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Research on the Mechanism of Green Finance Serving the Real Economy under the Background of Chinese Modernization

—Proof Based on Provincial Panel Data

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Abstract

This paper aims to explore the impact of green finance on the scale of the real economy in China, measurement methods for the efficiency of green finance in serving the real economy, regional efficiency trends in China, and their influencing factors. The study is based on panel data covering 30 provinces (municipalities and autonomous regions) from 2011 to 2020. At the scale level, the paper conducts a baseline regression, examines the reliability of conclusions through robustness tests and investigates spatial differences in heterogeneity. At the efficiency level, the paper establishes an SBM model to measure the effectiveness of green finance in serving the real economy and analyzes the development status of different regions. Finally, a random-effects panel Tobit model is employed to test the impact of green finance on efficiency. The conclusions are as follows: At the scale level, the comprehensive green finance index has a significant positive impact on the scale of the real economy. The impact is more pronounced and significant in financially developed regions, while the comprehensive index in financially underdeveloped regions has a smaller and insignificant effect on the real economy scale. At the efficiency level, over the course of a decade, the development of green finance in China has shown an overall upward trend in real economic efficiency. However, efficiency has consistently remained at low or ineffective levels with fluctuations. Guangdong and the northeastern region exhibit low-efficiency values with negative growth rates. In contrast, the southeastern coastal regions, Sichuan, and Guizhou have witnessed rapid efficiency growth over the decade. The comprehensive green finance index has a significantly negative impact on SBM efficiency. In conclusion, to address the current challenges of inadequate green

finance development and implement financial system reforms, this paper puts forward a series of policy recommendations.

Subject Areas

Finance

Keywords

Green Finance, Real Economy, Scale and Efficiency, Panel Model, SBM-Tobit Model, China

1. Introduction

Green finance, as an emerging financial model, directs capital toward environmental protection and sustainable development through the provision of green financial products and services, supporting the green transformation and sustainable development of the real economy. China continuously learns and practices advanced experiences in providing green financial services to the real economy. Given China's late start and slower development in green finance, the country adapts and refines its policies to achieve a "Chinese-style modernization" of the green finance industry. Chinese-style modernization combines sustainable development with economic growth and social progress, becoming one of China's core development objectives. Therefore, in this context, green finance holds significant development significance.

The 2023 Global Wealth Management Forum pointed out that the level of financial development is determined by the real economy and serves it. Green finance, by offering green financial products and services, guides funds toward environmental protection and sustainable development to support the green transformation and sustainable development of the real economy. In the face of the ongoing challenges of deteriorating global ecological conditions, achieving Chinese-style modernization requires the support of a healthy and green development of the real economy. Green finance can identify the risks faced by the real economy and actively promote its development while maintaining an environmentally friendly approach, realizing the green environmental protection concept of sustainable development.

Financial development theory suggests that the rational allocation of financial resources can promote the sustainable development of the real economy. However, in recent years, the coordination issues between green finance and the real economy have become increasingly prominent. Economic growth is often accompanied by higher environmental pollution, while the efficiency of green finance in serving the real economy is low and subject to significant fluctuations, leading to questions about its effectiveness. To fully unleash the potential of green finance, it is necessary to address the efficiency of the real economy, ensuring sustainable economic growth and efficient resource utilization.

Therefore, the development of the financial industry should return to the real economy, considering the dual constraints of resources and the environment. The development of financial services for the real economy should not only focus on the scale of its impact but also emphasize economic quality, including efficiency and green development issues. How can we assess the effectiveness of green finance in serving the real economy? What are the efficiency trends in green finance services for the real economy in different provinces? What factors influence the efficiency of green finance in serving the real economy? By researching these questions, we can not only understand the current status and trends of financial services for the real economy in various provinces but also analyze the factors affecting efficiency, providing reference suggestions for addressing the challenges of weak green finance development and advancing financial system reform.

2. Literature Review

Huang Wenting (2019) [1] focused on the impact of asset liability management behaviors of commercial banks on the real economy. The results show that the leverage ratio of banks has a positive effect on the strength of banks to support the real economy, while the length of capital channel has no significant effect on the strength of support. Wu Yongxia (2019) [2] indicates that the development of green finance is a realistic requirement for the sustainable development of the financial industry, and it is necessary to build a "four-in-one" strategy system for green finance to serve the real economy, so as to realize the harmonious development of finance and ecological environment and seek new profit growth points. Sun Hongyan *et al.* (2020) [3] used the input-output model to build a method to measure the indicators of the real economy of financial services, and found the characteristics of the disharmony between the development of China's finance and the real economy. The study also found that the higher the position of the real economy in the global value chain, the more it can promote financial services to the real economy. Tan Zhao (2020) [4] believes that the efficiency of China's financial services for the real economy is not high and there is a phenomenon of "shifting from real to virtual". Lestari *et al.* (2020) [5] explored the relationship between financial development, economic growth, and environmental degradation through panel data analysis of selected countries in Asia. The study found that financial development has a positive impact on economic growth, but it also leads to environmental degradation. Anu *et al.* (2023) [6] analyzed the data from 2000 to 2018 and used quantile regression to study the correlation between financial inclusion, green innovation and energy efficiency on economic development performance. The results show that the development of inclusive finance has a significant impact on economic growth in countries with higher ecological levels. Based on the data of 238 Chinese prefecture-level cities from 2012 to 2021, Hongmei Li *et al.* (2023) [7] adopted fixed effect, intermediary effect and threshold regression models and found that the development of digital

finance is conducive to improving the efficiency of urban green economy. Green technology innovation is the key mechanism for digital finance to promote the efficiency of urban green economy, and the impact of digital finance on efficiency is non-linear, especially in large cities and small and medium-sized cities. This provides practical experience for the improvement of urban economic efficiency. Kai Qiu *et al.* (2023) [8] used the generalized method of Moments (GMM) model to investigate the relationship among natural resource utilization efficiency, financial development, and economic growth in Asian countries during 2010-2021. It is found that there is a significant positive correlation between the efficiency of natural resource consumption and economic development, which emphasizes the importance of resource management. Financial development is positively correlated with economic growth, indicating that a good financial system can promote the economy. Natural resource efficiency and financial development together contribute to economic growth, underscoring the need to improve resource management processes. Kedong Yin *et al.* (2023) [9] found that the development of China's financial industry is affected by the progress of green technology and foreign direct investment. Foreign direct investment has positive effects on economy, but it has threshold effect and nonlinear characteristics. The scale, structure and efficiency of financial development also influence the impact of FDI on the economy.

Most of the existing foreign literature believes that green finance has a positive impact on economic efficiency, plays a key role in balancing economic growth and environmental protection, and promotes the upgrading and transformation of industrial structure. However, the existing Chinese literature does not pay enough attention to green finance and does not delve into its full impact on the real economy. On the one hand, these literatures focus on the relationship between the size of finance and the real economy. On the other hand, when evaluating the efficiency of green finance in serving the real economy, more comprehensive green finance indicators, such as carbon emissions and energy consumption, are ignored.

The existing efficiency measurement methods of green finance serving real economy mainly use entropy weight method, DEA or Malmquist index, but ignore the sustainable development nature of green finance system. In the context of the deepening of Chinese-style modernization, the green financial system should pay more attention to guiding economic activities toward resource-saving and environmentally friendly development.

