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Research on the Impact of Green Finance on Industrial Structure Optimization: Based on an Empirical Study of the Six Provinces in Central China

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Abstract: Green finance, as an important policy to promote high-quality economic development, has become a focus of attention in the academic and policy circles for its promotion of industrial structure optimization. Based on the data of six provinces in Central China from 2010 to 2023, this paper constructs a comprehensive index of green finance development by using entropy value method and empirically analyses the impact of green finance on industrial structure optimization. The results show that the level of green finance development has a significant contribution to the optimization of the industrial structure in the central region. Accordingly, this study provides suggestions for deepening green finance reform and accelerating industrial transformation and upgrading.

Keywords: Green finance; Industrial structure optimization; Green finance development index

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1. Introduction

Since the reform and opening up, China's economy has experienced rapid industrialization, with significant growth in economic output. However, this GDP-oriented development model has often neglected the sustainability of resources and the environment [1]. At present, the global promotion of green low-carbon development has become an unstoppable trend, and the green economy has become a new high ground for international industrial competition. Therefore, accelerating the transformation of the development mode, and promoting the formation of green and low-carbon production and lifestyle are of great significance.

The 20th Party Congress stressed that accelerating the promotion of industrial structure optimization is the key to green development. Therefore, the role of the financial sector cannot be ignored. However, there are significant differences in green finance development and industrial structure among different provinces in China. Based on this background, this paper selects the data of the six provinces of Central China (Shanxi, Anhui, Jiangxi, Henan, Hubei, Hunan Provinces) from 2010 to 2023 as the research object, makes an in-depth investigation of the relationship between green finance and the optimization of industrial structure, and provide suggestions for promoting the optimization of industrial structure with the help of the development of green finance, with a view to

providing theoretical support and practical reference for the sustainable development of the regional economy.

2. Literature review and research hypothesis

Green finance was first defined by Salazar (1998) as an innovative way for the financial industry to meet the financing needs of the industry, emphasising its importance in the economic development [2]. Scholars believe that green finance pays more attention to environmental factors in the economic growth by strengthening collaboration between the financial and environmental sectors, and by rationally allocating green financial resources to achieve sustainable development [3–5]. In China's green financial policy framework, green credit policy implementation is of high quality, which optimizes resource allocation, promotes economic restructuring, and industrial upgrading [6, 7].

Some scholars have proposed that industrial structural transformation can be subdivided into industrial rationalization and upgrading, and green finance has a key role in promoting structural transformation of industries in the central region [8]. Industrial structural adjustment involves the reallocation of production factors and changes in the proportion of production value among economic sectors, and relevant policies can promote the green transformation of industries and the sustainable development of the regional economy [9–11].

Regarding on the relationship between green finance and industrial structure, some scholars pay attention to the impact of green finance on industrial structural adjustment, pointing out that there is an interaction between the financial structure and industrial transformation [12–14]. Some studies show that green finance significantly promotes industrial transformation [15–16]. In addition, some studies have found that the synergistic effect of fintech and green finance is significant, and the green finance policy can promote the transformation and upgrading of industrial structure in pilot areas [17, 18]. Therefore, this paper puts forward the research hypothesis: The development of green finance can promote the optimization of industrial structure.

3. Research design

3.1. Research variables

3.1.1. Explained variables

This paper chooses the degree of optimization of industrial structure (ITR) as explained variables, including rationalization of industrial structure(theil), advancement of industrial structure (ais1) and upgrading of in industrial structure (ais2) [19, 20].

The Tel index takes the value of 0, it indicates that the resource allocation among industries reaches the optimal state; on the contrary, if the index deviates from 0, it reflects the existence of uncoordinated phenomenon of inter-industry development, the efficiency of resource allocation needs to be improved, and the industrial structure is unreasonable. The specific formula is as follows:

$$\mathrm{theil}_{i,t} = \Sigma_{m=1}^{3} y_{i,m,t} \ln\left(\frac{y_{i,m,t}}{l_{i,m,t}}\right), m = 1,2,3$$

The advancement of industrial structure is expressed by the industrial structure hierarchy coefficient, which denotes the proportion of industry *m* in region *i* to the regional GDP in period *t*. The specific calculation formula is as follows:

$$\mathrm{ais1}_{i,t} = \Sigma_{m=1}^{3} y_{i,m,t} \times m, m = 1,2,3$$

The upgrading of industrial structure adopts the ratio of output value between the secondary industry and the tertiary industry, and the specific calculation formula is:

$$ais2_{i,t} = y_{i,3,t}/y_{i,2,t}$$

Where, $y_{i,3,t}$ denotes the proportion of the tertiary industry in region *i* in period *t* in the GDP, $y_{i,2,t}$ denotes the proportion of the secondary industry in region *i* in period *t* in the GDP.

