How Does Green Finance Affect the Optimization and Upgrading of China's Industrial Structure?——Theoretical Study and Empirical Test

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Abstract: China's economic development has shifted from the stage of high-speed development to the stage of high-quality development. In the context of green development, the research on the relationship between green finance and industrial structure is also in depth. This paper selects panel data of 30 Chinese provinces from 2005 to 2020, constructs a green finance indicator system, and empirically tests the impact of green finance on the optimization and upgradation of industrial institutions in China using a random effects model. The study shows that the development of green finance can significantly promote the optimization and upgradation of regional industrial structure, and this finding still holds in the robustness tests of the full sample and sub-samples. This paper enriches the research related to green finance and industrial structure, and provides theoretical basis and implementation strategies for it: it is necessary to fully mobilize the enthusiasm of all subjects, improve the green financial service system, innovative rate of financial products and services, improve green financial supervision, and grasp the golden period of green financial development, so as to better meet the requirements of industrial institution optimization and upgrading and achieve sustainable and healthy economic development.

Keywords: Green Finance; Industrial Structure; Principal Component Analysis; High-Quality Development

1. Introduction

During the 13th Five-Year Plan period, the main direction of China's industrial policy is to focus on structural adjustment, promote industrial upgrading, and promote stable and robust economic development. During this period, the policy mainly serves to alleviate the contradictions in industrial structure and reduce the downward pressure on the economy. With the implementation of the policy in the 13th Five-Year Plan period, new changes in social development and the construction of industrial system have been achieved, which has put forward new requirements for the industrial policy in the 14th Five-Year Plan period. It is necessary to promote industrial upgrading as the main line, promote structural adjustment and optimization, and achieve high-quality economic development.

In recent years, green finance has been playing an increasingly important role in promoting the optimization and upgradation of industrial structure. As an economic activity that supports environmental improvement and promotes the economical and efficient use of resources, green finance conducts investment and financing activities and risk management in the fields of environmental protection and energy conservation. In 2017, the executive meeting of the State Council decided to build green finance reform and innovation pilot zones in five provinces: Zhejiang, Jiangxi, Guangdong, Guizhou and Xinjiang. Subsequently, Gansu and Chongqing were launched as experimental zones for green financial reform and innovation. After years of efforts, these areas have made a series of replicable and replicable experiences in innovating green financial products and services, improving policy support systems and incentive and constraint mechanisms, which will effectively support the development of local green industries and the green and low-carbon transformation of the social economy and society. At present, promoting the optimization and upgradation of industrial structure is another challenge for China's economy to enter the stage of high-quality development. The scientific construction of green

financial indicators and the in-depth investigation of the role of green financial development on the optimization and upgrading of industrial structure will be an important guidance for China to promote the transformation and upgradation of industrial institutions and high-quality economic development.

Studies have shown that green finance plays a positive role in the optimization and upgradation of industrial institutions. However, the construction of green finance indicators and the interaction between each indicator of green finance and industrial structure development still need to be explored in depth.

Based on the above considerations, this paper selects panel data of 30 Chinese provinces from 2005 to 2020, constructs a green finance indicator system, and uses a random effects model to conduct an empirical study on green finance and the optimization and upgrading of industrial institutions in 30 Chinese provinces.

2. Review of Literature

This paper reviews the existing literature from four aspects: green finance, industrial structure upgradation, the impact of green finance on the optimization and upgrading of industrial institutions, and the construction of green finance indicators.

The understanding and research of green finance by scholars is constantly deepening. Jose Salazar firstly proposed that environmental finance is a part of environmental economy, which is a financial innovation that caters to the financing needs of environmental industries [1]. The globalization of the economy has brought about the globalization of risk, and more and more scholars believe that environmental issues should be linked to financial issues. Sonia Labatt argue that environmental finance is the act or process of financing to improve environmental quality and transfer environmental risks [2]. It was not until 2011 that the International Development Finance Club elaborated on green finance, referring to the activities of investing and financing all environment-related projects and financial policies that advocate sustainable economic development. Back to the domestic research, An Wei defined the basic connotation of green finance based on the previous research results. He made an in-depth study on the mechanism of green finance's effect on energy conservation and emission reduction from three levels: regulating corporate business behavior, influencing the flow of entrepreneurial capital and promoting environmental technology innovation [3]. Fang Hao et al. believe that the essence of environmental finance is an innovative financial model based on the purpose of environmental protection [4]. From the views of different scholars mentioned above, finance or environmental finance is a financial tool to foster sustainable economic development. As the research progresses, the lack of a unified definition and appropriate evaluation indexes becomes an unavoidable problem. If this problem is not solved scientifically and effectively, it is likely to lead to a diversified evaluation system and eventually lead to insufficient standardization of research, which in turn hinders the development of green finance research.

