Research on green credit policy and corporate emission reduction performance

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Abstract: Since the implementation of the green credit policy, its functional mechanism and implementation effect have attracted much attention. In this paper, various pollutant emission data and carbon emission data from the social responsibility reports of domestic A-share listed companies from 2012 to 2021 and the green credit balance disclosed by 21 major banks were collected manually, and the influence of green credit policies on pollutant emission and carbon emission of enterprises was studied through the establishment of fixed effect model for empirical analysis. Through empirical analysis, it is found that the green credit policy significantly promotes enterprises to reduce pollutant emissions. Further research shows that: (1) Green credit policy has more significant pollutant emission reduction effect on regional enterprises with high financial development level; (2) Green credit policy has more significant effect on pollutant emission reduction of heavy polluting enterprises; (3) Green credit has an impact on reducing the emission of pollutants by affecting the total new production of enterprises; (4) Green credit policy has more significant pollutant emission reduction effect on enterprises with ISO14001 certification.

1. Introduction

In recent times, the economic growth of China has been nothing short of meteoric. However, this rapid expansion has come at a cost, as the focus on economic progress has overshadowed the imperative of environmental stewardship. Consequently, issues like the exhaustion of resources, the degradation of environmental quality, and the disruption of ecological harmony have emerged as pressing concerns. Recognizing the gravity of these challenges, the 19th National Congress of the Communist Party of China (CPC) took a historic step by enshrining the philosophy that "clear waters and lush mountains are as precious as gold and silver" into the Party's constitution. This marked a pivotal shift towards a sustainable development strategy, emphasizing the importance of green civilization and the long-term value of environmental conservation. The CPC's commitment to this principle signals a new era where economic prosperity is balanced with the preservation of natural resources and the health of our planet[1-3].

On June 3, 2007, the State Council issued the Notice on Printing and Distributing the Comprehensive Work Plan for Energy Conservation and Emission Reduction.

Efforts to conserve energy and reduce emissions have been elevated to a strategic imperative, designed to secure the enduring prosperity of China. In a significant move to drive this agenda

forward, the China Banking and Insurance Regulatory Commission (CBIRC) has promulgated a directive, catalyzing a nationwide initiative known as the "Green Shield" policy. This policy underscores the critical role of the financial sector in fostering a sustainable future, aligning economic growth with environmental stewardship. The CBIRC's proactive measures reflect a concerted effort to integrate energy efficiency and emission controls into the core of China's development strategy, ensuring that the nation's trajectory is both economically vibrant and environmentally responsible[4].

Opinions on the Implementation of the Environmental Protection Law to Regulate Credit Risk", China has introduced green credit and established relevant systems. In February 2012, China's former China Banking Regulatory Commission publicly issued the "Green Credit Guidelines", which put forward clear requirements to strengthen the promotion of green credit by banking financial institutions, marking the official implementation of China's green credit policy[5-9].

The existing studies on the micro effects of green credit policies mainly focus on the impact of green credit policies on corporate financing constraints, environmental protection investment, and green innovation, and there are few literatures that directly study the impact of green credit policies on corporate emission reduction effects. This paper manually collects the pollutant emission data and carbon emission data of the social responsibility reports of domestic A-share listed companies from 2012 to 2021 to establish a model, and analyzes and explores the impact of green credit policy on corporate pollutant emissions and carbon emissions and its mechanism. In addition, this paper expands the research on the effect of green credit policy on the reduction of pollutant emissions and carbon emissions of enterprises with different levels of financial development, heavy polluting and non-heavily polluting enterprises, and enterprises that have passed and not passed ISO14001 certification, and deeply studies the mechanism of green credit policy on corporate emission reduction, which is of great significance for further deepening the sustainable development and environmental protection of enterprises[10,11].

The research contributions of this paper are as follows: a fixed-effect model is established for the manually collected and processed data to verify whether the green credit policy has a significant effect on reducing corporate pollutant emissions and carbon emissions.

This study establishes a fixed-effect model for the manually collected and processed data to verify whether the green credit policy has a significant impact on reducing corporate pollutant emissions and carbon emissions.

His paper expands the research on the effects of the green credit policy on reducing pollutant and carbon emissions in enterprises with different levels of financial development, heavily polluting and non-heavily polluting enterprises, as well as enterprises that have passed and not passed ISO14001 certification. This paper delves into the mechanisms of the green credit policy on corporate emission reduction, which is of great significance for further deepening the sustainable development and environmental protection of enterprises.

It reveals the role path of green credit policy to promote enterprises to reduce pollutant emissions.