Most studies also fail to consider the green development perspective of finance. Therefore, the innovation points of this paper are as follows: 1) Introduce indicators such as energy consumption and industrial waste, build a more comprehensive SBM model, and evaluate the development level of financial services real economy in 30 provinces (municipalities and districts); 2) The random effects panel Tobit model is adopted instead of OLS or GMM model to reduce the model estimation error.

3. Theoretical Basis and Research Hypothesis

3.1. Financial Structure Theory

The theory of financial structure emphasizes the role of financial institutions and markets in the development of the real economy and provides support and services for the real economy. Financial structure is composed of financial instruments and financial institutions, reflecting financial development. The financial system includes commercial banks, securities companies, insurance companies and other institutions that provide services such as financing, payment and settlement, and risk management to support the real economy. Financial markets such as money markets, securities markets and foreign exchange markets provide financial products and services that facilitate the flow of funds and information.

According to the theory of financial structure, green finance serves the expansion of the scale of the real economy in many aspects. Financial institutions provide financial support and financing channels for the real economy by providing financing and other financial services. In the field of green finance, financial institutions can launch green financial products and services, such as green loans and green bonds, to support environmental protection and sustainable development projects and promote the expansion of the real economy. In addition, financial markets play an important role in the financial structure, facilitating the flow of funds and information through the provision of various financial products and services. In the field of green finance, the financial market can provide financing channels for green projects and environmentally friendly enterprises, and transmit relevant information to investors and market participants, thus promoting the growth of the scale of the real economy. For example, the development of a green bond market can attract more funds to green projects, while increasing investor awareness and participation in the green economy. Financial institutions and markets also assume the role of risk management and diversification, which helps the real economy to manage and diversify risks. In green finance, financial institutions can help green projects and environmental protection enterprises reduce risks and promote the expansion of their scale by providing services such as green insurance and green investment funds. These green financial products and services help manage and protect environmental and climate risks, and enhance the resilience of the real economy in terms of sustainable development.

Therefore, the first research hypothesis H1 of this paper is presented: the development of green finance will promote the development of the scale of the real economy.

3.2. Relational Financing Theory

Relational financing theory focuses on building trust, cooperation and long-term relationship, and improving financing efficiency and economic performance.

According to the theory, trust and cooperation between borrowers and lenders is the key to reduce information asymmetry and uncertainty and improve resource allocation efficiency through a stable relationship. Lenders have a deep understanding of borrower needs, provide customized financing solutions, and develop together to achieve long-term goals and growth. The relational financing theory guides financial institutions to improve financing efficiency and returns, and promotes cooperation with the real economy.

The application of relational financing theory to green financial services can effectively improve the efficiency of the real economy. The theory emphasizes the importance of building trust, cooperation and long-term relationships. In the field of green finance, financial institutions build trusting relationships with green project borrowers and gain insight into their environmental strategies, sustainable development goals and business practices. This trust and partnership helps reduce information asymmetries and uncertainties, improve financial institutions' understanding and confidence in green projects, and thus improve financing efficiency. At the same time, financial institutions have a deep understanding of the needs of borrowers and provide them with personalized financing solutions, thereby improving the financing efficiency of the real economy. In addition, by establishing long-term cooperative relationships with green project borrowers, jointly developing and implementing green project development plans, and providing continuous financing support and strategic guidance, financial institutions can increase the success rate and economic efficiency of projects, thereby improving the efficiency of the real economy.

Therefore, the second research hypothesis H2 is proposed in this paper: the development of green finance will promote the development of real economy efficiency.

4. Empirical Analysis at Scale Level

4.1. Scale Level Variable Selection and Data Source

This paper plans to study the impact of green finance composite index on the scale of real economy. The size of the real economy is selected as the explained variable, and the logarithm of the actual value of the gross regional product (GDP) after deducting the output value of the financial industry and real estate industry is used to measure the output value of the real industry, which reflects the ability of the economic activities in the region to create real wealth [10].

The explanatory variable was the green finance composite index. This paper uses the data of green credit, green securities, green investment, green insurance and carbon finance, measures the weights of the five original indicators, and then standardizes the standardized indicators. The overall score obtained is defined as the Green finance Composite Index to represent the level of green finance. The above data comes from China Statistical Yearbook, Provincial (city and district) Statistical Yearbook, China Financial Yearbook and Environmental Status Bulletin. **Table 1** shows the definition of each indicator.

Table 1. Scale level variable definition table.

Primary index	Secondary index	Variable definition
Green finance composite index	Green credit	High energy consuming industrial interest/ industrial interest
	Green securities	Six energy-intensive A-share market value/ total A-share market value
	Green investment	Anti-pollution investment/GDP
	Green insurance	Agricultural insurance income/ gross agricultural output value
	Carbon finance	CO_2 emissions/GDP

This paper takes urbanization rate, opening-up rate, industrial structure level, proportion of higher education students and per capita GDP as control variables to control other factors that may affect the scale of the real economy, so as to more accurately analyze the impact of the green finance composite index on the real economy. The above data are from China Statistical Yearbook and provincial (municipal and district) statistical Yearbook. In this paper, we collected the balance panel data of 30 provinces (municipalities and districts) in China except Xizang from 2011 to 2020, and obtained a total of 300 valid samples. The green finance composite index was calculated using the entropy weight method, while other data came from the provincial statistics bureau. In order to eliminate the dimensional difference of variables, some data are logarithmically processed in this paper. Table 2 shows the description and definition of scale level variables.

4.2. Panel Model Construction

Build a benchmark model to analyze the impact of green finance on the scale of the real economy, as follows:

$$\text{Real}_{i,t} = \alpha_0 + \varphi_i \text{Green}_{i,t} + \sum_k \beta_k LnX_{k,i,t} + \varepsilon_{i,t} \quad (1)$$

Among them, the explained variable $\text{Real}_{i,t}$ is the entity scale of the i province (city or district) in the t year, and the explanatory variable $\text{Green}_{i,t}$ is the green finance composite index of the i province (city or district) in the t year an φ_i is its coefficient. If $\varphi_i > 0$ is significant, it indicates that the green finance composite index will promote the expansion of the scale of the real economy. According to the research hypothesis H1, the coefficient is expected to be significantly positive. $LnX_{k,i,t}$ $(k = 1, 2, 3, \cdots)$ Is the logarithm of each control variable, α_0 is the intercept term, and $\varepsilon_{i,t}$ is the random error term.

4.3. Baseline Regression Analysis

Before the baseline regression, panel unit root, or cointegration test, is required for each variable, and the result shows that all variables reach first-order single integration, and KAO test shows that the p value corresponding to the ADF statistic is less than 0.05, rejecting the null hypothesis, that is, the variables of panel data have a cointegration relationship.

Table 2. Description of variables at scale level.

	Variable name	Variable definition	symbol	unit
Explained variable	Variable name	GDP value after deducting the output value of the financial industry and real estate industry, logarithm	Real	-
Explanatory variable	Green finance composite index	Entropy weight method	Green	-
Control variable	Urbanization rate	Urban population * 100/total population	X1	%
	Opening rate	Total import and export trade * 100/GDP	X2	%
	Government intervention rate	Fiscal expenditure * 100/GDP	X3	%
	Industrial structure level	Output value of the secondary industry * 100/output value of the primary industry	X4	%
	Proportion of people in higher education	Number of college students/ number of students enrolled	X5	-
	Per capita GDP	Real GDP per capita, logarithm	X6	-

In the panel regression model, there are three models: POOL model, fixed effect model and random effect model. F test, LM test and Hausman test are needed to find the optimal model.

