Evaluation and Research on the Coupling Coordination Degree of Green Finance and Low Carbon Economy under the "Double Carbon" Strategy

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Abstract

Based on panel data from 20 provinces and cities across the country from 2018 to 2022, this paper calculates the coupling and co scheduling of low-carbon economy and green finance using entropy method and coupling coordination model, and analyzes the results. The results show that: (1) In the past five years, the development level of green finance and low-carbon economy in most cities has been steadily improving. (2) The development of green finance presents regional characteristics. The development level of green finance in cities in the eastern region is generally good, followed by cities in the central region, and the development situation of green finance in cities in the western region is poor. The distribution of low-carbon economy at the provincial level is extremely uneven, resulting in polarization. (3) The degree of coupling and coordination between green finance and low-carbon economy in various provinces and cities is evenly distributed, but the degree of coupling and coordination in the western region is polarized. Factors affecting the coupling level include government policies, economic development levels, and urban characteristics.

Keywords

Green finance; Low carbon economy; Coupling coordination.

1. Introduction

In recent years, the world average temperature has continued to rise, and China is also facing a severe warming problem. In order to cope with the severe consequences of climate change, China has always been at the forefront. The Party Central Committee has issued relevant laws and regulations to limit greenhouse gas emissions, and has committed to achieving the carbon peak by 2030 and carbon neutral targets by 2060. The Party Central Committee has placed green development in a strategic position, indicating that in the new era of national economic development, the quality of economic development is more important than the speed of development.

The development of a low-carbon economy requires financial support, and green finance emerged as the times require. Green finance is the foundation for the development of low-carbon economy, and also the key to the rapid development of low-carbon economy. Its essence is to solve the problem of global warming through optimal financial engineering, which can effectively promote the low-carbon transformation of the economy. There are differences in economic foundation, cultural development, and industrial structure among provinces and cities in China, so the development of green finance also presents regional imbalances. In order to provide valuable suggestions for the coordinated development of low-carbon economy and green finance in China, this article conducts a study on the relationship between low-carbon economy and green finance in 20 provinces and cities across the country, calculates the coupling and coordination between the two, explores the characteristic distribution of each

region and the influencing factors of the degree of coordination, and proposes policy recommendations such as improving regulations and systems, adjusting regional heterogeneity, playing a market role, and paying attention to research and development investment.

2. Literature Review

In the study on the relationship between green finance and low-carbon economy, Guo Xiyu (2022) established a spatial simultaneous equation model based on panel data from 30 provincial administrative regions in China. The study showed that there is a two-way promoting effect between green finance and low-carbon economy, and the development of green finance can effectively promote the transformation of low-carbon economy in the region, and vice versa. Li Wangqin (2021) calculated the development index of green finance and low-carbon economy using entropy method based on the PVAR model and data from 30 provinces (cities) from 2007 to 2017. The research shows that the development level of green finance and low-carbon economy in the eastern region is higher than that in other regions of the country. In the eastern and central regions of China, there has been a benign mutual promotion relationship, while in the western region, there has not been an obvious dynamic correlation. Research by Zhang Heng, Zhang Xiaoheng, and Song Yufei (2022) shows that green finance has a significant positive correlation with low-carbon development, and there is a spatial spillover effect in green finance. Moreover, green finance has the best driving effect on economic growth, followed by environmental protection, and is not significant for industrial transformation.

Most scholars in the above literature use panel data to establish models, pulse effect analysis, spatial econometric models, and regression models to study the relationship between green finance and low-carbon economy. "Green finance and low-carbon economy are important means and ways to achieve both sides of the" dual carbon "process, and they need to be fully utilized and promoted in a coordinated manner.". Based on this, this article mainly constructs a coupling coordination model to explore the coordinated development level of green economy and low-carbon economy, explore the characteristic distribution of coordinated development of green economy and low-carbon economy in various regions, and analyze the factors affecting the coordination degree of green finance and low-carbon economy.

3. Index System Construction and Research Methods

3.1. Data source and indicator system

This article selects representative provinces and cities from various provinces and cities across the country for research. Through the websites of authoritative institutions such as the Bureau of Statistics, the Ministry of Science and Technology, the People's Bank of China, and various authoritative statistical yearbooks, including the national and provincial statistical yearbooks, environmental status bulletins, and some professional statistical yearbooks, panel data from 20 provinces and cities across the country from 2018 to 2022 were collected.