2. Literature review

A set of literature related to this paper verifies the micro impact of green credit policies and finds that green credit policies

Significantly inhibited bank credit for heavily polluting enterprises , increasing the scale of financial leasing as an alternative financing method for bank credit, Companies with high environmental scores are more likely to obtain favorable loan contracts than those with low scores. At the same time, the green credit policy also significantly inhibits the investment behavior of heavily polluting enterprises, and significantly improves the level of green innovation of enterprises

and environmental disclosure, forcing them to transform to green production methods and eliminate them Post-industry[12-14].

Another set of literature verifies the macro impact of green credit policies, mainly based on regional-level data, to examine the impact of green credit policies on pollutant emissions, carbon emissions, and industrial structure. Relevant studies have found that green credit can significantly reduce pollutant emissions and carbon emissions, reduce regional per capita carbon emissions as a whole, alleviate air pollution, and positively promote the upgrading of inter-regional industrial structure. However, the impact of green credit policy is regional, with a greater impact on the east and west, but no obvious effect on the central part[15-19].

The above literature discusses the micro and macro effects of green credit policies, and has formed a wealth of research results. At the macro level, the focus of research is on the effect of policies on regional emission reduction, and the mechanism of green credit policies on the environmental governance behavior of micro enterprises and the effect of emission reduction is not clear. At the micro enterprise level, the research focuses on the impact on corporate green innovation, green financing and other governance links, and pays little attention to the effect and mechanism of green credit policy on corporate emission reduction. Therefore, it is considered that neither of the two sets of literature can explain the emission reduction effect and mechanism of green credit policy at the enterprise level, and there is a lack of research in this aspect in the relevant literature.

3. Theoretical analysis and research hypotheses

The release of the green credit policy sends a signal to business managers that the state is more willing to invest in companies with a higher level of environmental governance. The state requires enterprises to carry out green production and implement green behaviors, further stimulate enterprises to increase investment in environmental governance, guide enterprises to improve production processes and processes, promote green innovation, and ultimately reduce pollutant emissions and carbon emissions. Therefore, companies must accept and assume internalized environmental governance responsibilities and establish a good environmental image to obtain green credit-related investments.

Based on the above analysis, the following research hypotheses are proposed:

The implementation of green credit policies can reduce the pollutant emissions and carbon emissions of enterprises.

4. Study design and study data

4.1 Sample selection and data sources

The sample of this paper is domestic A-share listed companies from 2012 to 2021.

In this paper, the above initial samples are processed to a certain extent: (1) the samples with missing data are eliminated, and (2) the samples with abnormal key variables are eliminated. In order to control the interference of extreme values on the research conclusions, this paper performs tail shrinking on the 1% and 99% quantiles of continuous variables. The green credit data in this article comes from the official website of the China Banking and Insurance Regulatory Commission and the social responsibility reports of major banks. The financial data of the sample companies were obtained from CSMAR database, Wind financial database, and CNRDS China Research Data Service Platform. In addition, due to the fact that the pollutant emissions and carbon emission data disclosed by domestic A-share listed companies are not uniform, this paper uses the pollutant emissions and carbon emissions of each enterprise to manually sort out the original data from the

social responsibility reports, sustainability reports, ESG reports, and environmental reports of domestic A-share listed companies to improve the accuracy of the data.

4.2 Model settings

To explore the impact of green credit policies on corporate efforts to curtail emissions, this study employs a fixed effects model as the analytical framework. By constructing a robust empirical model, the research aims to dissect the relationship between financial incentives aligned with environmental sustainability and the actual reduction of greenhouse gases by businesses. The model serves as a tool to quantify the influence of these policies, providing insights into how credit mechanisms can be fine-tuned to encourage more effective emission reduction practices across various industries. This approach is pivotal in understanding the interplay between economic policies and environmental outcomes, with the ultimate goal of informing future strategies for a greener economy.

Type (1):

$$y_{it}(S02, N0x, PM, SW, C0D, C02) = \beta_0 + \beta_1 \, LnLoan + \beta_2 \, Controls + \alpha_i + \lambda_t + \varepsilon_{it}$$

Among them, $y_{it}(S02, N0x, PM, SW, C0D, C02)$ is the explanatory variable, that is, the emission reduction performance of enterprises (sulfur dioxide emission intensity, nitrogen oxide emission intensity, particulate matter emission intensity, solid waste emission intensity, chemical oxygen demand emission intensity, carbon dioxide emission intensity), and LnLoan is the implementation level of green credit policy.

α_i is the individual fixed effect, λ_t is the time fixed effect, and ε_{it} is the random perturbation term.

