution will face higher financing constraints.Second, faced with huge environmental costs, enterprises can only reduce them by means of technological innovation, while with the support of green credit policy, enterprises can promote their technological innovation.Therefore, improve the technical level of the enterprise.To sum up, this paper proposes:

2.2 hypothesis

2.2.1 Hypothesis 1

Hypothesis 1: The implementation of green credit policy can significantly promote the micro effect of enterprise innovation.

In today's era of highly developed information, green credit enterprises can use ESG to convey their environmental message to the outside world to improve corporate performance.Media attention is an important medium for a company to communicate with investors, stakeholders and the public. On the one hand, this external restriction increases the transparency of the company's environmental information disclosure and shows its willingness to transform into environmental protection. On the other hand, it increases the company's attention.The constraint of green credit on the company is highly valued by the media. Therefore, in the clear message of the media, the company should actively adopt technological innovation to realize the coordinated development of economy and environment.To sum up, this paper proposes:

2.2.2 Hypothesis 2

Hypothesis 2: High media attention will help to greatly increase the micro effect of enterprise innovation after the green financing policy is put into place.

Commercial banks are biased toward the private sector of the economy and tend to favor state-owned businesses when taking into account risk, state assistance, and other considerations. As a result, private businesses in China face a considerable credit risk.At the same time, due to the rationality of bank credit system, it is difficult for financial institutions to get rid of their prejudice to the environment, thus increasing the difficulty of financing.In addition, state-owned enterprises are more sensitive to the state's macro-control than private enterprises, and the implementation effect of green credit is more significant in state-owned enterprises.Compared with non-profit enterprises, state-owned enterprises are more innovative and easy to realize the transformation of environmental protection. In addition, in order to meet the national environmental protection purposes, state-owned enterprises also need to meet the national environmental protection requirements.Will push the environmental shift even further.To sum up, this paper proposes:

2.2.3 Hypothesis 3

Hypothesis 3: After the implementation of green credit policy, it has a more significant promoting effect on the micro effect of state-owned enterprise innovation.

Compared with smaller companies, large-scale enterprises have more "financial resources", stronger technological innovation ability, stronger market control ability, and more sound marketing channels, which can ensure the innovation benefits of the company.In terms of improving corporate social responsibility, small-scale enterprises lack internal and external incentives because of their own risk appetite and are not willing to take the risks brought by innovation.With little incentive to innovate and minimize capital drain, large-scale enterprises are more likely to call for cooperation under the call of policy.Therefore, driven by environmental protection policies, large-scale enterprises carry out more green transformation, while small-scale enterprises are "unable to help" under the implementation of policies. Due to the constraints of capital, credit status and other factors, it is difficult to improve the innovation ability of enterprises.

3. Study on micro effect of green credit on firm innovation

3.1 Sample data sources

his study selected A-share companies from 2010 to 2019 as the initial research object, and the company's financial data mainly came from CSMAR.In order to further improve the accuracy of the test results, we sorted out the original accounting data as follows: excluding the financial industry, insurance industry, ST class, ST* class enterprises, excluding the omission of important financial data, as well as those companies whose asset-liability ratio exceeds 1.Finally, 9886 enterprises were obtained for the annual unbalanced panel statistical analysis.The number of patent applications and data of major companies from 2010 to 2019 are provided by the website of the State Intellectual Property Office, and the pertinent information is manually compiled in accordance with the rules, with media attention focused on the specifics of a particular corporation from major publications from 2010 to 2019,which the newspaper obtained from the Full-text Database of Important Chinese Newspapers. Stata15.1 was used for data processing.

Refer to Wang Xin, Wang Ying (2021)[11]For companies that are rated A for "environmental and social" in the Green Credit Guidelines, the industry in which they are located is defined.If the company is in the industries listed above, it will be listed as a company subject to green credit, and it will be listed as the experimental group;On the contrary, companies that are not subject to green credit constraints are the control group.