The selection of evaluation indicators should fully reflect the green finance and low-carbon economy system. Referring to existing literature research, research by Zhang Youguo (2020) and Guo Xiyu (2022), as well as various documents related to the development and construction of green finance and low-carbon economy issued by China, the green finance evaluation indicator system and low-carbon economy evaluation indicator system should be constructed from seven and five dimensions, as shown in Table 1.

Table 1. Green Finance and Low Carbon Economy Evaluation Indicator System

Primary indicator	Secondary indicators	Indicator Meaning	Indicator Properties
Green	Green investment (B1)	Investment in environmental pollution	+

finance (A1)		control in GDP	
	Green-credit policy (B2)	Credit proportion of environmental protection projects	+
	Green insurance (B3)	Promotion degree of environmental pollution liability insurance	+
	Green bonds (B4)	Development degree of green bonds	+
	Government support (B5)	Proportion of fiscal spending on environmental protection	+
	Green fund (B6)	Green fund proportion	+
	Green rights and interests (B7)	Depth of green rights and interests development	+
Low carbon economy (A2)	Low carbon output (B8)	Carbon productivity	+
		Energy processing and conversion efficiency	+
	Low carbon consumption (B9)	Household consumption of carbon emissions	-
		The government consumes its carbon emissions	-
	Low carbon resources (B10)	The proportion of zero carbon energy	+
		Energy and carbon emission coefficient	-
		Carbon sink density	+
	Low carbon policy (B11)	Low-carbon economic development planning	+
		We will establish a carbon emission monitoring, statistics and regulatory system	+
		Public knowledge popularization of low-carbon economy	+
		Implementation rate of environmental protection and energy saving standards	+
		Carbon tax policy	+
	Low carbon environment (B12)	Waste carbon emission intensity	-
		Industrial three-way waste treatment index	+

3.2. Research methods

3.2.1. Entropy method

This article uses the entropy weight method to determine the weight of each index. Before the formal start, it is necessary to standardize the data. Inconsistent indicator dimensions can lead to large and small data for different indicators.

Indicator selection: If there are m years, a province, and b indicators, then X_{tij} represents the jth indicator of province i in year t.

(1) Standardization of indicators.

Positive indicators: $X^{tij}{}' = \frac{X_{tij} - X_{min}}{X_{max} - X_{min}}$, Negative indicator: $X^{tij}{}' = \frac{X_{max} - X_{tij}}{X_{max} - X_{min}}$.

(2) Calculate the proportion of item j index in the ith province in year t, then $P_{tij} = \frac{X^{tij,}}{\sum_{t=0}^{m} \sum_{i=0}^{a} X^{tij}{}'}$.

(3) Calculate the entropy value of index j, then $e_j = -k \sum_{t=0}^{m} \sum_{t=0}^{a} P_{ij} \ln(P_{tij})$, $(k > 0, k = \ln(ma))$.

(4) Calculate the information utility value of the j index, then $g_j = 1 - e_j$.

(5) Calculate the weight of each indicator, then $w_j = \frac{g_j}{\sum g_j}$.

(6) Calculate the comprehensive evaluation value of each province, then $U_{ti} = \sum w_j \times X_{tij'}$.

3.2.2. Coupled coordination model

Coupling refers to the close coordination and interaction between two or more systems. This article uses the coupling coordination degree function to establish a coupling coordination degree model between two systems, with the formula:

$$C = 2 \times \left\{ \frac{A1+A2}{(A1+A2)^2} \right\}^{1/2} \qquad (1)$$

Where, C is the coupling degree, with a value range of [0,1]. A_1 and A_2 are the comprehensive evaluation values of green finance and low-carbon economy, respectively. The larger the value of C is, the greater the degree of interaction between green finance and low-carbon economy.

The coupling model can be used to study the degree of interaction between systems, but it cannot reflect whether subsystems restrict or promote each other at a low or high level. Therefore, the coupling coordination function is introduced to reflect the phased nature of the coordinated development level of green finance and low-carbon economy:

$$D = \sqrt{C \times T} \qquad (2)$$
$$T = \alpha A1 + \beta A2 \qquad (3)$$

The coupling coordination degree is between 0-1, with the maximum value indicating high-quality coordination and the minimum value indicating that there is no coordination. The evaluation criteria are shown in Table 2.