Foreign research on industrial structure optimization and upgrading is mainly developed from a macro perspective and based on the research on industrial structure theory [5]. In the 1950s, Miyohei Shinohara first studied the optimization and upgradation of industrial structure in his "Theory of Industrial Structure" and proposed the "income elasticity benchmark" and "productivity growth rate benchmark". It is mentioned that priority should be given to industries with high income elasticity so that the broad market of such industries can provide them with growth space. In addition, it is essential to protect the development of infant industries with high rates of productivity and technological progress in order to increase their share in the overall industrial structure [6]. In the 1960s, Walt Whitman Rostow divided the process of economic and social development into six stages, arguing that the stages of regional economic development are influenced by a combination of changes in leading industries and technological development [7]. Rostow's theory of economic growth stages provides a systematic summary of the optimization and upgrading of industrial structure, which has laid a solid theoretical foundation for later scholars' research. China's theoretical research on industrial structure optimization and upgrading was mainly concentrated after 1996. In the process of formulating the Ninth Five-Year Plan, China government put forward the target programs for industrial structure optimization and upgradation at all levels, which led to the prosperity of theoretical research on industrial structure upgrading. With the deepening of theoretical research, indicators such as income elasticity of demand, productivity, correlation and growth rate have been incorporated into the benchmark system, and qualitative and quantitative research has also been developed. The research results are abundant and have greatly contributed to the development of China's economy and society [5].

The current research on the impact of green finance on industrial structure is mainly divided into theoretical studies and empirical studies. In terms of theoretical research, Ma Jun (2015) argues that the establishment of a green financial system can help initiate new

economic growth points and accelerate the green transformation of industrial structure. He also provides specific and implementable policy recommendations for the construction of a green financial system in China [8]. In terms of empirical research, scholars have found that green financial development has a significant impact on industrial structure. Long, Yunan (2018) and others analyze the relationship between green finance and industrial structure using a gray correlation model [9]. Dong Xiaohong et. al find through their study that the coupling and coordination degree of green finance and local green economic system in each region showed an increasing trend year by year [10]. Hu Huaimin et. al showed that the tertiary industry in provinces with faster development of green finance better reflects the positive promotion effect of green finance and has more significant positive external spillover effect on the surrounding areas [11]. As a component of green finance, green credit has the role of matching the supply and demand sides of funds. Besides, green credit is also an important tool for national macro-control and becomes an effective means for the state to guide the transformation and upgrading of industrial structure, and its role in economic development has also received the attention of domestic scholars. Chen Weiguang et. al argue that green credit can promote the optimization and upgrading of industrial structure, but information asymmetry and other reasons make the optimization effect on industrial structure not obvious [12]. Liu et al. argue that the implementation of green credit policy has produced different financing penalty effects on different enterprises [13]. The policy effect of the pilot financial reform zone is also an important channel to analyze the impact of green finance on industrial development. From a macro perspective, the establishment of the pilot zones significantly promotes the heightened regional industrial structure; from a micro perspective, influencing the debt structure of enterprises and forcing heavy polluters to fulfill their social responsibility are the paths of the pilot zones of financial reform and innovation on the green innovation of enterprises [14].

