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Green technology innovation and high-quality economic development under the background of digital economy

--Take the Yangtze River Economic Belt, for example

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Abstract

High-quality economic development is the primary task of building a modern socialist country in an all-round way. Green technology innovation and digital economy closely promote each other. Through the study of the Yangtze river economic belt digital economy, green technology innovation and economic development of high quality the coupling relationship between three systems and obstacle factor evaluation, aims to fully grasp the comprehensive development situation, coordinated development situation and affect the development of the main obstacle factor, provide targeted Suggestions for regional coordinated development. Firstly, this paper selects 38 indexes to construct the comprehensive evaluation index system of digital economy, green technology innovation and high-quality economic development and makes data calculation; secondly, it reveals the relationship between the three systems and the latter to improve economic development.

Keywords

High-Quality Economic Development; Green Technology Innovation; Digital Economy; Coordinated Development Of Regional Economy.

1. Introduction

The report to the 19th National Congress of the Communist Party of China pointed out that China's economy has shifted from a stage of high-speed growth to a stage of high-quality development, and high-quality development has become the basic direction of China's economic and social development in the new era, and is the essential feature of the modern economic system. In the past five years, China has been committed to promoting high-quality economic development, China's economic aggregate has reached a new level, and the material foundation for development has been continuously consolidated. However, due to the imbalance of regional economic development caused by the geographical environment, resource endowment and scientific and technological level of various regions, it determines that China cannot simply require all regions to "march together" in the economic development. Therefore, in the "14th Five-Year Plan" period, under the new situation of increasing pressure and regional development is facing great challenges, how to promote the regional coordinated development has become the key to achieve high-quality economic development.

High-quality development fundamentally lies in the vitality, innovation and competitiveness of the economy. The vitality, innovation and competitiveness of economic development are

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closely linked to green development. The party's 20th annual report points out that China's main goals and tasks in the next five years are to make new breakthroughs in high-quality economic development. In the future, China will change from relying on low-end primary processing industries, demographic dividend and sacrificing environmental resources for economic growth to a high-quality, high-efficiency and sustainable economic development mode driven by scientific and technological innovation and driven by the optimization and upgrading of the industrial structure. Obviously, to promote the high-quality development of regional economy, we must pay attention to green development and technological innovation.

In recent years, the Internet, big data, cloud computing, artificial intelligence, block chain and so on are constantly emerging, the new economic form based on digital technology —— digital economy emerged at the historic moment, digital economy is a new economic form to create social wealth, will continue to empower the economy to achieve high-quality development. To a large extent, digital economy can effectively eliminate the excessive consumption of tangible resources and energy by traditional industrial production, cause environmental pollution, ecological deterioration and other hazards, and realize the sustainable development of social economy. In the face of the severe test of environmental deterioration and resource shortage, green economy is the breakthrough point to solve the problem of environment and development, and green technology innovation is the first driving force of green economy. How to use green technology innovation to promote the development of digital economy, so as to achieve high-quality economic development, has become an important issue.

2. Literature review

2.1. Review of the study content and literature

From the point of existing research, domestic scholars of digital economy, green technology innovation and high quality economic development between the three systems conducted a lot of research, one is the relationship between the digital economy and high quality economic development, the digital economy can promote high quality economic development from multiple angles (Zhao Tao, etc., 2020[1]; Li Jiaxin, 2022[2]); Second, the relationship between green technology innovation and high-quality economic development. Research shows that the coupling degree of green technology innovation to high-quality economic development is on the rise and has regional differences (Wu Yunliang etc., 2021[3]; Zhu Xinling etc., 2021[4]); Third, the relationship between green technology innovation and digital economy. Research shows that the development of digital economy significantly promotes the improvement of the level of green technology innovation (Zhao Huixin etc., 2022[5]). Some articles have studied the relationship between the three systems, and found that the digital economy can promote high-quality economic development through green technology innovation (Dai Xiumei etc., 2023[6]).

In general, the research on the three systematic relationship of digital economy, green technology innovation and high-quality economic development is still in the early stage, and there is a lack of systematic analysis and research, especially the discussion on the coordinated development and influencing factors of the three regional systems.

2.2. Review of theoretical methods

Through reading the literature and sorting out the theoretical methods, it is found that most of the evaluation indicators are calculated by entropy method to give the weight and comprehensive development level of the evaluation indicators (Wang Fuxi etc., 2013[7]; Cheng Zhenbo, etc., 2023[8]); The coupling degree model is mostly used for studying the relationship between two or more systems (Sun Chang etc., 2021[9]); Principal component analysis, regression and factor analysis are mostly used in the analysis of influencing factors among

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various systems, and many studies use the barrier model to explore the obstacle factors affecting the development of various systems.