Table 2. Evaluation Criteria

Coupling coordination	Level	Degree	Coupling coordination	Level	Degree
(0.0, 0.1)	1	Extreme disorder	[0.5, 0.6)	6	Forced coordination
[0.1, 0.2)	2	major maladjustment	[0.6, 0.7)	7	Primary coordination
[0.2, 0.3)	3	Moderate dysregulation	[0.7, 0.8)	8	Intermediate coordination
[0.3, 0.4)	4	Mild dysregulation	[0.8, 0.9)	9	Good coordination
[0.4, 0.5)	5	On the verge of dysregulation	[0.9, 1.0)	10	Quality coordination

4. Measurement Results and Analysis

4.1. Subsystem Analysis

According to the index of green finance and low-carbon economy, the development level of green finance and low-carbon economy in most cities is steadily improving during the five years from 2018 to 2022.

In terms of green finance, the first two cities with the best development by 2022 are Zhejiang Province and Shanghai, both with green finance indexes above 0.9, followed by Beijing, with a green finance index of 0.836808, while the last two cities with the worst development are Shaanxi Province and Guizhou Province. Among them, the green finance indexes of Guizhou Province and Shaanxi Province are only 0.158 and 0.142, and the development of green finance in this city is lagging behind. From the perspective of the green finance index of each province in the past five years, there has been a slight improvement in the development of green finance in some provinces and cities, with Zhejiang Province, Shanghai City, and Shandong Province having the highest increase, with an increase of 0.2. In cities with poor green finance development, there has been less improvement in green finance development in the past five years. The development of green finance presents regional characteristics. The development

level of green finance in cities in the eastern region is generally good, followed by cities in the central region, and the development situation of green finance in cities in the western region is poor.

In terms of low-carbon economy, the top five cities with the best development by 2022 are Beijing, Zhejiang Province, Shanghai City, Guangdong Province, and Jiangsu Province, with a low-carbon economy development index of above 0.9. However, Shaanxi Province and Guizhou Province are only 0.17 and 0.16 poor in terms of low-carbon economic development. The distribution of low-carbon economy at the provincial level is extremely uneven, resulting in polarization. From the perspective of low carbon economic indicators in the past five years, some regions have shown a downward trend, with most cities experiencing a small increase, with Shandong Province and Hubei Province having the highest increase, both with a 0.2% increase. The development of low-carbon economy is closely related to local GDP and carbon emissions. In the face of the current development situation of low-carbon economy, in order to improve the development level of urban low-carbon economy, provinces and cities should focus on improving urban carbon productivity in the future, producing more GDP per unit of carbon dioxide emitted. At the same time, promote green transformation of enterprises, improve industrial technology, production efficiency, etc. Although the current development of low-carbon economy in some cities is not ideal, it is closely related to the geographical location and industrial structure of the city, and there is still much room for improvement in various cities in the future.

4.2. Coupling coordination analysis

From Table 3, it can be seen that the coupling and coordination degree of green finance and low-carbon economy in various provinces and cities is evenly distributed, with five high-quality coordination, seven good coordination, six primary coordination, and two moderate imbalance. The value distribution of primary coordination provinces and cities is uniform, but there are no intermediate coordination provinces and cities. From Figure 1, it can be seen that from 2018 to 2022, the coupling and coordination degree of green finance and low-carbon economy in various provinces and cities has generally increased. From 2018 to 2022, the coupling and coordination degree of green finance and low-carbon economy in Zhejiang Province increased year by year, ranking first among 20 provinces and cities until 2022, while the coupling and coordination degree of Jiangsu Province, Hunan Province, and Jiangxi Province in 2022 decreased by 0.02 compared to 2018.

From Figure 1, it can be found that the coupling coordination degree in the western region presents a polarization, with Chongqing and Sichuan provinces in a coordinated state, while the development of green finance and low-carbon economy in Guizhou and Shaanxi provinces is in a moderate imbalance. On the whole, however, the coupling and coordination degree in the western region is improving, with the coupling and coordination degree in Shaanxi Province increasing by nearly 0.2 in the past five years. The overall coupling and coordination of green finance and low-carbon economy in the eastern region is the best among the eastern, western, and central regions. The overall coupling between green finance and low-carbon economy in the central region is moderate, and Hubei Province is expected to enter an excellent coordination level in the future.

