

An Empirical Study on Green Finance and High-quality Economic Development in Yangtze River Delta Region

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Abstract: As a "lubricant" and "booster" for green development, green finance plays an important role in promoting high-quality economic development. As one of the most active regions in economic development, the Yangtze River Delta region leads the country in the development of green finance. This paper takes the Yangtze River Delta region as the research object, uses the relevant data of green finance and high-quality economic development from 2010 to 2021, uses the coupled coordination model to analyze the coordinated development of green finance and high-quality economic development in the Yangtze River Delta region, and uses the grey correlation model to analyze the correlation degree of the two systems. It provides an empirical basis for the formulation of green finance policies in the Yangtze River Delta.

Keywords: Green finance, High-quality economic development, Yangtze River delta region.

1. Introduction

According to the report of the 20th National Congress of the CPC, promoting green and low-carbon economic and social development is a key link to achieve high-quality development. In order to adhere to the strategic positioning of ecological priority and green development, the Yangtze River Delta region has accelerated the transformation of ecological advantages into economic development advantages, proposed to focus on the development of green finance and other industries, cultivate new green driving forces, and set a new benchmark for the transformation of ecological advantages.

Salazar(1998) first proposed the concept of "green finance," emphasizing the concept that finance supports environmental protection [1]. Cowan(1998) further divided green financial products into green bonds, green funds and environmental liability insurance [2]. As a financial tool serving the construction of ecological environment, green finance can guide funds to the development of green industries such as environmental protection, energy conservation, clean energy and transportation through the functions of resource allocation, liquidity supply and risk management, stimulate innovation and promote high-quality economic development. Therefore, later scholars introduced the coupling coordination model to study green finance and high-quality economic development [3] [4]. Liu et al. (2022) found that the degree of coordination between green finance and high-quality economic development in China was low, but the positive interaction between the two was gradually strengthened [5]. Yu (2021) believed that green finance has an obvious positive role in promoting high-quality economic development, but the effect has a threshold effect, and only when the green finance is in a consistent pace can the promotion effect be realized [6]. Li et al.(2022) found that green finance only has a short-term promotion effect on high-quality economic development, while the promotion effect of high-quality economic development on green finance lags

behind [7].

However, at present, the overall development level of China's green financial system is low and in a lagging state of development. Pan (2017) pointed out that China's green finance started late, with insufficient capital supply, single products and services, insufficient endogenous power, and low overall development level and efficiency [8]. In the process of promoting high-quality economic development, green finance has encountered many institutional and technical obstacles, and its limitations highlight the necessity of coordination between green finance and high-quality economic development. At the same time, the Yangtze River Delta is one of the most active regions in China's economic development and financial innovation. China has elevated the integration strategy of Yangtze River Delta to a national strategy, and at the same time, it has put forward higher requirements for the integration of green finance.

To sum up, green finance and high-quality economic development interact with each other. However, most of the existing studies focus on the whole country, and there are few regional studies. In view of this, this paper takes the Yangtze River Delta region where the integration strategy is implemented as the research object, uses the relevant data of green finance development and high-quality economic development from 2010 to 2021, analyzes the coupling and coordinated development degree and correlation degree of the region, and deeply analyzes its internal reasons and influencing factors. This paper provides empirical basis for the formulation of green finance related policies in the Yangtze River Delta region, and promotes the integrated development of green finance and high-quality economic development in the Yangtze River Delta region.

2. Literature Review

Green finance is generally regarded as an important market means for financial institutions to support green

environmental protection and guide project financing. Green finance not only promotes environmental protection through financial means, but also, more importantly, helps the development of green industry by guiding financing, so that the industry can shift from high pollution and high energy consumption to low consumption and high efficiency mode, so as to improve the efficiency of resource utilization and achieve high-quality economic development.

In terms of the role of green finance in promoting economic development, Ou et al. (2023) proved the positive relationship between green finance and economic development through the study of China's provincial panel data, and believed that green finance policies could improve the scale and quality of economic growth. Starting from the aspects of sustainable operation and green innovation [9]. Wang et al. (2023) pointed out the important role of green system in mediating the relationship between economic development and environmental dilemma, and showed readers the development status of green finance in China through a series of model analysis, showing that the overall level is low and the synergy level is constantly improving [10]. Zhou et al. (2023) believed that green finance can guide the green transformation of real enterprises and prevent enterprises from deviating from the expected purpose, so as to achieve healthy economic development. As for the problems existing in the development of green finance [11]. Yu (2023) pointed out that the main problems in the development of green finance at present are high risks, low service penetration rate and degree of openness, and stagnant economic chain [12]. Lian(2023) also summarized from the study of green finance in the Yellow River Basin that the relevant balance mechanism of green finance is not sound, and it is difficult to increase the value of green financial assets and the financing path is single [13]. Ma (2023) pointed out that in the process of green finance development, the supporting mechanism is not sound, the professional talent reserve is insufficient, and the infrastructure construction is not perfect. As for the future development suggestions of green finance to promote economic development [14]. Wu et al. (2023) pointed out that enterprises should also improve their own green finance development system and give full play to the advantages of