3.1.2. Explanatory variable

This paper selects green financial development level (GRFI) as the key explanatory variable. Green financial development involves five segments: green credit, green investment, green insurance, green securities, and carbon finance [21]. Further, entropy method is used to measure the weight of each indicator. The measures and the weights of each indicator are shown in **Table 1**.

Table 1. Green finance development level indicators and their weights

Variables	Measures	Weights
Green credit	Bank loans of A-share listed environmental protection enterprises/ Total loans of financial institutions	18.47 %
	Interest expenditure of six major energy-consuming industries/ Total industrial interest expenditure	3.57%
Green investment	Expenditure on energy saving and environmental protection/ General budget expenditure	8.07%
	Total investment in environmental pollution control/ GDP	31.43 %
Green insurance	Agricultural insurance payout expenditure/ Agricultural insurance revenue	5.52%
	Agricultural insurance expenditure/Total property insurance expenditure	7.19%
Green securities	A-share value of environmental protection enterprises/ A-share total market capitalization	13.56%
	Energy-consuming enterprises A stock market value/ A shares of total market capitalization	3.44%
Carbon finance	Carbon emission / Loan balance in local and foreign currency	8.77%

3.1.3. Control variables

The control variables include marketisation level (SCH) and the level of opening up to the outside world (OPE).

3.2. Data resources

In this paper, the data of six provinces in central China during 2010-2023 are obtained from Wind database, CEIC data network, EPS database, as well as China Statistical Yearbook, China Financial Statistical Yearbook, China Industrial Statistical Yearbook, China Insurance Statistical Yearbook, China Energy Statistical Yearbook, China Forestry and Grassland Yearbook, China Environmental Statistical Yearbook and provincial statistical yearbooks. For some of the missing values in the dataset, this paper adopts the linear interpolation method to fill them in.

3.3. Model setting

In order to analyze the impact of green finance on industrial structure optimization in six provinces in Central China, the model established in this paper is as follows:

$$ITR_{it} = \alpha_0 + \alpha_1 GRFI_{it} + \alpha_2 COTL_{it} + \varepsilon_{it}$$

Where: *i* and *t* denote the province and time variables respectively. ITR_{it} denotes the degree of optimization of industrial institutions in each province, specifically including rationalization of industrial structure (theil), the advancement of industrial structure (ais1) and upgrading of industrial structure (ais2). $GRFI_{it}$ denotes the level of green finance development in each province. $COTL_{it}$ denotes the control variables, specifically including the de-

gree of openness to the outside world (OPE) and the level of marketisation (SCH). denotes the random term.

4. Empirical analysis

4.1. Descriptive statistics

The mean value of theil is 0.156, indicating that the overall industrial structure of the six provinces is relatively balanced, but the maximum value (0.356) is about eight times as large as the minimum value (0.044), suggesting that there is a difference between the provinces. The mean value of ais1 is 2.340, indicating that the six central provinces are still dominated by the secondary industry. The mean value of of ais2 is 0.972, close to 1, indicating that the scale of the secondary industry and the tertiary industry as a whole is comparable, with a minimum value of 0.5 and a maximum value of 1.509, indicating that the differences between some provinces are significant. The mean value of GRFI is 0.226, and the maximum value (0.610) is 6.5 times of the minimum value (0.094), indicating that some provinces are significantly ahead in terms of green financial policies or market activity.

4.2. Analysis of basic regression results

This paper chooses the random effect regression model to analyze the relationship between the green financial development level (GRFI) and industrial structure optimization (ITR).