Government policies can promote a rising level of coupling. In recent years, Zhejiang Province has continuously introduced policies to assist the development of green finance and low-carbon economy, accelerated the establishment and improvement of a green and low-carbon circular development economic system, issued the 14th Five Year Plan for the development of the financial industry in Zhejiang Province, and formulated the "Implementation Plan for Green Finance to Support Carbon Peak and Carbon Neutralization". At the same time, under the guidance of regulatory guidance, the management system of green finance organizations in

Zhejiang Province has been continuously improved. Therefore, from 2018 to 2022, the development of green finance and low-carbon economy in Zhejiang Province has undergone significant changes.

The level of economic development affects the coupling level. There is an interaction between green finance and the development of low-carbon economy. The development of green finance can help cities reduce carbon emissions, while in more economically developed regions, green finance has a stronger carbon reduction effect. The eastern region has a better level of economic development, larger industrial scale, more advanced industrial technology, and more mature and reasonable industrial structure construction; The development of the central and western regions is relatively lagging, and the development of green finance and low-carbon economy is relatively slow. Therefore, the coupling and coordination level of green finance and low-carbon economy in the eastern region is generally good, while the level in the central and western regions is relatively backward. However, green finance can provide enterprises with green transformation costs, which in fact contributes to regional economic development. The central and western regions can promote the development of low-carbon economy through green finance.

Urban characteristics affect the coupling level. Guizhou is rich in tourism resources, and the tertiary industry is the leading industry in the region. Therefore, the demand for green capital and carbon emission reduction is weak. Chongqing is a typical old industrial city, and the demand for green finance and carbon emission reduction will be stronger than that of Guizhou Province. Therefore, the coupling and coordination between green finance and low-carbon economy is better. In regions with large agricultural development scales, as agricultural insurance is the main component of green insurance, its green insurance indicators are higher than other regions, which is also conducive to promoting the coupling level.
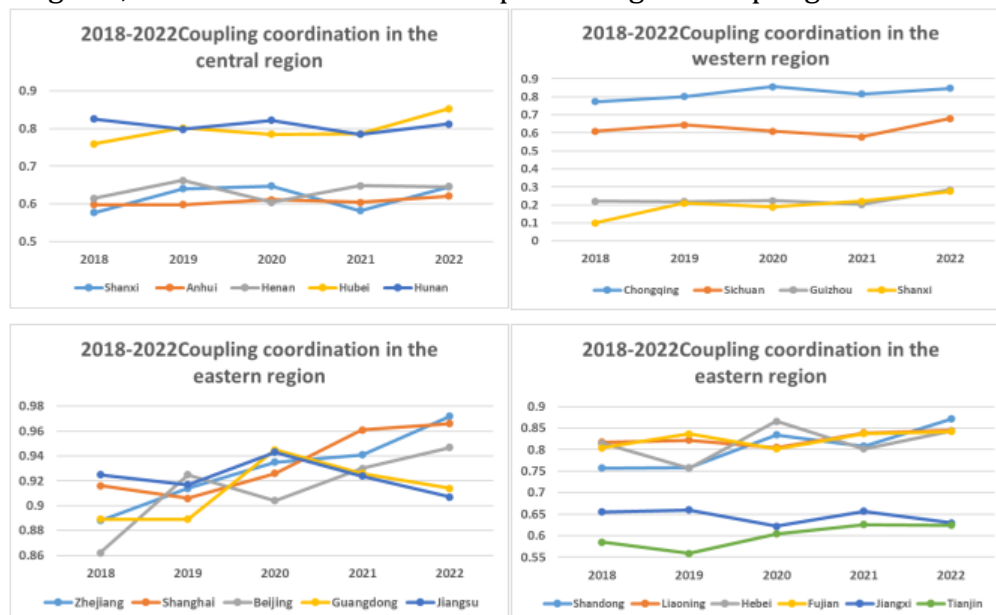