As can be seen from Table 3, at the significance level of 5%, F test shows that p value is 0.0000 < 0.05, which means that FE model is better than POOL model. LM test shows that p value is 0.0000 < 0.05, which means that RE model is better than POOL model. Hausman test shows that p value is 0.6817 < 0.05, which means that RE model is better. Therefore, this paper chooses RE model as the optimal model.

Table 4 presents the estimated results of the baseline regression model. Without considering other factors (Column 1), the green finance composite index is positively correlated with the size of the real economy, with a significance level of 5%. After gradually adding control variables (Columns 2 to 5), the results show that the regression coefficient of the green finance composite index on the scale of the real economy is still positive and significant. This shows that even if other factors are controlled, the development level of the green finance composite index is positively correlated with the size of the real economy. This finding supports the research hypothesis H1 that green finance has a positive impact on the size of the real economy.

The results of Table 4 are analyzed below:

1) Urbanization rate

The urbanization rate has a significant positive impact on the scale of the real economy. Urbanization has improved the efficiency of resource allocation, achieved

economies of scale through the concentration of labor, enterprise capital support and knowledge and technology innovation, reduced costs and improved output efficiency, and promoted the growth of the real economy. In addition, urbanization has promoted the upgrading of industrial structure, shifted rural labor to non-agricultural industries such as manufacturing and service industries, provided more labor resources for the diversification and optimization of the real economy, and played an important role in industrial growth. At the same time, the level of urbanization also promotes technological innovation and knowledge dissemination. There are positive knowledge externalities, human resources accumulation and competition and cooperation mechanisms in cities, which accelerate technological innovation and knowledge dissemination and further promote the growth of the real economy.

Table 3. Test results of regression model selection.

Check type	Purpose of inspection	Test value	Test conclusion
F test	Compare and select FE model and POOL model	F(29,265) = 118.87, p = 0.0000	FE model
LM test	Compare and select RE model and POOL model	$\chi^2(1)$ = 1104.72, p = 0.0000	RE model
Hausman test	Compare and select FE model and RE model	$\chi^2(6)$ = 3.96, p = 0.6817	RE model

Table 4. Baseline regression results.

Variable	Scale of real economy				
	(1)	(2)	(3)	(4)	(5)
Green finance composite index	3.0953935***	1.3549065***	1.3360472***	1.3006379***	1.4265912***
	(0.50548902)	(0.46595974)	(0.46045679)	(0.46818209)	(0.48561147)
Urbanization rate		2.6286649***	1.6185738***	1.5664344***	1.15553**
		(0.25360409)	(0.44825503)	(0.46310711)	(0.53022312)
Opening rate			0.01804632***	0.01857727***	0.02163924***
			(0.00662302)	(0.00673118)	(0.00779784)
Government intervention rate				−0.00099649	0.00105928
				(0.00221905)	(0.00232399)
Industrial Structure Level					0.01812618***
					0.00645447
Number of provinces	30	30	30	30	30
Observed value	300	300	300	300	300

Note: The values in square brackets under the regression coefficient are standard errors; *, **, and *** are significant at 10%, 5%, and 1% significance levels, respectively.

2) Opening-up rate

The rate of opening to the outside world has a significant positive impact on the scale of the real economy. This is consistent with the research results of Frankel (1999) [11], who pointed out that trade has a positive impact on economic growth, and there is a significant positive correlation between more open trade policies and higher economic growth rates. Since the reform and opening up, China has carried out a series of opening-up policies, such as introducing foreign capital and expanding foreign trade. These initiatives have made China the world's largest trader of goods and recipient of foreign direct investment, while the size of the provincial economy has been expanding.

3) Government intervention rate

The government intervention rate may have a certain impact on the development of the economy, but it may be interfered with or limited by other factors, resulting in its impact on the size of the real economy is not statistically significant in the panel regression model. On the one hand, the effect of government intervention is limited, and government intervention measures may be challenged and limited by implementation, and cannot effectively promote the development of the real economy. On the other hand, the market mechanism plays an important role in resource allocation and economic growth. If the market mechanism is more effective, and individuals and enterprises can make their own decisions and conduct economic activities according to market demand, the impact of government intervention on the size of the real economy may be relatively small.

4) Level of industrial structure

There are several reasons for the positive relationship between the high level of industrial structure and the larger scale of the real economy. First of all, high industrial structure indicates that there is a high level of technology and innovation ability, which can improve the production efficiency and competitiveness of enterprises, and help expand the scale of the real economy. Secondly, a high level of industrial structure means that different industries in the economy are balanced and diversified, thus reducing economic risks and improving the overall risk tolerance. Finally, the high level of industrial structure means that the labor force is transferred to the industries with high added value and high skill demand, which optimizes the allocation of human resources and improves labor productivity and skill level, thus promoting the growth of the scale of the real economy.

4.4. Robustness Test

4.4.1. Adding Control Variables

According to the regression results, after controlling the proportion of higher education students and GDP per capita, the green finance composite index still has a significant positive impact on the scale of the real economy, and the conclusion is robust. In addition, the regression coefficient of the proportion of higher education students is negative at the significance level of 10%, which in-

dicates that the proportion of higher education students may inhibit the growth of the scale of the real economy. This may be because a high proportion of the number of people in higher education may lead to brain drain or resource dispersion, which will lead to insufficient labor supply in the real economy and inhibit the growth of the size of the real economy. As for the coefficient of per capita GDP, it is not significant, so we cannot draw a conclusion on the impact of per capita GDP on the scale of the real economy.

4.4.2. Excluding Special Provinces

China's four municipalities have unique advantages in political center status, economic strength, international exchange and urban development. This enables the four municipalities to better promote the development of green finance. When analyzing the nationwide green finance composite index, the presence of these municipalities may have a greater impact on the results. Therefore, these four municipalities were excluded from the 30 provinces in the study, and the regression analysis was re-performed. The regression results show that the green finance composite index still has a significant positive impact on the scale of the real economy, with the significance level reaching 5%, and the result is stable.

4.4.3. Shorten the Sample Interval

2016 is regarded as the first year of green finance by the international community, and the G20 Summit discussed green finance issues and sought ways to solve the challenges facing green finance development. In 2016, the People's Bank of China issued the Guiding Opinions on Building a Green Financial System, aiming to enhance the financial system's ability to support green, low-carbon and high-quality development. This move emphasizes China's emphasis on green finance, which may increase the significance of the results, so the sample interval is shortened to 2011-2015 and then returned. Under the shortened sample interval, there is a significant positive correlation between the green finance composite index and the scale of the real economy at the significance level of 1%, and the benchmark result is robust.

Table 5 shows the results of the robustness test for the three cases.

4.5. Heterogeneity Test

According to the study of Duan Junshan *et al.* (2020) [12], based on the degree of regional financial development, this paper divides 31 provinces into 21 more developed regions and 10 less developed regions. The group test method is used to study the differences among different regions and accurately evaluate the heterogeneity of financial development.