To analyze the impact of green finance on the optimization and upgradation of industrial structure, the first step is to construct a green finance measurement index system. Zeng Xuewen (2014) sorted out the evaluation system of green finance from two main lines of macro and micro, and calculated the weights of the main green financial products through the expert scoring method [15]. Lili Zhang used entropy value method and envelope analysis method to measure the level and efficiency of green finance development in each province in China [16]. Lili Wei et al. measured the level of green finance development with three indicators: scale, efficiency, and structure, and calculated the weights of each indicator using the entropy value method, which focused on the objectivity of indicator weights, and multi-dimensional measurement indicators also made the study more comprehensive [17]. Huai-Min et al. constructed an indicator system of green finance and industrial structure change based on relevant data of provincial administrative regions, and used the entropy value method to derive the scores, and conducted an empirical study on the structure of green finance and industrial change at the provincial level in China [11].

3. Data Processing and Descriptive Statistics

3.1 Data sources and processing

In this paper, panel data of 30 provinces in China from 2005 to 2020 are selected, and the data of the explanatory and control variables are obtained from the National Bureau of Statistics of China, and the data of the explanatory variables are obtained from the China Industrial Statistical Yearbook, China Environmental Statistical Yearbook, China Insurance Yearbook, China Rural Statistical Yearbook, China Energy Statistical Yearbook, and China Statistical Yearbook in previous years.

3.2 Selection and construction of main indicators

The explanatory variable is the advanced industrial structure, which refers to the gradual shift in the center of gravity of the economic structure to the tertiary sector. Drawing on Wei Ping and Gu Yi, the ratio of the value added of the tertiary sector to the secondary sector is used as the measurement variable for the advanced industrial structure [18].

The explanatory variables are green credit, green investment, green insurance, and carbon finance. This paper constructs sub-indicators to measure the explanatory variables by the ratio of interest in high energy-consuming industries, the ratio of investment in environmental pollution, the scale ratio of agricultural insurance and carbon intensity, respectively.

In order to analyze the impact of green finance development on the optimization and upgradation of industrial structure more comprehensively, the following control variables are also set. Commodity price level is measured by consumer prices. The price level of industrial goods is measured by the ex-factory price index of industrial producers. The level of labor supply is measured by the logarithm of year-end resident population. In order to eliminate the effect of the magnitude and ensure the robustness of the regression

estimation, the above indicators are logarithmized in this paper.

Table 1 Specific definitions of the main variables

Variable type	Variable name	Variable symbol	Variable definition
Explained variable	Advanced level of industry structure	*UIS*	Ratio of added value of tertiary sector to secondary sector
Explanatory variables	Green Credit	*grecre*	High energy-consuming industrial industry interest/industrial industry interest
	Green Investment	*greinv*	Investment in pollution control/GDP
	Green Insurance	*greinsur*	Agricultural insurance income / total agricultural output
	Carbon Finance	*carbfin*	Carbon dioxide emissions/GDP
Control variables	Commodity price level	*LNcpi*	Logarithm of the consumer price index
	Price level of industrial products	*LNppi*	Logarithm of the Industrial Producer Ex-factory Price Index
	Labor supply level	*LNpop*	Logarithm of year-end resident population

3.3 Descriptive statistics

According to the results of descriptive statistics, this paper conducts the following analysis: the average of industrial structure advanced index is 1.20, which shows that China's industrial structure is gradually optimized and upgraded. The minimum value of this data is 0.53, the maximum value is 5.24, and the standard deviation is 0.67. There is a certain difference in the advanced level of industrial structure among provinces in China, but the overall difference is not that large. The mean value of green credit reaches 54%, with a standard deviation of 0.15, reflecting that the implementation of green credit in each province is strong and the level difference is small. The mean value of green investment is low, reflecting the high level of greening of our industry. The mean value of carbon finance is 2.7%, which is higher than the world average, indicating that there is still more space for China's economic development and industrial structure optimization and upgrading. Compared with the other three explanatory variables, the standard of green insurance is the largest, which to a certain extent reflects the uneven development of the scale of agricultural insurance in each province and indicates that the development of green insurance in China is not sound and needs joint support from the market and the government. Besides, there are significant opportunities for green insurance business in individual provinces.