4.3 Definition and description of the main variables

Table 1: Primary variable definition

Symbol	Variable	Variable
SO2	Sulphur dioxide emissions	
NOx	Nitrogen oxide emissions	
PM	Soot (particulate matter) emissions	Pollutant emissions/operating income
SW	Solid waste emissions	
COD	Chemical oxygen demand	
CO2	Greenhouse gas emissions	
LnLoan	The level of implementation of green credit policies	The green credit balance is logarithmic
Age	The age of the business	The length of time between the end of the year and the date of registration
Size	The size of the enterprise	The logarithm of the total assets of the enterprise
Lev	Debt-to-asset ratio	Total Liabilities/Total Assets
Ggdp	Economies of scale	GDP growth rate by province
Top1	The shareholding ratio of the largest shareholder	The largest shareholder's shareholding/the company's total shares
Tobniqd	Tobin Q value D	Market Value B/(Total Assets - Net Intangible Assets)
LnSubsidy	Government subsidy	Government subsidies are logarithmic
Stata	Nature of property rights	State-owned and non-state-owned enterprises are distinguished according to the actual controller
Roa	Return on assets	Net profit after tax/total assets
SecRate	Industrial structure	The proportion of the secondary industry in the city

1) Explanatory variable: Firms' performance in reducing emissions

2) Core Explanatory Data: Level of Green Credit Policy Implementation (LnLoan)

3) Control variables

In this paper, the following control variables are selected: Age, Size, Lev, Ggdp, Top1, Tobniqd, LnSubsidy, State, Roa, and SecRate.

Table 1 reports the specific definitions of the main variables in this article.

4.4. Descriptive statistics

Table 2 presents an overview of the descriptive statistics for the key variables under examination. Notably, the average asset-to-liability ratio (Lev) stands at 0.542, with a standard deviation of 0.198. This metric gauges the share of total funding that comes from debt, as well as the extent to which a company's assets can safeguard the interests of its lenders. A lower asset-liability ratio is indicative of stronger solvency, with an optimal range typically falling between 40% and 60%, where a firm's financial stability is considered robust and balanced.

The economic scale variable (Ggdp) exhibits a wide range, from a minimum of 2.200 to a maximum of 8.100, highlighting significant disparities in economic development across provinces and, by extension, the varying degrees of green credit policy adoption.

Tobinqd represents the quotient of a firm's market value and the residual value of its total assets after deducting intangible assets. This measure is employed to assess a company's growth and investment prospects in the context of green credit policy implementation.

Lastly, the return on assets (ROA) is computed as the ratio of a company's post-tax net income to its total assets, ranging from a low of -0.110 to a high of 0.190. This indicator provides insight into a firm's profitability and efficiency in utilizing its asset base.

Table 2: Descriptive statistics

Variable	Number of observations	Mean	Median	Standard deviation	Minimum	Maximum	Range
Age	1210	19.630	20.000	5.692	7.000	33.000	26.000
Size	1198	24.380	24.220	1.835	20.930	30.530	9.603
Lev	1197	0.542	0.560	0.198	0.130	0.930	0.800
Ggdp	1210	5.972	6.400	2.095	2.200	8.100	5.900
Top1	1147	0.351	0.347	0.185	0.000	0.796	0.796
Tobinqd	1199	2.214	1.390	2.248	0.741	13.900	13.150
LnSubsidy	1178	16.990	17.710	3.870	0.000	22.010	22.010
State	1095	0.666	1.000	0.472	0.000	1.000	1.000
Roa	1151	0.045	0.030	0.048	-0.110	0.190	0.300
SecRate	1206	37.060	40.380	10.260	15.800	53.900	38.100

5. Empirical results and analysis

Table 3 empirically tests the benchmark relationship between the level of green credit policy implementation and the emission reduction performance of enterprises.

Sulfur dioxide is the most important environmental pollutant in enterprises, so the following paper mainly studies the effect and mechanism of the implementation of green credit policy on sulfur dioxide emission intensity (SO_2).