According to Table 6, the coefficient of the green finance Composite index is the highest in the overall region and slightly lower in developed regions, but it is still significant. Financially developed regions with strong economic strength and financial infrastructure are better able to support the development of green finance. However, in the less developed areas, the coefficient of the composite

Table 5. Robustness test table.

Variable	Increment control variable		Eliminate important provinces	Shortening sample interval
	(1)	(2)	(3)	(4)
Green finance composite index	1.191135**	1.3549065***	1.148108**	1.433951***
	(0.4600469)	(0.46595974)	(0.5239981)	(0.3978341)
Proportion of people in higher education	−0.0426688*	−0.0398956*		
	(0.0223372)	(0.0226239)		
Per capita GDP		−0.1385438		
		(0.176459)		
Control variable	YES	YES	YES	YES
Number of provinces	30	30	26	30
Observed value	300	300	260	150

Table 6. Heterogeneity test.

Variable	Entirety	Financially developed areas	Financially underdeveloped areas
	(1)	(2)	(3)
Green finance composite index	1.238611***	1.121938**	0.9420915
	(0.4614502)	(0.5107712)	(1.125479)
Control variable	YES	YES	YES
Constant term	4.357888***	5.097524***	2.856292
	(0.8079439)	(0.8886734)	(1.819275)
Number of provinces	30	21	9
Observed value	300	210	90

index is the lowest and no longer significant. Financially underdeveloped regions may face obstacles such as limited resources, inadequate financial services, and weak technical capabilities, and need more policy support and input to promote the development of green finance [10].

5. Empirical Analysis of Efficiency

5.1. Selection of Efficiency Measurement Methods

Data Envelopment Analysis (DEA) was initially proposed by Charnes and his colleagues. It is a non-parametric analytical method that does not require mak-

ing assumptions about the production functions of inputs and outputs. Consequently, it holds promising prospects and objectivity, making it well-suited for complex scenarios involving multiple inputs and outputs. DEA can determine variable weights through linear programming to minimize the influence of subjective factors. Furthermore, it can provide efficiency-related information through both horizontal and vertical comparisons.

Typically, the DEA model is employed to assess the efficiency of green finance in serving the real economy. However, the traditional DEA model faces challenges related to the disproportionate scaling of input and output variables and is unable to consider or eliminate external interference factors. To address these issues, Tone introduced the non-radial Slack-Based Measure (SBM) model, incorporating slack variables into the objective function. When dealing with situations involving non-desirable outputs, such as environmental pollution, the SBM model proves to be a suitable choice. The fundamental structure of the SBM model is as follows:

$$\min \delta = \frac{1-\frac{1}{m}\sum_{q=1}^{m} s_q^- / x_{k0}}{1+\frac{1}{s+t}\left(\sum_{v=1}^{s} s_v^{d+} / y_{ro} + \sum_{p=1}^{t} s_p^{u+} / b_{po}\right)} \tag{2}$$

$$\begin{aligned} \text{s.t. } & x_0 = X\lambda + s_k^- \\ & y_o = Y\lambda - s_v^{d+} \\ & b_o = B\lambda - s_p^{u+} \\ & \lambda \geq 0, s_k^-, s_r^+, s_p^+ \geq 0 \end{aligned} \tag{3}$$

where: δ represents SBM efficiency value; s_q^- represents the redundancy of q inputs; s_v^{d+} is the expected output of v categories reduced; The input redundancy, expected output deficiency and non-expected output redundancy of DMU can be calculated by $s_q^- / x_{k0}, s_v^{d+} / y_{ro}, s_p^{u+} / b_{po}$, and the redundancy rate can be obtained by calculating the proportion of the slack variables. The λ in the constraint represents the weight. In addition, this paper only considers the Variable Returns to Scale (VRS).

5.2. Input-Output Index Selection and Data Source

This paper takes the scale of real economy as the expected output index to reflect the overall economic development level; the impact of the real economy on the environment was evaluated by taking the total amount of wastewater discharge, the amount of general industrial solid waste production and the intensity of carbon dioxide emission as the non-expected output indicators. Financial industry personnel, social financing scale and total energy consumption are used as input indicators to reflect the financial sector's support and resource input to the real economy. The time interval of the above indicators is selected from 2011 to 2020, and the various input-output combinations are shown in **Table 7**. Among them, the first is listed as a first-level indicator, the second is listed as a second-level indicator, and the third is listed as an indicator symbol.

Table 7. Input-output variable table.

Input	Financial industry people (bit)	T_1
Undesirable output	Social financing scale (ten thousand yuan)	T_2
	Total energy consumption (10,000 tons of standard coal)	T_3
	Total wastewater discharge (10,000 tons)	C_1
Expected output	General solid waste generation (10,000 tons)	C_2
	Carbon dioxide emission intensity (ton CO_2/10,000 yuan)	C_3
	Size of real economy (100 million yuan)	Q_1

On the basis of referring to relevant theoretical studies, the data used in this chapter are all from China Statistical Yearbook, provincial and municipal statistical yearbook and wind database.

5.3. SBM Efficiency Analysis

Using DEARUN software and BCC model with variable returns to scale, this paper measures the SBM efficiency of green finance in serving the real economy. The results are shown in Table 8. SBM efficiency can help measure whether the financial sector is efficient in providing resources for the development of the real economy, and can identify areas where resources are wasted or inefficiently used. It can be seen from Table 8 that from 2011 to 2020, the SBM efficiency of green finance serving the real economy in China's provinces (municipalities and districts) fluctuates greatly. Regions with a positive growth trend tend to be in the south of China, while regions with a negative decline trend tend to be in the north of China. By 2020, the efficiency value of most provinces (municipalities and districts) has not reached 1, and even some provinces (such as Anhui, Gansu, Guangdong, etc.) have an efficiency value less than 0.6. This shows that most provinces (municipalities and districts) are still in the initial exploratory stage in the development of green financial services for the efficiency of the real economy. Most provinces (municipalities and districts) are redundant in the input of resources. In order to analyze the contents of the table below in more detail, this paper continues to elaborate from the overall and subregional levels.

On the whole, Figure 1 shows that from 2011 to 2020, the average SBM efficiency of 30 provinces (municipalities and districts) in China presents an increasing trend, from 0.375 to 0.504. However, efficiency does not rise continuously, but fluctuates. The average efficiency was relatively stable between 2011 and 2014. Efficiency improved significantly between 2015 and 2018, followed by a significant decline between 2018 and 2020, from 0.650 to 0.504. This indicates that China has made some progress in output efficiency during this period. In particular, as can be seen from Figure 1, there has been a significant improvement in 2018 compared with previous years, both DEA efficiency and SBM efficiency have reached a peak, but in 2019, the rapid decline again. This paper suggests that the most important reason may be. Since 2018, the reform of the

Table 8. SBM efficiency of 30 provinces and cities during 2011-2020.