In general, there are various theoretical methods on the measure of evaluation indicators, the relationship between multiple systems and the influencing factors. According to the topic and research objectives of this article, this paper uses the entropy method to measure each evaluation index, studies the coordination relationship between the digital economy, green technology innovation and high-quality economic development through the coupling degree model, and uses the barrier degree model to dig and sort out the main obstacle factors.

3. Study design

3.1. Model construction

3.1.1. Entropy weight method

Entropy weight method is an objective empowerment method. Using entropy weight method to calculate the index weight helps to reduce the interference of human factors and make the evaluation results more objective. The calculation steps are as follows:

If there are m evaluation objects, n evaluation indicators, the initial data matrix is as follows:

$$X = \left(x_{ij}\right)_{m\times n} \ (i = 1,2,3\cdots,m; j = 1,2,3,\cdots,n) \tag{1}$$

(1) Standardized processing of the data

$$\text{Positive indicators: } x'_{ij} = \frac{x_{ij}-\min\left(x_{ij}\right)}{\max\left(x_{ij}\right)-\min\left(x_{ij}\right)} \tag{2}$$

$$\text{Negative indicators:} x'_{ij} = \frac{\max\left(x_{ij}\right)-x_{ij}}{\max\left(x_{ij}\right)-\min\left(x_{ij}\right)} \tag{3}$$

x'_{ij} In equation (2) ~ (3), for the standardized index value, the value is between 0 and 1, and the maximum and minimum values of the index in the study unit.$maxminij$

(2) Calculate the information entropy E_j , the larger the information entropy, the smaller the index dispersion degree, indicating that the less information the index can provide, the greater the index weight; otherwise, the smaller the index weight.

$$E_j = -k\sum_{i=1}^{m} p_{ij}\ln p_{ij} \tag{4}$$

$$\text{among,} p_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{m} x_{ij}}\ k = \frac{1}{\ln m}$$

(3) Determine the weight of the index:

$$w_j = \frac{1-E_j}{\sum_{j=1}^{n}(1-E_j)} \tag{5}$$

(4) Determine the comprehensive development level of the evaluation objects:

$$U = \sum_{j=1}^{n} w_j\, x'_{ij} \tag{6}$$

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3.2. Coupled coordination degree model

Couple from the concept of physics, is to point to two or more two subsystems with internal connection, with static similarity and dynamic interaction both exist coupling relationship, with coupling relationship system to guide and strengthen, can promote the two subsystem interaction, influence each other, stimulate their internal potential, realize the complementary advantages and ascension.

3.2.1. Coupling degree model

$U_1U_2U_3$ According to formula (1) ~ (6), the comprehensive development level of digital economy, the comprehensive development level of green technology innovation and the comprehensive level of high-quality economic development of the evaluation object can be found. Accordingly, the coupling evaluation model of digital economy, green technology innovation and high-quality economic development is constructed. The formula is:

$$C == \frac{3 \times (U_1 \times U_2 \times U_3)^{\frac{1}{3}}}{U_1 + U_2 + U_3} \tag{7}$$

C In equation (7): it is the coupling degree of the system, which reflects the high degree of interaction between the systems. The larger the value, the stronger the coupling degree of the system. By the existing coupling degree classification methods[10-12], This study divided the coupling degree into 4, as shown in Table 4:

Table 1. Coupling hierarchy and division criteria

Level division of the coupling degrees	Low coupling hierarchy	The antagonistic coupling hierarchy	Run-in level	High coupling hierarchy
C price	0.1~0.3	0.3~0.5	0.5~0.8	0.8~1

3.2.2. Coupled coordination degree model

In order to further study the coordination of the systems and whether it is a benign interaction, it is necessary to build a coupled coordination evaluation model of digital economy-green technology innovation-high-quality economic development. The formula is:

$$D = (C \times T)^{\frac{1}{2}} \tag{8}$$

$$T = \alpha \times U_1 + \beta \times U_2 + \gamma \times U_3 \tag{9}$$

TD Equation (8) ~ (9): for the coupling coordination coefficient and the coupling coordination degree, assume that digital economy and green technology innovation have equal important status with high-quality economic development, so it is taken and combined with existing research $\alpha = \beta = \gamma = \frac{1}{3}$[13], Classified the coupling coordination degree into different grades, as shown in Table 2:

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Table 2. Classification of coupling coordination levels$D$

Coordinated development stage	interval value$D$	The degree of coupling coordination
Dysregulation stage	(0.0~0.1)	Extreme disorder
	[0.1~0.2)	major maladjustment
	[0.2~0.3)	Moderate dysregulation
	[0.3~0.4)	Mild dysregulation
Run-in stage	[0.4~0.5)	On the verge of dysregulation
	[0.5~0.6)	Forced coordination
Coordination stage	[0.6~0.7)	Primary coordination
	[0.7~0.8)	Intermediate coordination
	[0.8~0.9)	Good coordination
	[0.9~1.0)	Quality coordination

3.2.3. Obap model[15]

The obstacle degree model is to clarify and dig out through the comprehensive evaluation model, and to dig out the main obstacle factors that have an impact on the evaluation target. The obstacle degree function is analyzed and diagnosed by three indexes: factor contribution degree, index deviation degree and obstacle degree. Factor contribution refers to the degree to which the individual index affects the total target, as shown in Equation (10). The index deviation degree refers to the gap between the actual value and the optimal value of each evaluation index, as shown in Equation (11). The degree of obstacle indicates the influence degree of a single index on the coordinated development of the system, and the larger, the higher the deviation degree of the index to the obstacle to the coordinated development of the system. As shown in equation (12), the degree of obstacle of the first-level index can be further calculated. The specific formula is as follows:$F_{ij}I_{ij}O_{ij}O_{ij}$

$$F_{ij} = w_{ij} \times W_{ij} \tag{10}$$

$$I_{ij} = 1 - x'_{ij} \tag{11}$$

$$O_{ij} = \frac{F_{ij} \times I_{ij}}{\sum_{j=1}^{n}(F_{ij} \times I_{ij})} \tag{12}$$

w_{ij}In formula (9) ~ (11), it is the weight of the index j in year i, and the weight of the first-level index in year i, which is the index value after standardized treatment.$W_{ij}x'_{ij}$

3.3. Construction of the index system

In line with the principles of scientificity, comprehensiveness, representativeness and operability, on the basis of referring to relevant literature, considering the integrity and availability of data, the corresponding indexes are selected to build a comprehensive evaluation index system. The original data of the selected variables are all from the official website of the National Bureau of Statistics and the statistical yearbook, which can ensure the authenticity, integrity and authority of the data. The data is of high quality and can meet the research needs.

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3.3.1. Construction of digital economy index system

Digital economy is the main economic form after agricultural economy and industrial economy. According to its connotation, this research establishes the digital economy evaluation index system from three aspects of digital infrastructure, digital industrialization and industrial digitalization.

Table 3. Digital economic index system

Level 1 indicators	Secondary indicators	Index unit
Digital infrastructureA_1	The X1 phone penetration rate is (+)	Department / person
	The X2 long-distance optical cable line length is (+)	Ten thousand kilometers
	Number of X3 domain names: (+)	Ten thousand
	X4 Internet Broadband access port (+)	Ten thousand
Digital industrializationA_2	X5 telecom business total volume of (+)	100 million
	The X6 software business revenue is (+)	100 million
Industrial digitizationA_3	X7 enterprises have (+) number (+)	individual
	X8 enterprises with e-commerce transactions are (+)	individual
	X9 e-commerce sales of (+)	100 llion

3.3.2. Construction of the index system of green technology innovation

Green technology innovation is a new type of modern technology system coordinated with the ecological environment system, which aims to protect the environment and realize sustainable development. According to Fang Chengwu, et al. (2020)[14]The research divides green technology innovation into four dimensions: green technology innovation input, green technology innovation output, green technology innovation environment and the diffusion of green technology innovation, which constitute the evaluation index system of green technology innovation.

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Table 4. Index system of green technology innovation

Level 1 indicators	Secondary indicators	Index unit
Investment in green technology innovationB_1	X10 R & D personnel full-time equivalent (+)	man-year
	X11 R & D expenditure in GDP proportion (+)	%
	X12 per capita power consumption of (-)	kW / person
	X13 per capita water consumption is (-)	cubic meter / person
Output of green technology innovationB_2	X14 authorized patents per 10,000 people are (+)	Item / ten thousand people
	The proportion of X15 invention patents granted in the number of patents granted is (+)	%
	X16 new product sales revenue in GDP proportion of (+)	%
	X17 industrial pollution control completed investment (+)	Wan Yuan
Environment for green technology innovationB_3	X18 Local fiscal education expenditure in GDP (+)	%
	X19 The average number of higher students per 100,000 population is (+)	Man / 100,000
	X20 household waste harmless disposal rate (+)	%
	The X21 forest coverage rate of (+)	%
Green technology innovation spreadsB_4	X22 Total investment of foreign-invested enterprises is (+)	billions of dollars
	X23 software business export volume of (+)	billions of dollars

3.3.3. Construction of an index system for high-quality economic development

High-quality economic development is guided by the five development concepts of "innovation, coordination, green, openness and sharing", so this research establishes an evaluation index system based on its guiding ideology and comprehensive economic development.