3.2 Variable Definition

In order to investigate the impact of green credit policy on the micro-effect of enterprise breakthrough innovation, this paper constructed the following difference model:

$GI_{i,t}=\alpha_0+\alpha_1*Treat_i*Post_t+\beta X_{i,t-1}+\mu_i+\omega_t+\varepsilon_{i,t}$ （1）

$GI_{i,t}=\alpha_0+\alpha_1*Treat_i*Post_t*Media+\beta X_{i,t-1}+\mu_i+\omega_t+\varepsilon_{i,t}$ （2）

(1) Explained variable: Micro-effect of breakthrough innovation (GI)

The explained variable GIi, T represents the micro effect of the breakthrough innovation of the ith listed company in the T year, referring to Liu Qiang et al. (2020)[18]To measure the micro effect of enterprise breakthrough innovation by the annual number of patent applications. In order to prevent the loss of observations and ensure the accuracy and reference of data, the data of each patent application is added by 1 and then the logarithm is taken when measuring indicators.

(2) Explain variable: Treat*Post

Treati indicates whether enterprise I is a green credit restricted enterprise. If it is, the value can be 1; otherwise, the value can be 0.Postt is a dummy variable of the implementation time of green credit policy. When T is greater than or equal to 2012, the value is 1; when T belongs to 2010-2011, the value is 0.

(3) Adjusting variable: Media

Mediating variable Media Attention Media, refer to Zhao Li and Zhang Ling (2020)[19]By adding one to the number of times a story headline appears about the company.

(4) Control variables

Its contents include: Cash Holdings (Cash), Company size (size), asset-liability ratio (Lev), return on assets (ROA), fixed asset density (PPE), Board Size (Board), ratio of independent directors (INDEP), Dual, Proportion of shares held by the largest shareholder (FIRS), Property rights (SOE)), company listing years (AGE), and company growth capacity (growth). Table 2-1 lists the specific variables.In the course of the study, due to the delay of the environmental impact, the internal impact was reduced, and a lag phase treatment was adopted.The dual-difference model is built as follows:

$$GI_{i,t}=\alpha_0+\alpha_1*Treat_i*Post_t+\beta X_{i,t-1}+\mu_i+\omega_t+\varepsilon_{i,t} \quad (1)$$

$$GI_{i,t}=\alpha_0+\alpha_1*Treat_i*Post_t*Media+\beta X_{i,t-1}+\mu_i+\omega_t+\varepsilon_{i,t} \quad (2)$$

Table 3-1 Description of variables

	The variable name	Variable definitions
Variable types	GI	Ln (Patent applications +1)
Explained variable	Treat	Green credit restricted enterprises, the value is 1, is the experimental group;Otherwise, the value is 0, indicating the control group
Explanatory variables	Post	In 2012 and later, the value is 1;Before 2012, the value is 0
	Media	Ln (number of newspaper reports +1)
Adjust the variable	cash	Year-end monetary funds/year-end total assets
	size	Ln (year-end total assets of the Company)
	lev	Total liabilities/total assets
	ROA	Net profit after tax/total assets
	PPE	Year-end net fixed assets/year-end total assets
	board	Ln (Number of Board members)
Control variables	indep	Number of independent directors/number of boards
	dual	1 if there is one chairman and one general manager, 0 otherwise
	firs	Proportion of shares held by the largest shareholder
	soe	Property rights are 1 for state-owned enterprises and 0 for non-state-owned enterprises
	age	Ln (years of listing)
	growth	Growth in total assets this year/total assets at the beginning of the year

3.3 Empirical Model Analysis

(1) Descriptive statistics of variables

The analysis results of descriptive statistics on variables in this paper are shown in Table 3-2. The mean value, maximum value and minimum value of GI of enterprise breakthrough innovation

are 1.79, 5.23 and 0.70, indicating that there are great differences in the level of micro effect of breakthrough innovation among different enterprises.The mean value of Treat was 0.31, indicating the existence of 31% enterprises with green credit restriction.Time variable (Post) average of 0.81, shows that the green credit guide after the sample accounted for 81% of the total sample;However, the average value of Treat*Post, which this paper mainly focuses on, is 0.23, The results show that 23% of the green credit constrained companies have a certain impact on the micro effect of breakthrough innovation after the implementation of green credit. The average value of the moderating variable Media characteristics (Media) is 2.21, the highest is 5.61, and the lowest is 0, which is very different, indicating that the Media characteristics of each company are very different;Control variables are in reasonable range.