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Anhui	0.232	0.226	0.227	0.223	0.216	0.227	0.234	0.320	0.291	0.268
Peking	1.000	0.601	1.000	0.656	0.746	1.000	0.827	0.908	1.000	1.000
Fujian	0.294	0.291	0.297	0.291	0.312	0.326	0.330	0.441	0.471	1.000
Gansu	0.263	0.247	0.261	0.241	0.225	0.243	0.272	0.521	0.299	0.304
Kwangtung	0.104	0.103	0.104	0.107	0.104	0.104	0.103	0.119	0.099	0.015
Guangxi	0.422	0.435	0.491	0.532	0.692	0.732	0.719	1.000	0.791	0.736
Guizhou	0.187	0.199	0.244	0.257	0.301	0.358	0.382	0.554	0.426	0.425
Hainan	1.000	1.000	1.000	0.740	0.728	1.000	1.000	1.000	1.000	0.688
Hebei	0.373	0.365	0.356	0.336	0.315	0.329	0.339	0.440	0.392	0.374
Henan	0.309	0.310	0.297	0.287	0.287	0.313	0.394	0.805	0.611	0.571
Heilongjiang	0.158	0.161	0.158	0.140	0.131	0.102	0.091	1.000	0.098	0.106
Hubei	0.230	0.237	0.252	0.262	0.280	0.290	0.301	0.554	0.407	0.345
Hunan	0.339	0.322	0.337	0.339	0.338	0.344	0.330	0.608	0.489	0.468
Ji Lin	0.365	0.375	0.423	0.433	0.473	0.512	0.503	1.000	0.244	0.218
Jiangsu	0.416	0.438	0.475	0.518	0.562	0.617	0.716	1.000	1.000	1.000
Jiangxi	0.270	0.308	0.308	0.316	0.310	0.316	0.302	0.426	0.295	0.246
Liaoning	0.268	0.298	0.309	0.312	0.377	0.247	0.244	0.339	0.220	0.228
Inner Mongolia	0.390	0.375	0.360	0.346	0.308	0.290	0.251	1.000	0.238	0.228
Ningxia	0.255	0.237	0.214	0.188	1.000	0.211	0.584	0.174	0.140	0.152
Qinghai	1.000	0.890	0.880	1.000	1.000	0.805	0.821	1.000	0.573	0.589
Shandong	0.359	0.413	0.477	0.511	0.529	0.586	0.660	1.000	0.829	0.736
Shanxi	0.222	0.217	0.208	0.204	0.235	0.242	0.275	0.437	0.311	0.315
Shaanxi	0.329	0.333	0.350	0.344	0.331	0.344	0.383	0.529	0.439	0.406
Shanghai	0.262	0.260	0.263	0.276	0.286	0.306	0.323	0.408	0.539	0.423
Sichuan	0.499	0.479	0.514	0.524	0.535	0.570	0.614	0.917	1.000	1.000
Tianjin	0.285	0.273	0.289	0.292	0.292	0.332	0.427	0.451	0.284	0.255
Xinjiang	0.383	0.391	0.398	0.408	0.379	0.375	0.463	1.000	1.000	1.000
Yunnan	0.454	0.461	0.530	0.543	0.522	0.549	0.548	0.558	0.652	0.616
Zhejiang	0.257	0.285	0.328	0.356	0.387	0.451	0.517	0.571	1.000	1.000
Chongqing	0.331	0.343	0.380	0.365	0.462	0.458	0.435	0.427	0.446	0.401

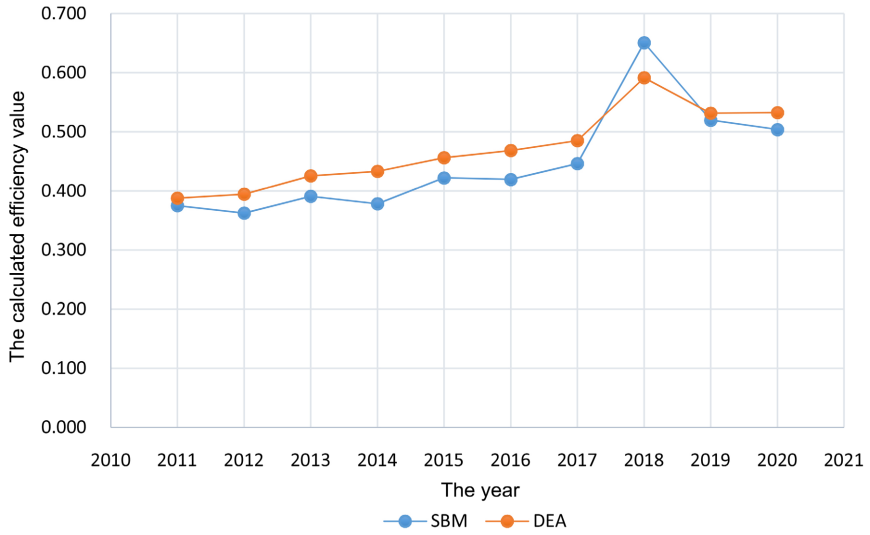

Figure 1. SBM efficiency and DEA efficiency mean of 30 provinces in China.

compensation system for ecological and environmental damage has entered a trial phase across China, and the system of restoration and compensation for ecological and environmental damage has been promoted nationwide. Ecological civilization has become an important national will, further deepening the consensus on green development and promoting green development practice. The reduction in undesired output resulted in the highest level of optimism for efficiency values in 2018. In 2019, due to the decline in the growth rate of China's real economy, coupled with the deepening dislocation of global economic policies, and the rising rise of geopolitics and trade protectionism, the problem of insufficient effective demand in China's real economy began to emerge, and risks and hidden dangers continued to increase. This may lead to a pessimistic scenario of a decline in efficiency values in 2019.

Although the SBM efficiency values of 30 provinces (municipalities and districts) in China showed an upward trend, they were all lower than 0.8. This means that the efficiency of green finance in serving the real economy has not been able to break through the boundaries of inefficiency or ineffectiveness. Combined with China's national conditions from 2011 to 2020 and the novel coronavirus epidemic, the following possible explanations are given. First, expected output is inadequate. The COVID-19 epidemic has had a major impact on China's real economy and has placed certain constraints on its scale growth. In addition, China is facing the challenges of overcapacity and rising labor costs in the course of economic transformation and structural adjustment. Second, the two outputs cannot be balanced. Our country is faced with the challenge of balancing economic development and environmental protection. Although the government has taken some environmental protection measures, such as the Air Pollution Prevention and Control Action Plan promulgated in 2013 and the updated version in 2018, there is still environmental pressure due to the huge base of the real economy. Especially in some traditional industries and regions, the

emission of three wastes is still very high. The figure below shows that DEA efficiency, excluding undesirable outputs, is consistently higher than SBM efficiency except in 2018. This shows that although the traditional extensive production mode of real industry improves economic benefits, the ecological environment non-point source pollution and carbon emission lead to efficiency loss and serious damage to the environment. Third, input is insufficient. Financial institutions in developed countries have launched a variety of green financial products, such as green bonds, green loans and green insurance, while the variety and scale of green financial products in China are relatively small, which may limit the financing and development of green economy. In addition, in terms of the evaluation and supervision of green finance, our country still has a certain weakness compared with developed countries. Developed countries have established sound green finance standards and indicator systems for assessing and regulating the environmental benefits and sustainability of green finance products and projects. In contrast, the construction of green finance standards and indicators in China still needs to be strengthened and improved.