Table 2 Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
UIS	480	1.202	.67	.527	5.244
grecre	480	.541	.145	.192	.906
greinv	480	.001	.001	0	.01
greinsur	480	.803	1.119	0	9.171
carbfin	480	.027	.023	.002	.128
LNcpi	480	4.631	.017	4.582	4.701
LNppi	480	4.619	.058	4.412	4.831
LNpop	480	8.183	.748	6.297	9.443

4. Econometric Models and Estimation Methods

4.1 Estimation methods

In the selection of fixed effects and random effects, this paper makes the following considerations. First, intuitively, the data used in this paper are national provincial panel data, which represent almost the whole research sample so that the comprehensiveness of the data can be guaranteed. Second, the result of the Hausman test shows that the chi2 is -3.57 and the Hausman test value is less than the critical value of the significance level (5%), we cannot reject the null hypothesis and should accept the original hypothesis. Therefore,

the random effects model should be selected as the baseline model for estimation.

4.2 Benchmark model

Based on the above theoretical analysis and the research exploration of various influencing factors, combined with relevant tests, the econometric benchmark model for the empirical analysis part was established.

$$UISit=\alpha i+\beta 1grecreit+\beta 2greinvit+\beta 3greinsurit+\beta 4carfinit+\beta 5LNcpiit+\beta 6LNppiit+\beta 7LNpopit+\varepsilon it$$

The corner labels i and t below the variables represent the data of province i in year t, αi is the intercept, βi is the regression coefficient of the variable, and εit is the random error term.

According to the results of the model selection test, the individual random effects model is regressed on data from 30 provinces, and the regression results obtained are shown in the following table.

Table 3 Baseline regression results

	(1)
	UIS
grecre	-0.757***
	(-5.21)
greinv	-41.43***
	(-4.21)
greinsur	0.213***
	(15.80)
carbfin	-3.542***
	(-3.34)
LNcpi	-1.582**
	(-2.54)
LNppi	-0.0119
	(-0.06)
LNpop	-0.0696
	(-0.78)
_cons	9.544***
	(3.57)
N	480

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Through the analysis of the above regression results, the main conclusions drawn are as follows.

(1) Green credit can positively pull the optimization and upgrading of industrial structure, and the effect is obvious.

(2) Green investment is an inverse indicator, which reflects the degree of pollution to a certain extent at this stage. With the development of green economy and the optimization and upgrading of industrial structure, the proportion of investment in pollution control to GNP will become a positive indicator.

(3) The higher the development level of green insurance is, the more it is conducive to promoting the optimization and upgrading of industrial structure, and the effectiveness is obvious.

(4) Promoting the development of carbon finance has a positive pulling effect on the advanced industrial structure, and the effect is very significant.

4.3 Possible problems of the model and solutions

4.3.1 Multicollinearity

This paper analyzes the multicollinearity of the baseline regression explanatory variables. From the regression results, we know

that the variance inflation factor of green insurance is 1.03, which has the weakest multicollinearity with other variables. The mean variance inflation factor of the explanatory variables is 1.41, which has weak multicollinearity and can pass the multicollinearity test.

Table 4 Results of variance expansion coefficients

Variable	VIF	1/VIF
greinv	1.62	0.617819
carbfin	1.59	0.628349
greinsur	1.03	0.968889
Mean VIF	1.41	

4.3.2 Robustness tests

4.3.2.1 Split-sample test

In order to verify the regression robustness, a split-sample test is conducted in this paper. The regression effect is still significant after excluding the data of Hainan Province from the eastern sample. Among them, green insurance and carbon finance are significant at the 1% level. In the central sample, the regression effect is significant after excluding the data of Heilongjiang Province, in which green credit and green insurance are significant at the 1% level. In the western sample, the regression effect is significant after excluding the data of Ningxia province, and the explanatory variables of green credit, green investment and green insurance are significant at the 1% level.

Interpreted in terms of the robustness gap among the explanatory variables, green insurance has the highest significance level and is more robust in the three regions, followed by green credit, green investment and carbon finance.