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Table 5. Index system for high-quality economic development

Level 1 indicators	Secondary indicators	Index unit
Comprehensive quality and efficiencyC_1	The X24 GDP per capita is (+)	Yuan / person
	X25 registered urban unemployment rate (-)	%
	X26 Total retail sales of consumer goods accounted for GDP proportion (+)	%
innovative developmentC_2	X27 science and technology financial expenditure intensity (+)	%
	X28 holds (+) per 10,000 patents	Item / ten thousand people
harmonious developmentC_3	X29 industrial structure rationalization (+)	-
	The X30 industrial structure is advanced to the (+)	-
	X31 The ratio of per-rural per capita disposable income is (-)	-
green developmentC_4	X32 urban sewage daily treatment capacity of (+)	Ten thousand cubic meters
	X33 per capita park green area of (+)	Square meters / person
Open developmentC_5	X34 total imports and exports to GDP proportion (+)	%
	X35 The proportion of foreign investment in GDP is (+)	%
Shared developmentC_6	X36 social security government expenditure proportion (+)	%
	X37 has a (+) number of hospitals per 10,000 people	Ten thousand people
	X38 per capita fiscal expenditure on education is (+)	first

4. The empirical results and analysis

Taking the Yangtze River Economic Belt as an example, this study measures the coupling and coordination degree of green technology innovation and high-quality economic development under the background of digital economy, and analyzes the obstacle factors affecting the coordinated development of the three, and provides reference for the coordinated development of digital economy, green technology innovation and high-quality economy in the Yangtze River Economic Belt. The data used are all from the data of the National Bureau of Statistics on the provinces and cities of the Yangtze River Economic Belt in 2021.

4.1. Analysis of the comprehensive development level

The weight of each index can be calculated from formula (1) ~ (6), as shown in Table 6 ~ 8. According to the weight results, the first-level indicators: digital infrastructure (43.10%) and industrial digitalization (32.29%) contribute greatly to the comprehensive development level of digital economy; the diffusion of green technology innovation (31.75%) contributes the most to the comprehensive development level of green technology innovation; open development (28.31%), shared development (19.48%) and coordinated development (18.03%) contribute more to the comprehensive development level of high-quality economic development. Among the secondary indicators: telephone penetration rate (15.61%) is the most heavily weighted

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indicator in the digital economy system, followed by software business revenue (13.95%). In the green technology innovation system, the export amount of software business (18.69%) and the total investment of foreign-invested enterprises (13.06%) have the largest weight, so it can be seen that the diffusion of green technology innovation is of vital importance to the development of green technology innovation. In the high-quality economic development system, total imports and exports to GDP (12.72%) and foreign investment to GDP (15.58%) contribute the most, which shows the importance of open development to high-quality economic development.

In general, digital infrastructure, industrial digitalization, diffusion of green technology innovation and open development contribute the most to the three systems of digital economy, green technology innovation and high-quality economic development.

Table 6. Weight of digital economic indicators

Level 1 indicators	Secondary indicators	weight
$A_1(0.4301)$	X 1	0.1561
	X 2	0.0855
	X 3	0.0746
	X 4	0.1140
$A_2(0.2469)$	X 5	0.1075
	X 6	0.1395
$A_3(0.3229)$	X 7	0.1079
	X 8	0.1008
	X 9	0.1142

Table 7. Weight of green technology innovation indicators

Level 1 indicators	Secondary indicators	weight
$B_1(0.2500)$	X 10	0.1126
	X 11	0.0550
	X 12	0.0440
	X 13	0.0384
$B_2(0.2321)$	X 14	0.0963
	X 15	0.0535
	X 16	0.0518
	X 17	0.0306
$B_3(0.2003)$	X 18	0.0793
	X 19	0.0565
	X 20	0.0193
	X 21	0.0453
$B_4(0.3175)$	X 22	0.1306
	X 23	0.1869

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Table 8. Weight of high-quality economic development indicators