At the regional level, by observing the changes in efficiency values in Guangdong Province and the three northeastern provinces (Liaoning, Jilin, Heilongjiang) in Table 9, and the improvement in efficiency in the southeast coastal region (Shandong, Jiangsu, Zhejiang, Fujian), the following analysis can be obtained:

Table 9. Spatial differentiation of SBM efficiency from 2011 to 2020.

Province	2011	2014	2017	2020	Province	2011	2014	2017	2020
Anhui	0.232	0.223	0.234	0.268	Jiangxi	0.270	0.316	0.302	0.246
Peking	1.000	0.656	0.827	1.000	Liaoning	0.268	0.312	0.244	0.228
Fujian	0.294	0.291	0.330	1.000	Inner Mongolia	0.390	0.346	0.251	0.228
Gansu	0.263	0.241	0.272	0.304	Ningxia	0.255	0.188	0.584	0.152
Kwangtung	0.104	0.107	0.103	0.015	Qinghai	1.000	1.000	0.821	0.589
Guangxi	0.422	0.532	0.719	0.736	Shandong	0.359	0.511	0.660	0.736
Guizhou	0.187	0.257	0.382	0.425	Shanxi	0.222	0.204	0.275	0.315
Hainan	1.000	0.740	1.000	0.688	Shaanxi	0.329	0.344	0.383	0.406
Hebei	0.373	0.336	0.339	0.374	Shanghai	0.262	0.276	0.323	0.423
Henan	0.309	0.287	0.394	0.571	Sichuan	0.499	0.524	0.614	1.000
Heilongjiang	0.158	0.140	0.091	0.106	Tianjin	0.285	0.292	0.427	0.255
Hubei	0.230	0.262	0.301	0.345	Xinjiang	0.383	0.408	0.463	1.000
Hunan	0.339	0.339	0.330	0.468	Yunnan	0.454	0.543	0.548	0.616
Ji Lin	0.365	0.433	0.503	0.218	Zhejiang	0.257	0.356	0.517	1.000
Jiangsu	0.416	0.518	0.716	1.000	Chongqing	0.331	0.365	0.435	0.401

In the period from 2011 to 2020, the efficiency value of green finance serving the real economy in Guangdong Province is close to 0, indicating that the rapid growth of the real economy is not commensurate with green development. The main reason is that Guangdong is dominated by manufacturing and export-oriented industries, which put greater pressure on resource consumption. The real economy of Guangdong Province is developing rapidly, but the problem of environmental pollution is prominent, resulting in low efficiency. In the period from 2011 to 2020, the efficiency of the three northeastern provinces remained low. Unlike Guangdong Province, the three northeastern provinces have lagged behind in economic development in the past few decades, and their economic structure is relatively undiversified, mainly relying on heavy industry and resource-based industries. The low investment in the financial sector, lagging real economic output and serious environmental pollution in the three northeastern provinces limit the ability of green finance to develop and improve efficiency.

In addition, the efficiency of green finance development in the southeast coastal areas has been significantly improved. The region is rich in economic base and industrial resources, which provides good conditions for green finance. These provinces actively build green finance markets, promote the development of financial products such as green bonds, encourage financial institutions to participate in green credit and investment, promote green project financing, and promote the prosperity and sustainable development of green finance markets. In addition, these regions are committed to combining green finance with scientific and technological innovation to create pilot and demonstration zones for green finance innovation. These provinces have made remarkable progress in coordinating green finance inputs with real economic outputs, providing a reliable basis for the effective operation of green finance.

Table 10 shows that the provinces with a positive growth rate of the efficiency of green financial services to the real economy are mainly distributed in the southern region of China, while the provinces with a negative growth rate are mainly distributed in the northern region of China. This regional difference may be related to the differences in green finance development and industrial structure between the southern region and the northern region. The southern region is likely to be more active in promoting sustainable development and the green economy through policy measures to support green project financing, green credit products and green investment. In addition, the industrial structure of the southern region may be more biased towards green physical industries and services, such as clean energy, environmental protection and renewable resources, and the development of these industries provides more opportunities and demands for green finance.

Specifically, each province promotes the development of green financial industry through corresponding policies. 1) Jiangsu Province proposes to establish and perfect a multi-level and diversified green financial product supply system

Table 10. SBM efficiency growth rate of 30 provinces (municipalities and districts) in China during 2011-2020.

Province	Efficiency growth rate	Type	Ranking
Zhejiang	288.53%	>100%	1
Fujian	239.84%	>100%	2
Xinjiang	161.04%	>100%	3
Jiangsu	140.48%	>100%	4
Guizhou	126.74%	>100%	5
Shandong	105.19%	>100%	6
Sichuan	100.27%	>100%	7
Henan	84.58%	(50%, 100%]	8
Guangxi	74.40%	(50%, 100%]	9
Shanghai	61.74%	(50%, 100%]	10
Hubei	50.13%	(50%, 100%]	11
Shanxi	41.81%	(0, 50%]	12
Hunan	38.13%	(0, 50%]	13
Yunnan	35.63%	(0, 50%]	14
Shanxi	23.45%	(0, 50%]	15
Chongqing	21.21%	(0, 50%]	16
Gansu	15.47%	(0, 50%]	17
Anhui	15.45%	(0, 50%]	18
Hebei	0.18%	(0, 50%]	19
Peking	0.00%	0	20
Jiangxi	−8.87%	(−50%, 0]	21
Tianjin	−10.58%	(−50%, 0]	22
Liaoning	−14.96%	(−50%, 0]	23
Hainan	−31.17%	(−50%, 0]	24
Heilongjiang	−32.79%	(−50%, 0]	25
Jilin	−40.12%	(−50%, 0]	26
Ningxia	−40.25%	(−50%, 0]	27
Qinghai	−41.13%	(−50%, 0]	28
Inner Mongolia	−41.54%	(−50%, 0]	29
Kwangtung	−85.83%	<50%	30

covering the whole province to provide precise support for industrial green development. 2) Zhejiang Province encourages banking and insurance institutions to carry out risk assessment and guide more funds to invest in investment and

financing activities in the field of climate change. Support the establishment of a database of industrial green development projects and promote the innovation of financial products and services. 3) Fujian Province has formulated a carbon peak carbon neutral implementation plan and a green finance work plan to clarify the development goals of green finance. We will provide support for industrial revitalization and environmental governance, and increase the supply of green finance. 4) As the largest clean energy province in China, Sichuan Province focuses on solving problems such as unclear regulatory rules, immature information disclosure and green certification processes, and insufficient policy incentives to promote the development of the green financial market. 5) According to the green finance development report and local actual conditions, Guizhou Province will explore and practice green finance system mechanisms, standards and platform construction, product and service innovation and other aspects to promote the development of green finance and promote the high-quality development of Guizhou economy.

In summary, the common feature of these provinces to promote green finance to serve the real economy is the selection of specific regions or demonstration zones as pilots, and planning, monitoring and evaluation to ensure that the experience gained can provide guidance and reference for province-wide promotion and implementation. The advantage of this approach is that it improves the efficiency and effectiveness of developing green finance while pooling resources, verifying the effectiveness of policies, reducing risks and popularizing experience.

6. Analysis of Factors Affecting the Efficiency of Green Finance in Serving the Real Economy

In this chapter, we will use panel data from 30 provinces (municipalities, and regions) in China and introduce relevant variables to quantitatively analyze the SBM efficiency of green finance in serving the real economy.