regional green finance [15]. Ou et al. (2023) clearly proposed that innovation capital plays an intermediary role in the transmission mechanism of "green finance and economic growth" and should guide the green transformation of the financial sector and serve the real economy [9]. From the perspective of fintech, Ma (2023) confirmed that fintech has a significant positive effect on the development of green finance through the analysis of provincial data in China in the past five years [14]. Chen et al. (2023) pointed out that the key to achieving green and low-carbon transformation lies in green financial innovation [16]. Therefore, we should actively develop fintech, strive to promote financial reform and innovation, and win more opportunities for the development of green finance.

To sum up, most of the existing research focuses on the whole country, and there is a lack of research on the coordinated development between green finance and high-quality economic development. Therefore, this paper takes the Yangtze River Delta region, which is in a leading position in the development of green finance in China, as an example to study the coordinated development between green finance and high-quality economic development in the region, measure the correlation between various indicators, and deeply analyze its influencing factors, so as to provide empirical basis for the formulation of policies related to green finance development in the Yangtze River Delta region.

3. Index Construction and Research Methods

3.1. Index construction and data sources

3.1.1. Index construction

Referring to previous studies, considering the availability of data and other issues, combined with the actual situation of the Yangtze River Delta region and the availability of data, this paper selects four first-level indicators respectively in terms of green finance and high-quality economic development evaluation indicators. Specific second-level indicators and indicator attributes are shown in Table 1.

Table 1. Index system construction

System	First-order index	Secondary index	Indicator symbol	Index attribute	Index weight
Green finance	Green bond	The proportion of green bonds issued	X1	+	16.236
	Green insurance	The proportion of agricultural insurance scale	X2	+	17.781
	Green investment	Proportion of investment in industrial pollution control in GDP	X3	+	34.928
	Green credit	The proportion of high energy consumption industry interest expenditure	X4	-	31.055
High-quality economic development	Economic growth	The proportion of tertiary industry GDP	Y1	+	11.27
		GDP growth rate	Y2	+	4.953
	Ecological civilization	Forest coverage	Y3	+	15.536
		The proportion of days with air quality at or better than Grade II	Y4	+	12.875
	Social development	Ratio of urban and rural disposable income	Y5	-	10.272
		Urban registered unemployment rate	Y6	-	4.489
		Consumer price index	Y7	+	12.262
	Scientific and technological progress	Intensity of R&D expenditure	Y8	+	6.361
		Patents granted per 10,000 people	Y9	+	12.948
		R&D employees per 10,000 people	Y10	+	9.035

3.1.2. Data sources

The data in this paper mainly come from the corresponding years of statistics bureau, statistical yearbook, China Industrial Statistics Yearbook, China Insurance Yearbook, China Environmental Statistics Yearbook, Wind Database, etc., of provinces and cities in the Yangtze River Delta region. The data of some indicators and some years are missing, and this paper uses the mean value method to fill in.

3.2. Research methods

3.2.1. Entropy weight method

In order to ensure the objectivity of weight calculation results, entropy weight method is used in this paper to assign values. The specific calculation formula is as follows:

$$\text{Positive indicators: } Y_{ij} = \frac{x_{ij} - \min\{x_{ij}\}}{\max\{x_{ij}\} - \min\{x_{ij}\}} \quad (1)$$

$$\text{Negative indicators: } Y_{ij} = \frac{\max\{x_{ij}\} - x_{ij}}{\max\{x_{ij}\} - \min\{x_{ij}\}} \quad (2)$$

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^n x_{ij}} \quad (i=1,2,\dots,m, j=1,2,\dots,n) \quad (3)$$

$$e_j = -\frac{1}{\ln m} \sum_{i=1}^m P_{ij} \ln p_{ij}, j=1,2,\dots,n. \quad (4)$$

$$g_j = 1 - e_j, j=1,2,\dots,n. \quad (5)$$

$$w_j = \frac{g_j}{\sum_{j=1}^n g_j}, j=1,2,\dots,n. \quad (6)$$

In the formula, X_{ij} refers to the value of index i in the j year, Y_{ij} refers to the standardization of the value of the i index in the j year, P_{ij} refers to the proportion of the i index in the j evaluation object, e_j refers to the entropy of the j index, g_j refers to the coefficient of variation of the j index, w_j refers to the proportion of the j index.