Table 3-2 variable descriptive statistics

variable	Sample size	The average	The standard deviation	The minimum value	The maximum	The median
GI	9886	1.79	1.08	0.7	5.23	1.59
Treat	9886	0.31	0.47	0	1	0
Post	9886	0.81	0.42	0	1	1
Treat*Post	9886	0.23	0.43	0	1	0
Media	9886	2.21	1.37	0	5.61	1.95
cash	9886	0.17	0.11	0.02	0.59	0.13
size	9886	21.42	1.31	19.15	25.34	21.22
lev	9886	0.43	0.19	0.07	0.85	0.43
ROA	9886	0.04	0.05	0.19	0.18	0.04
PPE	9886	0.21	0.15	0.01	0.67	0.17
board	9886	2.03	0.19	1.53	2.57	2.09
indep	9886	0.35	0.05	0.31	0.54	0.34
dual	9886	0.26	0.42	0.00	0.95	0.00
firs	9886	0.33	0.14	0.09	0.71	0.31
soe	9886	0.38	0.47	0.00	0.95	0.00
age	9886	2.13	0.67	0.66	3.14	2.19
growth	9886	0.19	0.32	0.24	1.97	0.10

(2) Analysis of regression results

1. Parallel trend hypothesis testing

The underlying assumption of the dual difference method is to conform to the parallel trend, that is, to ensure that the experimental group and the control group maintain the same trend before the event, so as to ensure that exogenous events are the only cause of the difference between the two.To test this hypothesis, refer to Qian Xuesong et al. (2019)[22]To conduct the T-test on the number of invention patent authorization in the experimental group and control group from 2011 to 2020.According to the test results in Table 3-3, before 2013, there was no difference in the number of invention patents between the experimental group and the control group.It shows that it accords with parallel trend and satisfies the preconditions of parallel trend of dual difference method.

Table 3-3 parallel trend test

time	The experimental group	The control group	differences	P values
2011	1.624	1.748	0.124	0.232
2012	1.715	1.776	0.061	0.804
2013	1.702	1.752	0.05	0.321
2014	1.802	1.742	0.06	0.125
2015	1.815	1.774	0.041	0.653
2016	1.923	1.815	0.108	0.351
2017	1.975	1.850	0.125	0.382
2018	2.052	1.891	0.161	0.412
2019	2.504	1.888	0.616	0.491
2020	1.622	1.767	0.145	0.408

Figure 3-1 shows the relationship between green credit and green credit lines and the firm's innovation output for the period 2011-2020, with the horizontal axis being the year, the longitudinal axis of sample after the innovation patent filings add 1 natural logarithm, and the Y axis parallel to the line for the "green credit guide" (hereinafter referred to as the "guidance") year of implementation, as a dividing line, The sample period was divided into pre-implementation of the Guidelines (2010-2011) and post-implementation of the Guidelines (2011-2020).It can be seen that before and after the implementation of the Guidelines, the average growth trend of green innovation output of enterprises with green credit restrictions and enterprises without green credit restrictions is basically the same.At the same time, it can be seen that after the implementation of the Guidelines, the gap in the average growth amount of green innovation output of enterprises with green credit restriction and enterprises without green credit restriction significantly widened, thus meeting the parallel trend test.
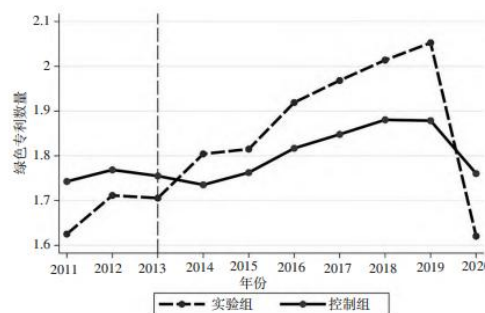

Fig. 3-1 parallel trend chart

2, PSM matching

In this paper, based on nearest neighbor matching method, using Logit model to estimate tended to match score, select the continuous variables as control variables in this paper a covariate[12]To test variables before and after the match the significant difference.Matching results as shown in table 3-3, the sample standard deviation of the experimental group and control group after the match is greatly reduced, the coefficient of the mean difference was not significant, showed that matching results conform to the requirements.