6.1. Selection of Efficiency Variables and Data Sources

In this study, we will use the SBM efficiency derived from the Data Envelopment Analysis (DEA) model for the years 2011 to 2020 as the dependent variable. The explanatory variable will be the comprehensive green finance index. Control variables include the level of openness to international markets, the proportion of higher education enrollment, per capita GDP, and fixed asset investment. The data sources for these variables include the "China Statistical Yearbook" and provincial statistical yearbooks, among others. The panel data for the 30 provinces, municipalities, and regions will be analyzed. These control variables are intended to help manage the influence of other potential factors, ensuring a more precise assessment of the impact of the comprehensive green finance index on SBM efficiency.

The level of openness to international markets reflects the degree of economic interaction with the global market. The proportion of higher education enroll-

ment indicates the extent of higher education accessibility in the region. Per capita GDP provides information on the economic level, and fixed asset investment reflects the level of investment activity. Table 11 presents the names and relevant descriptions of the efficiency-level variables.

6.2. Model Construction and Empirical Analysis

6.2.1. Model Introduction and Construction

The Tobit model was first proposed by the economist Tobin in 1958, and has since been generalized to various structures such as panel data and semi-parameters. In 1976 Heckman proposed the simultaneous equation, which provided the theoretical basis for the estimation of the Tobit model. Since the efficiency value calculated by the SBM method is limited at 0 - 1, the estimation using general OLS and GMM methods will lead to large estimation variance, thus affecting the accuracy of the results. Therefore, the Tobit model is the best choice when the explained variables are limited. The general form of the Tobit model for a panel assuming a left truncation at 0 is:

$$y_{it}^{*} = \begin{cases} y_{it}^{*} = \beta^{\mathrm{T}} x_{it} + u_i + \varepsilon_{it}, & \text{if } y_{it}^{*} > 0 \\ 0, & \text{if } y_{it}^{*} \le 0 \end{cases} \tag{4}$$

In the above formula, y_{it}^{*} is the potential dependent variable, which can be observed when $y_{it}^{*} > 0$, and truncated at 0 when $y_{it}^{*} \le 0$; β^{T} is the parameter vector to be estimated; x_{it} is the argument vector; U is individual effect; The error term E is independent and follows a normal distribution with an expectation of 0, indicating the time. If u_i is not correlated with x_{it}, then the model is a random effect; Otherwise, it is a fixed effect. In this paper, a Tobit model using panel random effects is chosen because conditional maximum likelihood estimation cannot be performed in the fixed effects Tobit model due to the lack of sufficient statistics to account for individual heterogeneity. At the same time, introducing the dummy variables of panel units directly into the mixed Tobit regression model will also lead to inconsistencies in the fixed effect estimators.

Table 11. Definition table of efficiency level variables.

	Variable name	Variable definition	Symbol	Unit
Explained variable	SBM efficiency	Data envelopment method	SBM	-
Explanatory variable	Green Finance Composite Index	Entropy weight method	Green	-
Control variable	Level of opening up	Total import and export trade/GDP	C_1	-
	Proportion of talents in higher education	Number of college students/ Number of students enrolled	C_2	-
	Per capita GDP	Real GDP per capita, logarithm	C_3	-
	Investment in fixed assets	The actual value of investment in fixed assets, logarithm	C_4	-

The Tobit model of panel random effects is constructed to analyze the impact of green finance on the efficiency of the real economy, as follows:

$$\mathrm{SBM}_{i,t} = \alpha_0 + \gamma_i \mathrm{Green}_{i,t} + \sum_k \beta_k C_{k,i,t} + \varepsilon_{i,t} \quad (5)$$

Among them, the explained variable $\mathrm{SBM}_{i,t}$ is the SBM efficiency of the i province (municipality directly under the central government or autonomous region) in the t year, the explanatory variable $\mathrm{Green}_{i,t}$ is the green finance composite index of the i province (municipality directly under the central government or autonomous region) in the t year, and γ_i is its coefficient. If $\gamma_i > 0$ is significant, it indicates that the green finance composite index will promote the efficiency growth of the real economy. The coefficient is expected to be significantly positive. $C_{k,i,t}$ $(k = 1,2,3,\cdots)$ is each control variable, α_0 is the intercept term, $\varepsilon_{i,t}$ is the random error term.

6.2.2. Result Analysis

The empirical analysis results are shown in Table 12. From the coefficients of model (1) to (5), it can be observed that the green finance composite index has a negative impact on the efficiency of SBM. With the gradual introduction of control variables, the coefficient of the green finance composite index is stable at about −0.7, and has a significant negative impact on the efficiency of SBM. This indicates that green finance may face certain problems or challenges in improving the efficiency of the real economy. In addition, after taking into account control variables such as the level of opening to the outside world, the proportion

Table 12. Results of Tobit regression.

Variable	Green finance serves the efficiency of real economy				
	(1)	(2)	(3)	(4)	(5)
Green finance composite index	−0.04822211	−0.22642137	−0.73611667***	−0.70454343***	−0.70487507***
	0.24350121	0.24880496	0.25374008	0.25437389	0.25437347
Level of opening up		−0.32197***	−0.19313214*	−0.19199543*	−0.19004181*
		0.10884528	0.10670511	0.10774252	0.1079085
Per capita GDP			0.25961362***	0.32043386***	0.32296136***
			0.04383332	0.05546699	0.05593626
Investment in fixed assets				−0.05742701*	−0.05779133*
				0.0312937	0.03132473
Proportion of people in higher education					−0.00498559
					0.01374279
Number of provinces	30	30	30	30	30
Observed value	300	300	300	300	300

of higher education students, per capita GDP and fixed asset investment, these variables may play a moderating role in the relationship between the green finance composite index and SBM efficiency.

There is a paradox between the Tobit regression results and hypothesis H2. Combined with the background of China's early development of green finance, there are several possible practical reasons why green finance has a negative impact on the SBM efficiency of serving the real economy:

1) China's green finance is currently in the initial stage of adjustment. The government has introduced a series of green finance policies, but the implementation and enforcement of these policies takes time, so green finance has temporarily had a negative impact on the efficiency of the real economy. There are still a number of shortcomings in the regulatory framework, including the unclear division of regulators and responsibilities, which limits the effective implementation and supervision of regulatory measures. At the same time, the development and implementation of regulatory standards and guidelines are lagging, making it difficult to ensure that green finance development meets high standards and compliance requirements. However, our government is improving its work in the area of green finance. For example, the China Banking and Insurance Regulatory Commission has issued Green Finance Guidelines to guide the banking and insurance industries to actively develop green finance, provide support for economic activities with environmental and social benefits, promote pollution prevention and control, and achieve carbon peak and carbon neutrality goals. China is learning and practicing the experience of advanced green finance serving the real economy, and constantly adapting and adjusting policies according to the adjustment background of China's green finance and real economy industrial structure to realize the modernization of China's characteristic green finance industry.

