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Research on the Impact of Green Credit on Carbon Emission and Mechanism Analysis

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Abstract. Green credit policy is one of the important measures to promote the green transformation of economy and society and achieve the double carbon goal, which has developed rapidly in recent years. The sample was selected from 30 provinces and cities in China (excluding Tibet) from 2008 to 2019 to empirically investigate the effect of green credit on carbon emission intensity, and the study found that (1) green credit reduces carbon emission and plays a role in environmental protection. (2) Green credits act on carbon emissions through three major mediating variables: scale, technology, and structural effects, respectively, and ultimately reduce carbon intensity. This study provides a scientific basis for the formulation of green credit policy in China's energy conservation and emission reduction policy, and proposes policy measures to give full play to green credit to improve the quality and enthusiasm of economic and social growth, and to transform the economic development model to promote green economic development.

Keywords: Green Credit,Carbone mission,Scale effect,Technical effect, Structural effect.

1. Introduction

Green development is starting to lead the economic trend. In 2017, the 19th Party Congress raised environmental development to the strategic level of "three reform battles". In September 2020, General Secretary Xi proposed that carbon dioxide emissions should strive to reach their peak value by 2030 and become carbon neutral by 2060, a goal that reflects China's proactive response to climate risks and its insistence on a green and low-carbon transition strategy, This goal reflects China's attitude and determination to adhere to the green and low-carbon transition strategy. As of June 30, 2017, the energy saving and carbon dioxide equivalent emission reduction was 490 million tons. Have green credits really promoted carbon emission reduction? This paper selects green credit, which represents debt financing, as a proxy variable for green finance, and empirically investigates the carbon emission reduction effect of green credit and the analysis of the impact mechanism.

2. Research background

There are abundant research results on influencing factors of carbon emission at home and abroad. The key driving factors identified are economic growth, technological innovation, urbanization, industrial structure, financial development, etc. However, at present, the academic circle has not formed a consistent view on the impact of financial development on carbon emissions, and there is a lack of research on the indirect influence mechanism between the two.

2.1 Green finance related research

Green finance is a financial instrument that can improve environmental quality and transfer the diffusion of environmental business risks through the power of market economy mechanism. Fengrong Wang and Kangsi Wang (2018) studied in depth the impact of "green policies" of government departments on the effect of green funds allocation and found a positive impact; and compared the "green" fiscal policy with the "green "green" fiscal policy and "green" regulatory policy, and compared their differential effects. Song (2013) found that there is still a big gap between China's green finance and the western banking industry. xuLe et al. (2021) use a two-way

fixed effects model, instrumental variables approach and spatial econometric model to test whether heterogeneous green innovations have a synergistic effect on carbon emission performance.

2.2 Related research on green credit

Lian, Lili (2015) argues that green credit policies have a positive effect on the development of green SMEs and a disincentive effect on high pollution and high energy-consuming SMEs. Dongwei Su and Lili Lian (2018) further focus on the impact of green finance on heavy polluters, arguing that green credit has a strong investment and financing penalty effect and a capital disincentive effect on heavy polluters. Similarly, Ding and Jie (2019) explored the effect of green credit policies using the double difference method and also showed that green credit controlled loan investments of heavy environmental pollution companies. Hongli Jiang et al. (2020) studied the impact of green credit and green venture capital at the portfolio level and found that both had a positive effect on carbon emission reduction, but the effect had a large difference.

In summary, the exploration of green credit and its impact has focused on the development stage of green credit, comparisons and lessons learned at home and abroad, and the relationship between green credit and environmental protection. The research is not deep and extensive enough, and relatively few explore the mechanism of the effect of green credit on carbon emission. Based on this, this paper uses inter-provincial panel data and selects green credit representing debt financing as a proxy variable of green finance to empirically study the effect of carbon emission reduction and the analysis of the influence mechanism of green credit.

3. Theoretical mechanism analysis of green credit on carbon emission

The impact of the development of green credit on carbon emissions can be divided into direct impact and indirect impact. The direct impact is that green credit support has an impact on carbon emissions, while the indirect impact is that green finance affects carbon emissions through scale, technology and structure effects.

3.1 The influence mechanism of green credit on carbon emission

Su Dongwei and Lian Lili (2018) believe that green credit guides enterprises to pay more attention to environmental pollution through the implementation of differentiated credit policies. On the one hand, green credit inhibits the development of energy-consuming enterprises and reduces their carbon emission level by influencing their investment and financing level. On the other hand, green and environmental protection enterprises can get preferential interest rate credit support to ease their financing constraints, improve their output level through the increase of capital input, promote the development of green and environmental protection enterprises, and thus reduce carbon emissions.