Since the indicators selected in this paper include positive indicators and negative indicators, they need to be preprocessed, and the standardized data is then solved by weight. The results are shown in Table 1.

After summing the weights obtained respectively and calculating their comprehensive scores, the final index of green finance and high-quality economic development in the Yangtze River Delta from 2010 to 2021 is shown in Table 2.

Table 2. Green finance development index and high-quality economic development index.

Year	Green Finance Development Index (%)	Index of high-quality economic development (%)
2010	0.21359	0.29079
2011	0.29341	0.31962
2012	0.29481	0.27837
2013	0.32714	0.39077
2014	0.37987	0.40265
2015	0.26373	0.46799
2016	0.35355	0.50885
2017	0.30242	0.49093
2018	0.36931	0.53423
2019	0.36597	0.59360
2020	0.40029	0.66236
2021	0.50723	0.70347

3.2.2. Coupling coordination degree model

This paper uses the coupled coordination degree model to study the coordination level of green finance and high-quality economic development in the Yangtze River Delta. The specific formula is as follows:

(1) coupling degree.

$$c = 2 * \left[\frac{u_1 u_2}{(u_1 + u_2)^2} \right]^{\frac{1}{2}} \quad (7)$$

Where, u_1 is the green finance development index, u_2 is the high quality economic development index, and c is the coupling degree.

By referring to the research achievements of existing scholars and combining with the actual situation of this paper, the coordinated development of green finance and high-quality economic development can be divided into the following four types according to the value of coupling degree, as shown in Table 3:

Table 3. Coupling types of green finance and high-quality economic development

Number of coupling degree	Coupling type	characteristic
$C \in [0,0.3]$	I.Near-coupling misalignment	The degree of correlation between the two systems is low
$C \in (0.3,0.5]$	II.Forced coupling coordination	The internal correlation between the two systems is gradually enhanced
$C \in (0.5,0.8]$	III.Primary coupling coordination	The two systems show benign coupling characteristics
$C \in (0.8,1.0]$	IV.Well-coupled coordination	In the period of high level coordination coupling, the correlation degree is higher

(2) Coupling coordination degree.

$$T = \alpha u_1 + \beta u_2 \quad (8)$$

$$D = \sqrt{CT} \quad (9)$$

Where, α, β denotes the relative importance of the two. In this paper, $\alpha = \beta = 0.5$ is taken as equal importance to both, and D denotes the degree of coupling coordination. For the convenience of comparison and analysis, this paper divides the coupling coordination degree into five levels by referring to previous studies, as shown in Table 4.

Table 4. Classification of coupling coordination degree

D-value interval	Degree of coordination	Coordination level	characteristic
(0.0,0.2]	Severe disorder	I	The economy is overdeveloped and green finance is seriously under-developed
(0.2,0.4]	Moderate disorder	II	Economic development is a big advantage, but the level of green finance is also gradually improving
(0.4,0.6]	Basic coordination	III	The economy began to slow down and the transition to green development began
(0.6,0.8]	Moderate coordination	IV	Green finance has developed well and the quality of economic development has improved
(0.8,1.0]	Highly coordinated	V	Green finance and economic development are mutually reinforcing

3.2.3. Grey correlation model

Grey correlation analysis can quantify the degree of correlation between various system factors, and the larger the calculated value, the higher the degree of correlation between the two. The specific calculation formula is as follows:

$$\zeta_i(q) = \frac{\min_i \min_q \{\Delta_i(q)\} + \rho \max_i \max_q \{\Delta_i(q)\}}{\Delta_i(q) + \rho \max_i \max_q \{\Delta_i(q)\}} \quad (10)$$

$$\Delta_i(k) = |Y_i^* - X_i^*|, i=1, \dots, n, k=1, \dots, m. \quad (11)$$

$$r_i = \sum_{k=1}^n w_k \zeta_i(k), i = 1, \dots, m, q = 1, \dots, n. \quad (12)$$

Where, $\zeta_i(q)$ is the gray correlation coefficient, r_i is gray weighted correlation degree, ρ value is 0.5.

4. Empirical Results and Analysis

4.1. Analysis of coupling coordination degree

In order to understand the coordinated development of green finance and high-quality economic development in the Yangtze River Delta region and its three provinces and one city, this paper establishes a coupling coordination degree model to analyze it. First, the coupling degree is measured. The specific data of the coupling degree are shown in Table 5.