Table 5 Sub-sample regression

	(East)	(Mid)	(West)
	UIS	*UIS*	*UIS*
grecre	-0.401**	-0.983***	0.750***
	(-2.19)	(-3.90)	(5.52)
greinv	32.82**	-37.62**	-90.08***
	(2.10)	(-2.12)	(-5.85)
greinsur	0.241***	0.163***	0.0498***
	(18.02)	(3.58)	(2.84)
carbfin	-16.43***	-1.777*	-2.215**
	(-7.03)	(-1.95)	(-2.14)
LNcpi	-1.966**	-1.843	-2.099***
	(-2.36)	(-1.52)	(-2.67)
LNppi	0.543*	0.330	-0.297
	(1.75)	(0.91)	(-1.29)
LNpop	0.438***	-0.223***	-0.0158
	(2.83)	(-4.39)	(-0.55)
_cons	4.452	10.38**	12.03***
	(1.29)	(2.11)	(3.54)
N	160	112	160

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.3.2.2 Full-sample test

In order to overcome the influence of statistical variable selection on the results and verify the reliability of the research findings, this paper applies the entropy value method to process the data for a full-sample test, in which green investment and green insurance

are defined as positive indicators, and green credit, green securities and carbon finance are defined as negative indicators. Based on the above, this paper derives the comprehensive evaluation index of green finance, and uses this index as the explanatory variable to re-estimate the model.

According to the regression results, green finance has a positive impact on the advanced industrial structure, which is significant at the 1% level, and the conclusions of this paper are robust.

Table 6 Full sample regression

	(1)
	UIS
Score	0.491***
	(3.19)
LNcpi	-2.886***
	(-3.17)
LNppi	-0.440
	(-1.64)
LNpop	0.400***
	(3.39)
_cons	13.19***
	(3.39)
N	480

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.3.3 Endogeneity test

Endogeneity issues include measurement error, omitted variables, and reverse causation. This paper uses official statistics with relatively accurate data and low measurement error. This paper adds three control variables to the panel to solve the endogeneity problem at the omitted variable level. Finally, this paper tests the endogeneity caused by reverse causality. We use the ground method of Sun, Chu-Ren to circumvent endogeneity with core explanatory variables lagged by one period [19].

According to the test results, all explanatory variables are significant at the 1% level, and the endogeneity problem caused by reverse causality is circumvented.

Table 7 Endogeneity test

	(*grecre*)	(*greinv*)	(*greinsur*)	(*carb*)
	UIS	*UIS*	*UIS*	*UIS*
grecre	-1.518***	-79.68***	0.232***	-4.428***
	(-5.94)	(-3.81)	(14.84)	(-3.32)
greinv	-36.69***	-0.783***	-0.737***	-0.844***
	(-3.39)	(-5.10)	(-4.87)	(-5.68)
greinsur	0.181***	0.197***	-39.91***	-42.28***
	(11.49)	(13.70)	(-3.81)	(-4.05)
carbfin	-5.183***	-4.107***	-3.809***	0.202***
	(-4.38)	(-3.47)	(-3.27)	(14.25)
LNcpi	-1.585**	-1.443**	-1.557**	-1.636**
	(-2.36)	(-2.15)	(-2.36)	(-2.50)
LNppi	0.0175	-0.0561	0.00695	-0.0143
	(0.09)	(-0.28)	(0.04)	(-0.07)
LNpop	-0.224**	-0.161*	-0.138	-0.131

	(-2.34)	(-1.70)	(-1.48)	(-1.39)
_cons	11.16***	9.947***	9.880***	10.39***
	(3.92)	(3.53)	(3.54)	(3.75)
N	450	450	450	450

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5. Results of the empirical analysis

The explanatory variables in this paper are green credit, green investment, green insurance as well as carbon finance, and these indicators measure the level of green financial development.

Green credit can positively pull the optimization and upgrading of industrial structure, and it is effective. According to the calculated results, the coefficient of green credit development level (i.e., the ratio of interest in high energy-consuming industrial industries to interest in industrial industries) is -0.757, which is significant at the 1% level. While And according to the logic of data construction, the coefficient of green credit is negatively related to the level of green credit development, so it is concluded that the development of green credit and advanced industrial structure promote each other.