Hypothesis 1 is put forward: the implementation of green credit policy can reduce carbon emissions.

3.2 Scale effect

In the stage of rapid economic development, the scale effect of green credit on carbon emissions exists in two situations: first, growth will promote the expansion of economic scale, resulting in increased energy consumption and thus increased carbon emissions; Second, green credit drives high-quality economic development, promotes the reform of Chinese economic development mode, from extensive improvement to attach importance to ecology, thus reducing carbon emissions. Thus, the scale effect of green credit on carbon emissions is unknown.

Hypothesis 2 is proposed: green credits can reduce carbon emissions through economic scale effects.

3.3 Technical effect

Li Jiangtao and Huang Haiyan (2022) believe that green finance has a strong marginal effect on technological upgrading of enterprises. Green credit provides external financing for energy saving, emission reduction and low-carbon enterprises in the form of preferential interest rates, and encourages enterprises to achieve green transformation by easing credit constraints through technological progress. Green credit policy internalizes the external uneconomic cost generated by enterprises on the environment into the production cost of enterprises. Enterprises can reduce the negative externalities caused by environmental pollution by improving the technological progress in the fields of green environmental protection, energy conservation and emission reduction, thus reducing carbon emissions.

Hypothesis 3 is put forward: green credit can reduce carbon emissions overall through scientific and technological progress.

3.4 Structural effects

According to Li Yu et al. (2020), the "incentive" and "push" mechanisms of green credit can promote the upgrading of industrial structure. First, the policy guidance mechanism. With the support of direct government funding, tax incentives, and government purchases, the financing cost of green industries will be much lower than that of traditional industries, and the ability to create capital will be strengthened, and the profitability and competitiveness of industries will be improved. Second, the capital formation mechanism. Banking and financial institutions as a "reservoir" of social capital, green credit policy to guide the flow of money market capital to the environmental protection industry, forcing the rough industry to low-carbon green industry development to achieve corporate transformation, reduce carbon emissions.

Propose hypothesis 4: Green credit reduces carbon emissions by accelerating industrial structure upgrading。

4. Empirical analysis

4.1 Model construction and index selection

4.1.1 Model Setting

1.Baseline model

To investigate the impact of green credits on carbon emissions, we first consider the following fixed effects model:

$$C_{i,t} = \alpha_1 GF_{i,t} + \alpha_2 FDI_{i,t} + \alpha_3 TRAD_{i,t} + \alpha_4 URB_{i,t} + \alpha_5 RD_{i,t} + \mu_i + \nu_i + \varepsilon_{i,t} \quad (1)$$

Where Ci, t are explained variables, defined as the carbon emission of city i in year t. GFi,t is the core explanatory variable, representing green finance of city i in year t; Its coefficient reflects the impact of green credit on carbon emissions. Control variables, including foreign investment level (FDIi,t), foreign trade level (TRADi,t), urbanization rate (URBi,t) and R&D expenditure proportion (RDi,t); μ_i represents City fixed effect; ν_i represents time fixed benefit; $\varepsilon_{i,t}$ is the random error term.

2.Mediated effects model

In this paper, referring to the mediating effect test of Zhonglin Wen et al. (2014), the following model is constructed to test whether green credit reduces carbon emissions through the scale effect GDPi,t, the technology effect LPi,t and the structural effect STRi,t:

$$Y_{i,t} = \alpha_1 \cdot Treat \cdot T + \sum \beta_j \cdot Control + \mu_i + \nu_i + \varepsilon_{i,t} \quad (2)$$

$$Mech_{i,t} = \alpha_2 \cdot Treat \cdot T + \sum \beta_k \cdot Control + \mu_i + \nu_i + \varepsilon_{i,t} \quad (3)$$

$$Y_{i,t} = \alpha_3 \cdot Treat \cdot T + \alpha_4 Mech_{i,t} + \sum \beta_l \cdot Control + \mu_i + \nu_i + \varepsilon_{i,t} \quad (4)$$

Where Mech is the three mechanism variables that affect carbon emissions respectively. The regression of model (2) is conducted first to test whether the regression coefficient α1 of green credit and carbon emission is significant, if it is negative, it means that the green credit can significantly reduce carbon emission, then proceed to the next step, otherwise stop the test; then the regression of model (3) is conducted to test whether the regression coefficient α2 of green credit and mechanism variables is significant, if it is significant, it means that the green credit has a significant effect on mechanism variables. The next test is carried out; otherwise, the test is stopped. Then, the regression of model (4) is carried out to test whether the regression coefficients α2 and α4 of green credit, carbon emission and mechanism variables are significant.If the coefficients α2 and α4 are significant, then the indirect effect is significant, and if the coefficient α3 is significant, then the direct effect is significant; the last step is to compare the signs of α2, α4 and α3, if they are the same sign, they belong to partial mediation effect, otherwise belongs to the masking effect.