Table 5. The degree of coupling between high-quality economic development and green finance

Year	Yangtze River Delta		Anhui Province		Jiangsu Province		Zhejiang Province		Shanghai City	
	C value	type	C value	type	C value	type	C value	type	C value	type
2010	0.199	I	0.230	I	0.258	I	0.214	I	0.199	I
2011	0.206	I	0.246	I	0.392	II	0.417	II	0.334	II
2012	0.389	II	0.334	II	0.819	IV	0.782	III	0.734	III
2013	0.779	III	0.719	III	0.891	IV	0.992	IV	0.979	IV
2014	0.874	IV	0.738	III	0.958	IV	0.901	IV	0.981	IV
2015	0.835	IV	0.784	III	0.926	IV	0.845	IV	0.824	IV
2016	0.956	IV	0.832	III	0.833	IV	0.961	IV	0.995	IV
2017	0.936	IV	0.765	III	0.930	IV	0.931	IV	0.851	IV
2018	0.935	IV	0.843	IV	0.989	IV	0.944	IV	0.944	IV
2019	0.970	IV	0.873	IV	0.993	IV	0.980	IV	0.930	IV
2020	0.994	IV	0.836	IV	0.988	IV	0.812	IV	0.828	IV
2021	0.969	IV	0.892	IV	0.999	IV	0.981	IV	0.978	IV

The coupling degree of the Yangtze River Delta and its three provinces and one city can be divided into four types according to the intensity of interaction between the green finance system and the high-quality economic development system. The coupling degree of the Yangtze River Delta and its three provinces and one city on the whole presents a gradual rising trend from 2010 to 2021. Specifically, in the whole Yangtze River Delta, the coupling imbalance was near

in 2010 and 2011, the coupling coordination was barely in 2012, the coupling coordination was primary in 2013, and the coordination was good in other years. For three provinces and one city, Jiangsu, Zhejiang and Shanghai were basically in good coupling and coordination condition in 2013 and after, and Anhui Province was in good coupling and coordination condition after 2018. It shows that in recent years, green finance in three provinces and one city is increasingly

interrelated with high-quality economic development, which cannot be separated from local governments' attention to green finance development. However, the coupling degree value of Anhui Province is lower than that of other provinces and cities in the Yangtze River Delta region on the whole, indicating the unbalanced development of green finance and high-quality economic development in the Yangtze River Delta region, which may be related to the geographical location, economic development level, human resources and

other aspects of each province and city.

After analyzing the coupling degree of the Yangtze River Delta and its three provinces and one city, in order to understand its coordinated development level, this paper analyzes the coupling coordination degree of the Yangtze River Delta and its three provinces and one city. The specific data of the coupling coordination degree are shown in Table 6.

Table 6. The degree of coupling coordination between high-quality economic development and green finance

Year	Yangtze River Delta		Anhui Province		Jiangsu Province		Zhejiang Province		Shanghai City	
	D value	grade	D value	grade	D value	grade	D value	grade	D value	grade
2010	0.426	III	0.293	II	0.276	II	0.304	II	0.315	II
2011	0.469	III	0.283	II	0.321	II	0.470	III	0.241	II
2012	0.222	II	0.322	II	0.685	IV	0.231	II	0.446	III
2013	0.349	II	0.241	II	0.551	III	0.544	III	0.609	IV
2014	0.517	III	0.554	III	0.303	II	0.634	IV	0.634	IV
2015	0.613	IV	0.449	III	0.422	III	0.530	III	0.542	III
2016	0.656	IV	0.595	III	0.729	IV	0.863	V	0.746	IV
2017	0.589	III	0.581	III	0.821	V	0.594	III	0.656	IV
2018	0.644	IV	0.586	III	0.496	III	0.635	IV	0.635	IV
2019	0.758	IV	0.609	IV	0.632	IV	0.742	IV	0.612	IV
2020	0.695	IV	0.673	IV	0.742	IV	0.712	IV	0.700	IV
2021	0.715	IV	0.743	IV	0.946	V	0.831	V	0.813	V

From Table 6, it can be seen that from 2010 to 2021, the Yangtze River Delta region has been upgraded from basic coordination to high coordination; among the three provinces and one city, Jiangsu, Zhejiang and Shanghai have been upgraded from moderate discoordination to high coordination; Anhui has been upgraded from moderate discoordination to moderate coordination. It can be seen that the coordinated development of green finance and high-quality economic development in the Yangtze River Delta and its three provinces and one city in recent years is getting better and better, which is related to the Yangtze River Delta's increasing attention to the implementation and implementation of green finance related policies in recent years. In 2021, Jiangsu, Zhejiang and Shanghai will all achieve a high degree of coordination, with green finance and economic development mutually reinforcing. In the same year, Anhui was in moderate coordination, which again showed the unbalanced development of green finance in the Yangtze River Delta region. As Anhui province lags behind other provinces and

cities in the Yangtze River Delta in terms of human resources and institutional innovation, its green finance development level is also relatively backward. On the whole, the coordinated development level of green finance and high-quality economic development in the Yangtze River Delta and its three provinces and one city is developing well. In recent years, green finance and high-quality economic development have been mutually promoting at a high level, but there is still some room for improvement.