Table 3-4 covariate matching results

variable	Sample match	The mean		Deviation from standardization	Deviation (%)	T value	P values
		The experimental group	The control group				
cash	unmatched	0.146547	0.1756645	24.32	91.58	10.26	0
	matched	0.1469935	0.1459485	0.855		0.3705	0.66405
size	unmatched	21.7949	21.3028	35.245	80.56	15.751	0
	matched	21.78635	21.8614	5.32		1.9285	0.0399
lev	unmatched	0.481289	0.4117965	33.345	85.03	14.516	0
	matched	0.4804055	0.4876825	3.515		1.368	0.14345
ROA	unmatched	0.031863	0.0367175	5.985	67.74	2.584	0
	matched	0.0316445	0.033041	1.71		0.722	0.42465
PPE	unmatched	0.234422	0.196175	23.085	93.01	10.659	0
	matched	0.2321515	0.232959	0.475		0.1615	0.8189
board	unmatched	2.0558	2.03053	12.16	70.87	5.548	0
	matched	2.05409	2.06055	3.135		1.1305	0.22135
indep	unmatched	0.3573615	0.3554235	3.325	18.62	1.539	0.1007
	matched	0.356934	0.355376	2.66		0.9595	0.29545
firs	unmatched	0.3351505	0.3326235	1.615	7.32	0.7315	0.4199
	matched	0.334153	0.33649	1.52		0.5415	0.5377
age	unmatched	2.497455	1.999275	79.04	94.43	33.079	0
	matched	2.49375	2.4909	0.475		0.1995	0.79515
growth	unmatched	0.154869	0.226024	11.59	70.30	5.1015	0
	matched	0.1559995	0.1374745	3.04		1.425	0.12825

(3) Main effect analysis

This paper will use green credit propensity score matching and double difference method to test the micro impact of green credit on enterprise breakthrough innovation. and matched samples were used for regression analysis.As shown in Column (1) of Table 4, when no control variables were added to the regression results and only enterprises and years were controlled, the regression coefficient of the main test was significantly positive at the 1% level.Column (2) shows that after the addition of control variables, the regression coefficient of the master test increases significantly and is still at the level of 1%, which further indicates that the effect of the implementation of "guidance" on the green credit line significantly promotes micro-enterprise innovation., hypothesis 1 through inspection.

(4) Test of regulating effect

Media attention, as one of the main factors that influence the enterprise external and investigation of its regulating effect on both is indispensable, Table 3-4 shows the regulatory relationship between green credit policy and micro effect of enterprise innovation. using PSM to match samples after adding control variables before and after comparison.When there is no control variable, the coefficient of cross product term is significantly positive at 1% level.After the introduction of control variables, there is still a relatively large positive relationship within the range of 1%, which indicates that companies highly concerned by the media will further improve their technological innovation ability, specifically, by 6.2%. Hypothesis 2 has passed the test.

Table 3-5 Results of baseline regression and adjusted regression

variable	(1)	(2)	(3)	(4)
Treat*Post	0.128 * * * (5.19)	0.129 * * * (4.48)		
Treat*Post*Media			0.101 * * * (10.98)	0.059 * * * (5.70)
Controls		YES		YES
Constant		4.915 * * * (16.38)		4.695 * * * (15.56)
Firm fixation effect		is		is
Year fixed effect		is		is
N	9787	9787	9787	9787
R2	0.008	0.171	0.017	0.172

Note: *, **, and *** indicate significant at the level of 10%, 5%, and 1% respectively, with T values in brackets

(3) Further analysis

(1) Heterogeneity analysis based on the nature of enterprise property rights

State-owned enterprises and non-state-owned enterprises in the credit financing when facing different degree of discrimination, which may result in both a micro enterprise innovation effect in the green credit policy under the influence of different level, which shall be carried out in accordance with the nature of the ownership of the listed company group regression, by page 2 can be seen in table 5, after the implementation of green credit policy, Compared with non-state-owned enterprises with green credit restriction, state-owned enterprises with green credit restriction significantly improve the micro-effect of enterprise breakthrough innovation, and state-owned enterprises are greatly influenced by policy effects, thus affecting green innovation behavior. Hypothesis 3 has passed the test.