4.1.2 Indicator Selection and Description

1.Explained variable

Carbon Emission Intensity. Carbon intensity is the ratio of carbon emissions to real GDP, representing the carbon emissions corresponding to each unit of economic output. Compared with total carbon emissions or average carbon emissions, the carbon intensity indicator is more comparable for samples of different economic sizes. Referring to the carbon emission measurement method provided by IPCC to account for the provincial carbon emissions in China, the calculation formula is

$$C = \sum E_n \times \beta_n \times \alpha_n \times \frac{12}{44} \quad (5)$$

In equation (5), C is the carbon emission; En denotes the consumption of the nth energy source; βn is the CO2 emission factor of the nth energy source, which can be obtained from the IPCC Guidelines for National Greenhouse Gas Inventories 2006; αn is the standard coal conversion factor of the energy source; and 12/44 is the carbon multiplier factor, which indicates the molecular mass ratio of carbon to CO2.

2.Core explanatory variables

Green credit GCL. T.Xie and J.H. Liu (2019) selected the ratio of interest expenditure of the six high-energy-consuming industries to the total interest expenditure of industrial industries in each province as an inverse indicator to measure green credit. Considering that interest expenditure can reflect the scale of credit, the total interest expenditure of non-six high-energy-consuming industries is selected to represent green credit, and the formula is: green credit = total interest expenditure of industrial industries in each province - interest expenditure of six high-energy-consuming industries.

3.Intermediate variables

GDP. expresses the size of the economy by dividing the actual GDP of each province and city by the number of resident population, calculated with reference to Xiaojing Cao and Kunrong Shen (2014).

LP. express the technology effect in terms of labor productivity output/number of employed people, with specific reference to Ren, Li, and Zhu, Dongbo (2017).

STR. measures the structural effect by dividing the sum of value added of secondary and tertiary industries by GDP. The value added of secondary and tertiary industries can reflect the efficiency of production to a certain extent and reflect the ration of economic structure.

4.Control variables

The level of foreign direct investment (FDI);Foreign trade level;Urbanization rate;R&D expenditure level.

5.Data source

The sample data were selected from 30 provinces and cities in China (excluding Tibet) from 2008 to 2019. Tibet data are incomplete and not very representative, so Tibet data are excluded.The data of intermediate variables are obtained from China Statistical Yearbook, and the data of control variables are obtained from wind database and China Statistical Yearbook.

4.2 Overall Regression Analysis of Green Credit Impact on Carbon Emissions

4.2.1 Descriptive statistical analysis

Table 1 Descriptive statistics of variables

Variables	Variable Name	Average value	Standard deviation	Minimum value	Maximum value
C	Carbon Emissions	0.773	0.566	0.060	2.720
GCL	Green Credit	0.187	0.093	0.072	0.879
GDP	GDP per capita	4.346	2.619	0.975	16.185
LP	Labor productivity	7.763	5.114	1.529	27.844
STR	Value-added ratio of secondary and tertiary industries	0.898	0.057	0.713	0.997
FDI	Foreign direct investment level	0.023	0.021	0.000	0.121
TRAD	Foreign trade level	0.293	0.324	0.013	1.597
URB	Urbanization rate	0.559	0.132	0.291	0.942
RD	R&D expenditure level	0.016	0.011	0.002	0.063

The descriptive results of each variable are shown in the table. It can be seen from the table that the mean and standard deviation of per capita GDP of the intermediary variable is 4.346 and 2.619, reflecting the large fluctuation of the scale effect. By analyzing the reasons, we can see that the scale effect is composed of the ratio of real GDP to the number of permanent residents, and the standard deviation is large due to the unbalanced level of regional economic development. The mean value and standard deviation of the intermediary variable labor productivity are 7.763 and 5.114, reflecting the large fluctuation of the technology effect. The analysis of the reasons shows that the technology effect is composed of the ratio of real GDP and the number of employed people, and the reasons are consistent with the scale effect.