Figure 1. Changes in the coupling and co scheduling of green finance and low-carbon economy in various provinces and cities from 2018 to 2022

Table 3. Coordination of Green Finance and Low Carbon Economy in 20 Provinces and Cities from 2018 to 2022

Region	2018	2019	2020	2021	2022	Mean
Zhejiang	0.888	0.914	0.935	0.941	0.972	0.93
Shanghai	0.916	0.906	0.926	0.961	0.966	0.935
Beijing	0.862	0.925	0.904	0.93	0.947	0.9136

Guangdong	0.889	0.889	0.945	0.926	0.914	0.9126
Jiangsu	0.925	0.917	0.943	0.924	0.907	0.9232
Shandong	0.757	0.758	0.834	0.808	0.871	0.8056
Hubei	0.759	0.802	0.785	0.786	0.853	0.797
Chongqing	0.773	0.801	0.857	0.815	0.848	0.8188
Liaoning	0.817	0.822	0.805	0.839	0.844	0.8254
Hebei	0.815	0.757	0.866	0.802	0.843	0.8166
Fujian	0.804	0.836	0.802	0.837	0.842	0.8242
Hunan	0.825	0.798	0.822	0.785	0.812	0.8084
Sichuan	0.61	0.645	0.609	0.577	0.68	0.6242
Shanxi	0.577	0.64	0.647	0.582	0.646	0.6184
Henan	0.615	0.662	0.604	0.648	0.646	0.635
Jiangxi	0.655	0.66	0.622	0.657	0.63	0.6448
Tianjin	0.585	0.559	0.604	0.626	0.624	0.5996
Anhui	0.598	0.598	0.611	0.604	0.621	0.6064
Guizhou	0.221	0.219	0.225	0.204	0.284	0.2306
Shaanxi	0.1	0.211	0.19	0.221	0.275	0.1994

5. Conclusions and Suggestions

5.1. Conclusion

This paper selects panel data from 20 provinces and cities in China from 2018 to 2022 as research samples, and measures the degree of coordination between the two through entropy method and coupling coordination model. The following conclusions can be drawn. (1) Development level. In the past five years, the development level of green finance and low-carbon economy in most cities has been steadily improving. The development of green finance presents regional characteristics. The development level of green finance in cities in the eastern region is generally good, followed by cities in the central region, and the development situation of green finance in cities in the western region is poor. The distribution of low-carbon economy at the provincial level is extremely uneven, resulting in polarization. The development of a low-carbon economy is closely related to local GDP and carbon emissions. (2) Coupling co scheduling. The coupling and coordination degree of green finance and low-carbon economy in various provinces and cities is evenly distributed, but it is found that the coupling and coordination degree in the western region presents a polarization. Factors that affect coordination include government policies, economic development, and urban characteristics. For example, Zhejiang Province has continuously introduced relevant policies to improve the green financial system, and the coupling and coordination degree of Zhejiang Province has undergone significant changes in the past five years.

5.2. Suggestions

(1) Improve rules and regulations. Research data show that the development level of green finance has improved in recent years, and it has also significantly promoted the low-carbon economy. However, the current regulation is not perfect, and it is necessary to promote the development of green finance through legislation. Improving relevant rules and regulations can reduce the occurrence of green washing and bleaching in the market, and can also promote the participation of all sectors of society in a low-carbon lifestyle.

(2) Regulate regional heterogeneity. In this study, it can be seen that the impact of green finance on the development of low-carbon economy in the eastern, central, and western regions is different, with the most obvious being the eastern region, while the central and western regions have a weaker impact. Based on this, the central government can establish a complementary

mechanism to strengthen the technology transfer from the eastern region to the central and western regions, drive the overall development of low-carbon technology, and promote coordinated regional development.

(3) Play a market role. The development of green finance cannot only rely on the driving force of the government, but also needs to handle the relationship between the government and the market, fully tap market potential, guide enterprises to issue or purchase green bonds or other financial products, fully play the role of the market, and further expand green finance.

(4) Focus on research and development investment. In order to maximize the role of green finance, it is necessary to increase investment in technology research and development, focus on cultivating innovative talents, and focus on introducing talents. At the same time, increase efforts to support new technology companies with green technology, and accelerate the development of regional low-carbon economy.

Acknowledgments

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