(2) based on the analysis of enterprise scale heterogeneity, this paper takes median boundary of enterprise scale, the listed company is divided into big and small, thus to explore the microscopic effect of different scale enterprise breakthrough innovation under the green credit policy differences;By grouping, benchmark regression, the results as shown in table 5, large-scale green credit limit enterprises significantly increased the microscopic effect of breakthrough innovation, hypothesis 4 through inspection, that a green credit limit due to its powerful asset base, more capable of enterprise innovation transformation, build a green management system, The regulation effect of green credit policy on large-scale enterprises is stronger. Meanwhile, it shows that green credit policy does not pay enough attention to small and medium-sized enterprises, and the impact on promoting their innovation transformation is not significant.

(3) Heterogeneity analysis based on financing constraints

This paper uses SA index to measure corporate financing constraints[13]The specific formula is as follows:

SA = 0.043 * age size12-0.04-0.737 x the size (3)

Size1 is the changed size of the enterprise divided by the total assets by the natural log of 1 million, that is, the company's listing years. In order to better judge the level of corporate financial constraints, this paper adopts the absolute value of SA index and groups them according to the median. on the basis of general grouping samples, regression results as shown in table 3-5, low financial constraint level of green credit limit can be even more significant to enhance the level of the microscopic effect of enterprise innovation, However, high financing constraints will have the opposite effect on the innovation transformation of enterprises. Hypothesis 5 has passed the test.

Table 3-6 heterogeneity regression analysis results

variable	State-owned enterprises	The state-owned enterprises	On a large scale	small	High financing constraints	Low financing constraints
Treat*Post	0.228 * * *	0.0312 * *	0.181 * *	0.003	0.139 * * *	0.189 * * *
	5.57	2.21	4.58	0.09	3.99	3.26
Controls	YES	YES	YES	YES	YES	YES
Constant	5.102 * * *	4.806 * * *	6.009 * * *	1.901 * * *	1.701 * * *	6.902 * * *
	(11.52)	(11.01)	(12.69)	(2.58)	(3.81)	(15.60)
Enterprise fixed effects	is	is	is	is	is	is
Year fixed effect	is	is	is	is	is	is
N	3962	6010	4991	4981	4878	4878
R2	0.1843	0.15105	0.1558	0.05795	0.08835	0.08835

Note: *, **, and *** indicate significant at the level of 10%, 5%, and 1% respectively, with T values in brackets

4. Summary

Based on the total number of patent applications of Listed companies in China from 2010 to 2019, this paper constructs a quasi-natural experiment case, and selects Green Credit Guidelines as the case. In this paper, pSM-DID analysis is used to investigate the micro-effect of firm breakthrough innovation and the moderating effect of media on firm innovation capability. Factors such as different ownership, enterprise scale and capital constraint will influence enterprise innovation behavior. The results show that :(2) with the increase of media attention, the micro impact of green credit policy on breakthrough innovation becomes more obvious; (3) restricted by the government's green credit policy, (4) green credit policy has little impact on the micro-effect of breakthrough innovation;(5) With fewer capital constraints, the restriction effect on micro effects of company breakthrough innovation is more obvious.

Through the above research, this paper believes that the implementation of "green credit" can effectively improve China's innovation ability, and accordingly puts forward the following suggestions: 1) Local governments should improve the green credit system.As the leader of the global environmental governance, countries should strengthen the green credit policy innovation, perfect green credit system, perfect the system of the green credit, green credit system, strengthening the construction of financial market credit system, strengthen financial regulation, set up financial institutions, financial risk and related laws and regulations, promote green credit policy impact on micro enterprise innovation effect.(2) to strengthen the media objective and independent.At present, our country's news media is not completely objective, it will be on our country's green credit policy execution produce certain negative effects, therefore, must strengthen the interference of media, strengthen the independence of the media, so as to better achieve its external regulatory functions.(3) Establish differentiated green credit policies to adapt to different types of companies, improve green credit policies more suitable for private and small companies, Increase innovation support for private enterprises and make full use of government financial resources; Encourage enterprises to develop green, guide investors to participate in the transformation of green innovation, and reduce financing constraints; (4) Strengthen the green concept that green credit constrains enterprises, seize opportunities, pay attention to sustainable development of enterprises, improve technological capabilities of enterprises, and develop green economy.

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