The regression analysis in **Table 2** shows that GRFI and Theil are significantly negatively correlated, with a regression coefficient of -0.270 ($p < 0.01$). This indicates that enhancing the development level of green finance can effectively optimize the allocation of regional factor resources and promote the upgrading of industrial structure. Additionally, there is a significant positive correlation between the GRFI and ais1, with a regression coefficient of 0.690 ($p < 0.01$), indicating that the development of green financial development can effectively promote the transformation of the industrial structure from the primary industry to the secondary and tertiary industries. Moreover, regression analysis shows that there is a significant positive correlation between GRFI and ais2, with a regression coefficient of 2.054 ($p < 0.01$). This indicates that the development of green finance can effectively promote the transformation and upgrading of industrial structure.

In summary, the hypothesis of this paper is established. The development of green finance can obviously promote the optimization of industrial structure.

Table 2. Regression results

Variable	(1) Theil	(2) ais1	(3) ais2
GRFI	-0.270***	0.690***	2.054***
	(0.055)	(0.082)	(0.262)
SCH	-0.502**	0.909***	0.749
	(0.217)	(0.208)	(0.666)
OPE	-1.080***	-9.53e-05	0.394
	(0.199)	(0.206)	(0.658)
Constant	0.444***	1.996***	0.308*
	(0.052)	(0.052)	(0.166)
Observations	84	84	84

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, standard errors are in parentheses, similarly hereinafter.

4.3. Robustness test

In order to verify the above results, the following two methods were used. First, this paper lags one period of green financial development level (GRFI) and reconstructs the regression model. The robustness test results of (1)(2)(3) in **Table 3** show that GRFI with one lag period is significantly negatively correlated with theil, and significantly positively correlated with ais1 and ais2, and the regression coefficients are all significant at the 1% level. Second, this paper further selects the data from 2016–2023 and controls regional effects in the analysis. The results of (4)(5)(6) in **Table 3** show that GRFI is significantly negatively correlated with theil, and significantly positively correlated with ais1 and ais2. The above results not only confirm that the promotion of green finance on industrial structure optimization has a sustained effect, but also further verifies the robustness of the benchmark regression results.

Table 3. Robustness test results

Variables	(1) Theil	(2) ais1	(3) ais2	(4) Theil	(5) ais1	(6) ais2
L.GRFI	-0.283***	0.764***	2.247***			
	(0.067)	(0.102)	(0.328)			
GRFI				-0.085*	(0.201**)	0.863***
				(0.042)	(0.0794)	(0.287)
SCH	-0.422*	0.831***	1.079	-0.402*	0.906**	4.687***
	(0.231)	(0.220)	(0.838)	(0.209)	(0.379)	(1.370)
OPE	-1.136***	0.099	1.194	-0.902***	1.100***	4.520***
	(0.207)	(0.217)	(0.800)	(0.165)	(0.299)	(1.082)
Constant	0.430***	1.999***	0.147	0.342***	2.011***	-0.656*
	(0.058)	(0.060)	(0.218)	(0.053)	(0.096)	(0.346)
Area control				YES	YES	YES
Observations	78	78	78	48	48	48

5. Suggestions

In view of the inter-provincial differences in the development of green finance and industrial structure in the six provinces, it is recommended to implement a regional synergistic development strategy. Firstly, inter-provincial green industry investment funds and special bonds for green technology transformation can be established, focusing on supporting green infrastructure construction and low-carbon transformation of traditional industries in less developed areas. Secondly, a training base for green financial science and technology talents may provide a basis for labor force. Thirdly, a green financial science and technology innovation center can be set up in Hefei, Wuhan and other digital hub cities. Through the three-dimensional linkage of balanced allocation of material capital, quality improvement of human capital and in-depth empowerment of digital technology, the regional development gap will be effectively narrowed, and a solid foundation will be laid for green finance to promote the optimization and upgrading of industrial structure.

Regional synergy and a green finance-industry mechanism should be improved. It is recommended that the six provinces can establish a cross-regional green finance cooperation framework to promote mutual recognition of green finance standards, data sharing and policy synergy.

6. Conclusion

This paper selects the data of six provinces in Central China from 2010 to 2023, and systematically examines the impact of green finance on industrial structure optimization. The study finds that, firstly, the industrial structure of the six provinces in Central Chian and the development of green finance show significant differentiation characteristics. Secondly, the regression results show that green finance significantly promotes the transition from primary industry to secondary and tertiary industry by optimizing the allocation of resource factors, and directly increases the proportion of tertiary industry in the national economy, making the industrial structure more reasonable. Thirdly, after the robustness test, the findings remain stable.

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