4.2.2 Baseline return

Stepwise regression of the model was performed to determine the effects of green credit and each control variable on carbon emissions.

Table 2 Baseline regression of the carbon reduction effect of green credits

Variables	（1）	（2）	（3）
	Basic model	Add control variables	Further time control
GCL	-2.208***	-1.293***	-1.215***
	（-9.05）	（-4.92）	（-4.49）
FDI		-0.666	-1.077
		（-0.69）	（-1.14）
TRAD		-0.196	-0.277
		（-1.26）	（-1.52）
URB		-3.829***	-2.705***
		（-12.69）	（-3.73）
RD		8.127	-20.11***
		（1.43）	（3.33）
Intercept term	1.185***	3.094***	2.540***

	（24.91）	（19.98）	（7.19）
Time	/	/	控制
Goodness of fit	0.199	0.507	0.562

Note: t statistic in brackets, *p<0.1, **p<0.05, ***p<0.01, same as the table below

The stepwise regression method was used to test. Compared with (1), the green credit coefficient changed from -2.208 to -1.293. The control variables dispersed the influence of green credit on carbon emissions, but did not reach the degree of sudden change. Compared with (2), (3) added time fixed effect to control the time. The final baseline model is selected Model (3).

First of all, in general, green credit is negatively correlated with carbon emissions. The core variable green credit is significant at the 1% level, indicating that green credit reduces carbon emissions on the whole.

Secondly, the influence of variables on carbon emissions is controlled. The urbanization ratio coefficient is significantly negative at the 1% level, indicating that urbanization improves the level of science and technology and urbanization, thus reducing carbon emissions. The corresponding coefficient of research costs is significantly negative at the 1% level, indicating that Chinese research costs have a positive impact on scientific and technological progress, improve the technical standards of conservation and emission reduction, enhance production efficiency, and thus reduce carbon emissions.

4.2.3 Mechanistic path analysis of green credit affecting carbon emissions

Table 3 Mechanistic Path analysis

Variables	Baseline Model	GDP	C	LP	C	STR	C
	（3）	（4）	（5）	（6）	（7）	（8）	（9）
GDP			-0.0229**				
			（-2.23）				
LP					-0.0107*		
					（-1.73）		
STR							-1.752***
							（-4.94）
GCL	-1.215***	10.38***	-0.977***	15.78***	-1.046***	0.107**	-1.028***
	（-4.49）	（7.01）	（-3.38）	（6.41）	（-3.64）	（2.57）	（-3.89）
FDI	-1.077	-4.593	-1.182	-17.50**	-1.264	-0.0441	-1.154
	（-1.14）	（-0.89）	（-1.26）	（-2.04）	（-1.33）	（-0.30）	（-1.26）
TRAD	-0.277	1.411	-0.244	2.813*	-0.246	0.0885***	-0.121
	（-1.52）	（1.41）	（-1.34）	（1.70）	（-1.35）	（3.16）	（-0.68）
URB	-2.705***	-10.74***	-2.951***	-6.082	-2.770***	-0.0150	-2.731***
	（-3.73）	（-2.71）	（-4.05）	（-0.92）	（-3.83）	（-0.13）	（-3.91）
RD	-20.11***	147.6***	23.49***	329.4***	23.63***	0.226	20.51***
	（3.33）	（4.47）	（3.79）	（6.00）	（3.71）	（0.24）	（3.52）
Intercept	2.540***	4.114**	2.634***	0.640	2.547***	0.831	3.996***

term						***	
	（7.19）	（2.13）	（7.45）	（0.20）	（7.23）	（15.33）	（8.86）
Time	Control	Control	Control	Control	Control	Control	Control
Goodness of fit	0.562	0.663	0.568	0.706	0.566	0.236	0.593

1.Impact of green credit on carbon emissions - scale effect analysis

First, green credit increases the scale of social economy, with a significant coefficient of 10.38. On the supply side, the development of green credit expands the channels of small and medium-sized enterprises, which in turn encourages them to increase production and increase economic scale. From the consumer side, some commodities provided by green credit can stimulate consumer consumption, thus reducing the production cost of consumer financing loans. In the face of budget constraints, increasing consumer consumption will also bring about the growth of the scale of the national economy. According to the stepwise method, the mediating effect is obtained by multiplying the coefficients. Therefore, the carbon scale effect of the development of green credit industry is -12.61. The negative scale effect indicates that the vigorous development of green ecological finance reduces energy consumption and leads to the reduction of carbon emissions during the expansion of the scale of national economy. This shows that green credit reduces carbon emissions through economic scale path.