Green investment reflects the level of investment in combating pollution. At the early stage of green financial development, the level of productivity development is limited and the government focuses on the quantitative growth of economic development, thus neglecting the improvement of development efficiency. In this context, investment in pollution control is a passive investment, which means that a high level of pollution in the context of a low level of industrial structure development leads to a high level of investment in pollution control. At this stage, green investment is an inverse indicator, which is consistent with the results of the empirical analysis in this paper. Green investment is significantly and negatively related to the advanced industrial structure. With the development of green economy and the optimization and upgrading of industrial structure, the concept of harmonious coexistence between human and nature is deeply rooted, and this paper speculates that the ratio of investment in pollution control to GNP will become a significant and positive indicator.

The higher the level of green insurance development is, the more it is conducive to the optimization and upgrading of industrial institutions, and the effectiveness is obvious. According to the regression results, the development of green insurance has a significant promotion effect on the optimization and upgrading of industrial structure. With the growth of international population and the acceleration of economic globalization, the economic development method based on carbon emission receives great challenges. Under the increasingly severe environmental pollution situation, green insurance plays the function of risk transfer, loss prevention and disaster mitigation.

Promoting the development of carbon finance has a positive pulling effect on the advanced of industrial institutions, and the effect is significant. According to the definition of the variable, the carbon finance indicator is an inverse indicator, and the larger the value, the lower the level of carbon finance development. From this, it can be judged that the regression coefficient of carbon finance is -3.542, which is negative at the 1% significant level. Therefore, carbon finance should be vigorously developed to reduce greenhouse gas emissions with relevant financial trading activities and promote positive development efficiency, thus leading to the optimization and upgrading of industrial structure.

In this paper, commodity price level (*LNcpi*), industrial price level (*LNppi*) and labor supply level (*LNpop*) are used as control variables. The regression coefficient is -1.582. It is thus known that the commodity price level plays a constraining role in the optimization and upgrading of the industrial organization. If the commodity price level rises, this will lead to inflation leading to a decrease in the purchasing power of money, a decline in social savings funds, and a hindrance in financing the production chain, which is not conducive to industrial restructuring and upgrading.

6. Conclusions and Policy Recommendations

6.1 Research Conclusion

This paper selects panel data of 30 provinces in China during the period of 2005-2020 as a sample, and conducts an empirical

analysis for the correlation between green finance and the optimization of industrial structure in China. The empirical analysis shows that the development of green finance positively promotes the advanced industrial institutions in China, and the increase of price level plays a restraining role in the optimization and upgrading of industrial structure.

The development of green finance brings about the development of science and technology and industrial innovation, which has a crucial impact on the optimization of industrial efficiency and the sustainable development of new industries. Therefore, it is imperative to seize the golden period of green finance development to better meet the requirements of the direction of industrial structure optimization and upgrading and achieve sustainable and healthy economic development.

6.2 Policy Recommendations

In summary, green finance has a positive role in promoting the optimal development of industrial structure. In order to play the role of green finance and promote the transformation and upgrading of China's industrial structure, measures can be carried out from the following aspects.

Provide a basis for the standardized development of green finance by formulating a system of laws, regulations and standards related to the development of green finance. Clarify the rights and responsibilities of green finance-related subjects. Ensure that information sharing and timely feedback can be made between various functional departments and financial institutions to create a good development environment for accelerating the construction of green financial service system.

Various measures should be taken comprehensively to stimulate the enthusiasm of relevant subjects, improve the incentive and restraint mechanism, and guide the flow of financial resources to green industries. On the one hand, it is very important to adopt policy subsidies and other forms to mobilize financial institutions to widely participate in green investment. On the other hand, the supervision concerning green finance should be strengthened, and a green financial information supervision system should be established to reduce green financial risks.

Risk assessment and prevention is the top priority for the development of green finance. Therefore, risk reduction and risk sharing should be called the main focus of green financial innovation. Relevant departments should make every effort to build a green financial brand, innovate green financial products and services, and help the real economy transform to green.

Strengthening cooperation and exchange in the field of green finance is an important path to develop green finance. It is necessary to strengthen information sharing and learning exchanges, promote the establishment of unified international standards, reach bilateral cooperation and multilateral cooperation, and enhance China's voice in the global green transformation and upgrading.

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