Table 3: Green credit and corporate performance in reducing emissions

Variable	(1) SO2	(2) NOx	(3) PM	(4) SW	(5) COD	(6) CO2
	-0.328**	0.023	-0.294***	-100.368**	-0.193	-5.649
LnLoan	(0.106)	(0.143)	(0.065)	(33.782)	(0.589)	(55.949)
	0.076**	-0.012	0.060***	6.786	0.037	-0.754
Age	(0.025)	(0.025)	(0.013)	(4.328)	(0.112)	(10.415)
	-0.194**	-0.026	0.012***	13.515	0.001	5.669
Size	(0.071)	(0.045)	(0.003)	(15.716)	(0.020)	(13.077)
Lev	0.09SO24	0.012	0.011	-157.094*	-0.153	-42.081
	(0.166)	(0.158)	(0.015)	(61.458)	(0.147)	(49.878)
	0.031*	0.008	0.003***	2.475*	0.004	-2.461
Ggdp	(0.012)	(0.023)	(0.001)	(1.176)	(0.007)	(1.742)
	0.100*	0.008	0.006	2.414	0.035	-2.302
Top1	(0.048)	(0.062)	(0.006)	(23.571)	(0.081)	(18.153)
	0.049	-0.004	0.002	1.811	0.018	0.427
Tobinqd	(0.041)	(0.027)	(0.002)	(1.539)	(0.022)	(2.734)
	-0.003	-0.001	0.000	2.880***	0.000	0.573
LnSubsidy	(0.002)	(0.002)	(0.000)	(0.756)	(0.002)	(0.499)
	0.004	0.018	0.001	-1.062	-0.004	-0.167
State	(0.018)	(0.016)	(0.002)	(4.913)	(0.010)	(5.022)
	-0.411	-0.636	0.047*	-267.123*	-0.383	-74.312
Roa	(0.366)	(0.554)	(0.019)	(130.876)	(0.333)	(67.296)
	-0.003*	0.002	0.005***	-9.069***	0.002	-0.724
SecRate	(0.002)	(0.003)	(0.001)	(2.308)	(0.002)	(1.446)
Individual fixation	Yes	Yes	Yes	Yes	Yes	Yes
The time is fixed	Yes	Yes	Yes	Yes	Yes	Yes
N	203.000	189.000	126.000	164.000	215.000	409.000
R2	0.476	0.172	0.587	0.787	0.197	0.052

6. Extended research

Upon reviewing pertinent academic sources, it has been observed that areas characterized by advanced regional financial development exhibit a heightened consciousness of environmental conservation. In such regions, the implementation of green credit policies is more effective, leading to enhanced emission reduction outcomes among businesses. Notably, heavily polluting enterprises tend to be more responsive to green credit initiatives, demonstrating a greater commitment to improving their emission reduction metrics compared to their non-heavily polluting counterparts.

This study reveals that green credit policies can enhance corporate emission reduction performance by curbing the expansion of new gross output. Firms that adhere to the ISO 14001 environmental management system standards demonstrate a superior understanding of green credit policies. They are more proactive in environmental stewardship and achieve more commendable results in reducing emissions.

6.1 The level of regional financial development

The development level of regional green finance is closely related to the effect of green credit policies (Shu et al., 2022).

The higher the level of regional green finance development, the greater the implementation of green credit policies, the higher the investment in green development research and development, and the more complete the green industrial structure. This paper refers to Wang Yao's (2019)

practice of measuring the level of local green finance development, and takes the median of the green finance development index as the cut-off point, and the provinces (autonomous regions and municipalities directly under the central government) above this data are the regions with a high level of green finance development, and conversely, the regions with a low level of green finance development. The samples were divided into two groups for group regression according to the level of green finance development in the regions where the sample companies are located. The effect of green credit policy on SO2 emission reduction is more significant in areas with high levels of green finance development, which is consistent with the above logic.

6.2 The nature of the enterprise's industry

In terms of credit choice, financial institutions are more willing to lend to companies that comply with environmental protection laws, while financial institutions can restrict or refuse to lend to heavily polluting enterprises (Ma et al., 2020). In order to improve their ability to finance debt, heavily polluting companies must reduce the scale of "high pollution and high emissions" through transformation and reduce pollutant emissions. This article is based on the Guidelines for the Industry Classification of Listed Companies revised by the China Securities Regulatory Commission in 2012, the Catalogue of Classified Management of Environmental Protection Verification Industries of Listed Companies (Huanbanhan [2008] No. 373) formulated by the Ministry of Environmental Protection in 2008, and the Guidelines for Environmental Information Disclosure of Listed Companies (Huanbanhan [2010] No. 78). Regression analysis shows that the green credit policy has a better effect on pollutant emission reduction for heavily polluting enterprises than for non-heavily polluting enterprises.