2.Impact of Green Credit on Carbon Emissions - Analysis of Technology Effects

Secondly, green credit has a positive impact on technological progress, with a significant coefficient of 15.78. Green credit is more inclined to support green ecological small and medium-sized enterprises. After receiving support, small and medium-sized enterprises will carry out financing technology innovation and promote technological development. However, small and medium-sized enterprises that develop green technology in the past are more likely to get green ecological financial support, so green credit is beneficial to technological progress. The technical effect of green credit development on carbon emissions is -19.17. The vigorous development of green credit encourages the development of green technology enterprises, thus greatly reducing carbon emissions, which indicates that green credit reduces carbon emissions through technological upgrading.

Finally, green credit promotes the transformation of industrial structure to tertiary industry with a significant coefficient of 0.107. Green credit can lead the flow of capital from high pollution and high energy construction industry to environmental protection, green energy saving and low carbon construction industry, and efficiently transform the financial service resources in the middle of the product and focus on the service industry, so green credit helps the service of production structure. The structural effect of green credit development affecting carbon emissions is -0.13, which shows that green credit reduces carbon emissions through the structural upgrading path. The combined effect of green credit on carbon emissions is equal to the sum of the effects compared to each effect. Using the stepwise regression method, the overall effect of green credit can be measured as -31.91, indicating that current green credit reduces carbon emissions in general, which is consistent with the findings in the above section.

4.3 Robustness tests

To further demonstrate the effect of green credits on carbon emissions, carbon emissions per capita are used as a proxy for the above carbon emissions for robustness testing.

Table 4 Robustness tests

Variables	Per capita carbon emissions	Per capita carbon emissions
GF	-2.015***	-3.426***
	(-2.64)	(-4.36)

FDI	2.292	5.226*
	(0.82)	(1.90)
TRAD	-0.318	0.264
	(-0.70)	(0.50)
URB	7.791***	-0.413
	(8.89)	(-0.20)
RD	-4.980	-47.19***
	(-0.30)	(-2.69)
Intercept term	-0.996**	3.242***
	(-2.21)	(3.16)
Time	NO	Control
Goodness of fit	0.236	0.321

Robustness test adopts the estimation method of fixed effect model. As can be seen from Table 4, when the explained variable is replaced by per capita carbon emission, the regression coefficient symbol is consistent with the above results. First, the scale effect of green credit development on carbon emissions is significant, which is -35.56 , and the negative scale effect leads to the reduction of carbon emissions. Second, the technical effect of green credit development on carbon emissions was significantly -54.06, and green credit reduced carbon emissions. Thirdly, the structural effect of green credit development on carbon emissions was significantly -0.37, and green credit reduced carbon emissions. Finally, it can be calculated that the comprehensive effect of green credit development on carbon emissions is -89.99. Overall, current credit developments have led to reductions in carbon emissions, consistent with this conclusion.

5. Conclusions and Suggestions

This paper selected the data of 30 provinces and cities (excluding Tibet) from 2008 to 2019 to empirically investigate the effect of green credit on carbon emission intensity. The empirical analysis shows that: (1) Green credit reduces emissions and plays a role in environmental protection. (2) Green credit reduces carbon emissions through scale, technology and structure effects. The overall effect of green credit on carbon emissions is negative. Therefore, green credit acts on carbon emissions respectively through three intermediary variables, and ultimately reduces carbon emissions. Therefore, the following suggestions are put forward:

1. Increase the proportion of green credit, gradually tighten the flow of funds to the "two high" industries, and increase the investment of credit funds to the "two low" industries. Establish environmental review and evaluation criteria for bank credit, and develop preferential loan policies for green enterprises and projects that have the potential to significantly reduce greenhouse gas emissions and generate ecological benefits.

2. Bring into play the capabilities of the market. The growing green credit policy system and the difficulty of financing environmental protection enterprises coexist because the costs and benefits of green environmental protection investment projects are not equal and the economic benefits of environmental protection are not correctly calculated, and the problem must be solved by technical means such as reasonable prices, common unified trading platforms, and increased visibility of market investors.

3.The use of advanced science and technology to enhance the sustainability of the green finance industry. The completion of supporting policy development, institutional mechanism innovation and major breakthroughs, financial services technology will turn into the power to promote the sustainable and healthy development of green financial services.

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