2) Green finance faces a series of implementation and operational challenges in the process of serving the real economy. These include immature technologies and methods in green project assessment, risk management and supervision, which may lead to miscalculation and risk spillover. In addition, the development of the green finance market may also be affected by issues such as asymmetric information, insufficient understanding of market participants and investor preferences. These factors may lead to an imbalance between the supply and demand of green financial products, deviating from the demand of the real economy, and negatively affecting the efficiency of the real economy. Finally, some environmentally friendly projects may take longer to pay off, subject to factors such as market conditions, policy changes and technological advances. This could dampen the willingness of financial institutions and entities to invest in green finance projects, negatively impacting SBM efficiency. Therefore, it is necessary to comprehensively consider factors such as technology maturity, market operation and investment return to meet the challenges of green finance in serving the real economy.

7. Conclusions and Suggestions

7.1. Main Conclusions

7.1.1. Scale Level

1) Green finance has a significant positive impact on the scale of the real economy. The robustness of the benchmark regression results is proved by eliminating important provinces, increasing control variables and shortening the sample interval. The possible reason is that green finance provides specialized financial support and financing channels to promote the development of green industries and environmentally friendly projects. This has provided a financial guarantee for the real economy to expand its scale and develop innovatively.

2) The urbanization rate has a significant positive impact on the scale of the real economy. The improvement of urbanization is accompanied by the improvement of resource allocation efficiency, the upgrading of industrial structure and the promotion of innovative technology.

3) The opening rate has a significant positive impact on the scale of the real economy. Studies have shown a positive correlation between more open trade policies and higher economic growth rates. China has become the world's largest commodity trading country and foreign direct investment inflow country, while the scale of the real economy is also expanding.

4) The relationship between the government intervention rate and the size of the real economy is not significant, which is consistent with the results of previous studies. Possible reasons include the limited effectiveness of government intervention and the important role that market mechanisms play in resource allocation and economic growth. Therefore, the government intervention rate has less impact on the size of the real economy.

5) The level of industrial structure has a positive impact on the size of the real economy, and the possible reasons include technological progress and innovation, industrial diversification and upgrading, and optimal allocation of human resources.

6) Green finance in financially developed regions has a greater impact on the real economy, indicating that the government, financial institutions and society have made significant contributions to sustainable development. However, the comprehensive index of the less developed areas is low and has no significant impact on the scale of the real economy, which indicates that they face greater development challenges and obstacles.

7.1.2. Efficiency Level

1) The SBM efficiency value of green financial services to the real economy in 30 provinces (municipalities and districts) in China showed a gradual growth trend from 2011 to 2020. Although there are fluctuations, the overall point is that the output efficiency of our country has improved. Especially between 2014 and 2018, SBM efficiency increased significantly.

2) The SBM efficiency value of green financial services for the real economy in 30 provinces (municipalities and districts) in China is lower than 0.8 from 2011

to 2020 and is in the stage of inefficient or ineffective. Possible reasons include bottlenecks and challenges in the scale transformation and structural adjustment of the real economy, the constraints of the COVID-19 pandemic on real economic activities, the challenge of balancing environmental protection, the insufficient supply of green financial products and services, and the relatively lagging construction of green financial standards and indicator systems.

3) The efficiency decline of Guangdong Province may be due to the incoordination between economic development and a green finance, the low efficiency of the three northeastern provinces may be due to the lagging economy, relatively unitary economic structure and environmental problems, while the efficiency improvement of the southeast coastal areas benefits from the developed economic foundation and active green finance development policies.

4) The provinces with a positive growth rate in the efficiency of green finance serving the real economy are mainly distributed in the southern region of China, while the provinces with a negative growth rate are mainly distributed in the northern region of China. The southern region is more active in green finance policy support and implementation, committed to promoting sustainable development and green economy, and the industrial structure is more inclined to green physical industries and services, such as clean energy, environmental protection, renewable resources and other fields. Some provinces, such as Jiangsu, Zhejiang, Fujian, Sichuan and Guizhou, have promoted the coordinated development of green finance and the real economy by formulating green finance development plans and policies.

5) The green finance composite index has a negative impact on the SBM efficiency serving the real economy. This is because China's green finance is in the initial adjustment stage, policy implementation and implementation take time, the regulatory framework is imperfect, there is immature technology and methods, information asymmetry, market participants lack understanding and investor preferences and other issues affect the development of green finance market, resulting in supply and demand imbalance, "out of real to virtual". In addition, the long payback cycle of environmentally friendly projects and the impact of market conditions, policy changes and technological advances have weakened the willingness of financial institutions and entities to invest in green finance projects.

7.2. Policy Recommendations

7.2.1. Scale Level

1) Actively change the mode of service and optimize the economic structure. The financial industry needs to change from a quantitative expansion to a quality-first, efficiency-oriented service mode to meet the needs of the real economy. This includes intensive development, customer demand-oriented, emphasis on service to create value, strengthening the optimization of direct and indirect financing, with a special focus on the financing management system of small and medium-sized financial institutions.

2) Strengthen the focus on the main business. The financial industry needs to pay more attention to the core services, improve the quality of services, reduce the cost of financial services, and avoid the situation of only charging and no service. At the same time, it is necessary to optimize the intermediate link, shorten the capital chain, and reduce the financing cost, in order to achieve the unity of economic and social value of financial services.

3) Strengthen service innovation. Innovation is key for financial services to the real economy, but innovation must be legal and compliant to prevent financial risks. Financial institutions should innovate around the diversified needs of the real economy, while strengthening standardized management and addressing issues such as internal control, asset quality, service level and competitiveness, so as to provide effective protection.

4) Promote green finance. Financial institutions should actively build a green financial system and provide financial services across the industry chain to support the development of green industries and environmental protection projects. This includes industry chain finance, differentiated financial products and services to meet the needs of different enterprises, especially rural revitalization and important industrial clusters.

5) Strengthen financial services in weak areas. Small and medium-sized enterprises are still a weak link in the financial market. Financial institutions should build a reasonable credit management system and strengthen financial services for small and medium-sized enterprises and poverty alleviation, so as to achieve the common development of urban and rural financial systems and improve the efficiency of resource allocation and the level of industrial structure.

7.2.2. Efficiency Level

First, optimize resource utilization and environmental management. The government needs to strengthen the treatment and management of wastewater and solid waste, adopt more environmentally friendly production technologies and processes, reduce the amount of waste generation and waste discharge intensity, and promote the development of the circular economy. We will reduce the intensity of carbon dioxide emissions, replace traditional energy sources with clean energy, improve energy efficiency, promote energy-saving and emission-reduction technologies, and promote the development of a low-carbon economy. Provinces with a single industrial structure should learn from the experience of provinces with diversified industrial structures and innovation and upgrading, starting from pilot areas and gradually expanding to the whole province.

Second, strengthen financial support and risk management. Financial institutions should increase financing support for green industries and environmental protection projects, provide innovative green financial products and services, encourage investors to participate in the green financial market, and promote capital flow to green sectors. At the same time, risk management should be strengthened to ensure the sustainability and stability of green finance projects to reduce operating costs and improve the efficiency of financial services to the

real economy.

Third, formulate green finance policies. Establish a sound green finance policy and standard system, provide guidance and support for the development of green finance, and ensure the regulation and transparency of the green finance market. In addition, governments at all levels should promote the sharing of green finance policies and financial data, improve information transparency, provide financial institutions and investors with accurate and comprehensive green finance information, and increase the understanding and participation of market participants.

Conflicts of Interest

The authors declare no conflicts of interest.

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