6.3 The total new output of the enterprise

Table 4: The mechanism of green credit policy affecting corporate pollutant emissions: new output of enterprises

Variable	(1) Output	(2) SO2
	-122.161**	-0.762**
LnLoan	(44.330)	(0.265)
		0.001*
Output		(0.001)
	19.810*	0.177***
Age	(8.984)	(0.050)
	13.795**	-0.372***
Size	(4.325)	(0.045)
	-15.916	0.138
Lev	(26.126)	(0.273)
	-0.026	0.015
Ggdp	(0.807)	(0.013)
	-2.457	0.114
Top1	(8.059)	(0.071)
	-5.086**	0.015
Tobinqd	(1.891)	(0.053)
	0.228	-0.021
LnSubsidy	(0.270)	(0.017)
	-69.691	0.960
Roa	(39.997)	(0.576)
Individual fixation	Yes	Yes
The time is fixed	Yes	Yes
N	239.000	67.000
R2	0.325	0.902

The literature suggests a bidirectional relationship between corporate social responsibility performance and financial performance, implying a reinforcing cycle between the two. Building on this premise, the paper posits that the aggregate new production output of businesses could influence their emission reduction performance, potentially curbing the release of pollutants. The central research inquiry posed is whether green credit policies can influence the emission levels of enterprises by modulating their overall new production output.

Examination of Table 4 reveals the mediating role of enterprise total new output (Output) in this relationship. Columns (1) and (2) indicate that the green credit policy (Lnloan) has a statistically significant negative impact on the total new output of enterprises at a level exceeding 5%. Furthermore, the relationship between total new output (Output) and sulfur dioxide emission intensity (SO2) is positively significant at a level greater than 10%. These findings suggest that an increase in total new output tends to augment pollutant emissions, yet the implementation of green credit policies can effectively curb this output, thereby mitigating the emission of pollutants. The mediating effect of emissions substantiates the proposed research question, confirming that green credit policies can indeed impact pollutant emissions by influencing the total new output of enterprises.

6.4 Corporate environmental management

Table 5: Green Credit & Environmental Management Certification: Consider the impact of passing ISO14001 certification

Variable	Not ISO14001 certifiedSO2	ISO14001 certifiedSO2
	-1.389	-0.621**
LnLoan	(0.929)	(0.207)
	0.294	0.184**
Age	(0.174)	(0.056)
	-0.266**	-1.531***
Size	(0.091)	(0.428)
	-0.312	-1.758**
Lev	(0.446)	(0.571)
	0.105**	0.068**
Ggdp	(0.037)	(0.024)
	-0.063	2.959**
Top1	(0.112)	(0.876)
	-0.086	-2.365***
Tobinqd	(0.072)	(0.657)
	0.020	0.350***
State	(0.048)	(0.095)
Individual fixation	Yes	Yes
The time is fixed	Yes	Yes
N	145.000	72.000
R2	0.437	0.852

IS014001 At the beginning of the process of building an environmental management system, the environmental management system standard needs to first analyze its major environmental elements and environmental impacts, and determine the quantitative impact of specific links in production and business activities on the environment

Guided to find the source of pollution and implement control on it. Therefore, it is believed that enterprises that have passed the ISO14001 certification have a high awareness of environmental

protection and a high awareness of green credit policies. In this paper, the enterprises are divided into two groups: those who have passed the ISO14001 certification and those who have not passed the ISO14001 certification, and the results of the analysis are shown in Table 5. As can be seen from Table 5, green credit policies have a better effect on reducing emissions from ISO14001-certified companies than non-ISO14001-certified companies.

7. Conclusions and policy recommendations

This study focuses on the carbon and pollutant emission data of A-share listed companies in China from 2012 to 2021, manually collecting relevant information to explore the impact of green credit policies on corporate emission reduction effects. The research finds that green credit policies have played a significant role in promoting corporate emission reduction, especially in regions with more mature green finance development, where the effects are more pronounced. Additionally, compared to non-heavily polluting enterprises, green credit policies have a more significant impact on the emission reduction of heavily polluting enterprises. The study also reveals that the implementation of credit policies has effectively curbed the growth of new output from enterprises, thereby affecting their emission reduction performance. Notably, enterprises that have passed the ISO14001 environmental management certification are more environmentally friendly, and the implementation of green credit policies is more effective for them.

Based on the empirical analysis results, this study proposes the following policy recommendations: Firstly, considering that China's green credit is in its infancy, policy implementation should be adjusted according to the level of regional green finance development, with incentives such as interest discounts, targeted approvals, and re-loans supplemented and adjusted to encourage enterprises to focus on pollutant emission reduction. Secondly, local governments should fully leverage the positive role of enterprises in reducing pollutants, taking policies as the main driver, and cooperating with banking financial institutions to track and supervise the implementation of green credit policies for enterprises throughout the process, reducing information asymmetry between the government and enterprises, and ensuring the authenticity of the effect of green credit policies on enterprise emission reduction and environmental improvement. Finally, policy formulation can start with suppressing new production by enterprises and continuously improve the green credit policy to promote enterprises to achieve the desired emission reduction effect.

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