4.2. Grey correlation analysis

After understanding the coordinated development level of green finance and high-quality economic development in the Yangtze River Delta region, in order to further analyze the degree of correlation between the two systems, this paper uses the grey correlation model to study it, and calculates the correlation value of each index of green finance and high-quality economic development, as well as each index of high-quality economic development and green finance. The results are shown in Table 7.

Table 7. Correlation degree value of each index

Correlation degree between green finance and indicators of high-quality economic development		The correlation between high-quality economic development and green finance indicators	
Indicator symbol	Correlation degree	Indicator symbol	Correlation degree
Y ₇	0.751	X ₁	0.823
Y ₂	0.696	X ₂	0.718
Y ₉	0.661	X ₃	0.637
Y ₁₀	0.630	X ₄	0.629
Y ₆	0.630		
Y ₈	0.609		
Y ₄	0.587		
Y ₁	0.564		
Y ₃	0.485		
Y ₅	0.456		

It can be seen from Table 7 that among the correlation degree between green finance system and indicators of high-quality economic development, the correlation degree between green finance and Y7 (consumer price index) of social development is the highest, which is 0.751. The correlation degree with Y2 (GDP growth rate) of economic growth is 0.696. It shows that economic growth and ecological civilization can greatly affect the development of green finance. In scientific and technological progress, Y9, that is, the correlation degree between the number of patents granted per 10,000 people and the green finance system, is 0.661, indicating that the innovative development of science and technology can also promote the development of green finance to a certain extent. In the correlation degree between the economic high-quality development system and green finance indicators, the correlation degree between the economic high-quality development system and green bonds is 0.823; The correlation degree with green insurance is 0.718. This shows that the issuance of green bonds and the development of green insurance can well promote the high-quality development of local economy.

5. Conclusions and Suggestions

In this paper, the entropy weight method is used to construct the index of green finance and high-quality economic development, the coupled coordination degree model is used to empirically analyze the mutual relationship and coordinated development level between the two systems, and the grey correlation model is used to analyze the correlation degree between the two systems, and the following conclusions are drawn: (1) From the perspective of coordinated development, the coordinated development of green finance and high-quality economic development in the Yangtze River Delta region is generally good and in a good direction, but there is a phenomenon of regional development imbalance. (2) From the perspective of correlation, economic growth and ecological civilization can influence the development of green finance to a large extent, and the innovation and development of science and technology can also promote the development of green finance to a certain extent; The issuance of green bonds and the development of green insurance can well promote the high-quality development of local economy.

Based on the above empirical analysis and by referring to a large number of relevant literatures, this paper puts forward the following suggestions:

(1) The government and financial institutions should continuously improve the green finance system and solve the problem of transaction information asymmetry. Improve the information disclosure mechanism and create a favorable market environment. At the same time, a coordinated development mechanism should be established to alleviate the unbalanced development of regional green finance.

(2) Government departments have introduced and improved relevant supporting policies, increased relevant preferential fiscal policies, and promoted the institutionalization and standardization of green financial products. The government and financial institutions have increased the policy and financial support for green industries, and formulated relevant policies to continuously guide the transformation and upgrading of industries with high energy consumption and high pollution, and promote the adjustment

of industrial structure. At the same time, financial institutions should be encouraged to actively carry out green finance activities, so that more customers know about green finance.

(3) A financial institution shall actively introduce professional personnel and strengthen relevant professional training for its internal personnel. Continuous innovation of green technology and improvement of green finance system, active innovation to continuously enrich green financial products, improve the development level and service quality of green finance. Thus, it can provide better financial services for green economy and promote sustainable economic development.

6. Data Availability

The data in this paper mainly come from the corresponding years of statistics bureau, statistical yearbook, China Industrial Statistics Yearbook, China Insurance Yearbook, China Environmental Statistics Yearbook, Wind Database, etc.

7. Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgment

This research is funded by the 2023 Undergraduate Scientific Research and Innovation Fund Program of Anhui University of Finance and Economics (No.: XSKY23088).

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