Level 1 indicators	Secondary indicators	weight
$C_1(0.1301)$	X 24	0.0695
	X 25	0.0230
	X 26	0.0376
$C_2(0.1207)$	X 27	0.0393
	X 28	0.0814
$C_3(0.1803)$	X 29	0.0718
	X 30	0.0825
	X 31	0.0260
$C_4(0.0910)$	X 32	0.0699
	X 33	0.0211
$C_5(0.2831)$	X 34	0.1272
	X 35	0.1558
$C_6(0.1948)$	X 36	0.0652
	X 37	0.0414
	X 38	0.0882

The comprehensive developmental level scores of the three systems calculated from the entropy method are shown in Table 9 and visualized with the cluster diagram in Figure 1.

Table 9. Comprehensive development level of digital economy, green technology innovation and high-quality economic development

area	U_1	U_2	U_3
Shanghai Municipality	0.5085	0.5300	0.7886
Jiangsu Province	0.7368	0.7098	0.4695
Zhejiang Province	0.6184	0.5614	0.3965
Anhui Province	0.2249	0.3447	0.2765
Jiangxi Province	0.0928	0.3175	0.1761
Hubei province	0.1869	0.3227	0.2558
Hunan Province	0.1929	0.3432	0.1875
Chongqing City	0.1330	0.2767	0.3195
Sichuan Province	0.4677	0.2669	0.2453
Yunnan Province	0.0786	0.2094	0.1621
Guizhou Province	0.1208	0.2019	0.1365

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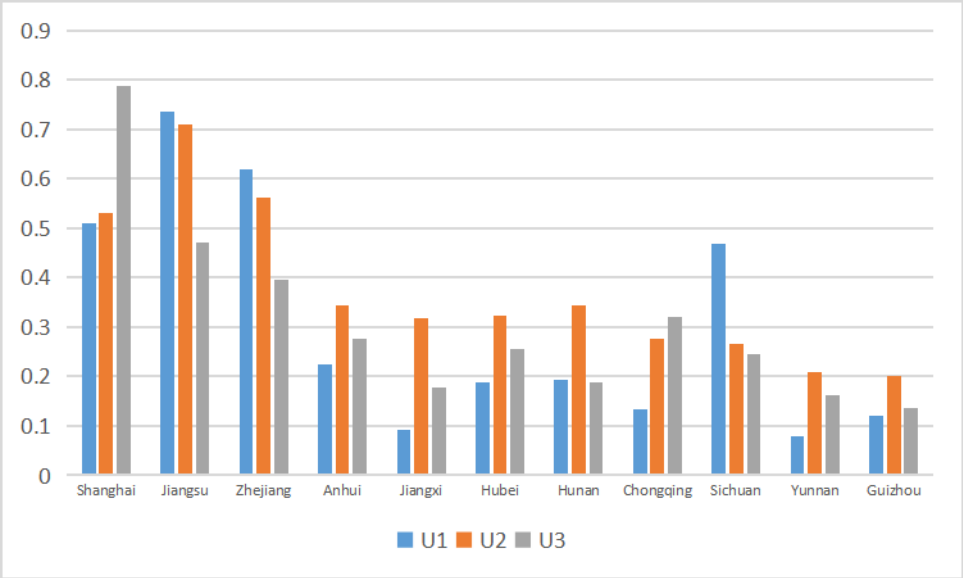

Figure 1. Digital Economy- -Green technology innovation- -Comprehensive development level of high-quality economic development

As can be seen from Table 9 and Figure 1, the development level of digital economy: Jiangsu and Zhejiang are developing well (0.6~0.8), Shanghai and Sichuan are at the middle level (0.4~0.6), and the development level of digital economy in other provinces is low. For green technology innovation and high-quality economic development level: the distribution trend of all provinces in the Yangtze River Economic Belt is roughly the same. From the coordinate axis of the figure, the trend is "down-up-down-up-down" trend, among which only the green technology innovation and development level of Jiangsu, Zhejiang and Shanghai reached above 0.5; only Shanghai high-quality economic development level reached above 0.5. Generally speaking, Jiangsu, Shanghai and Zhejiang provinces have the best development level, ranking the top three; Jiangxi, Yunnan and Guizhou provinces have the worst development level, digital economy and high-quality economic development level are at a low level (less than 0.2).

4.2. Coupled and coordinated development analysis

From formula (7) ~ (9), the coupling degree and coupling coordination degree results of the three systems of digital economy-green technology innovation-high-quality economic development in the Yangtze River Economic Belt in 2021 are shown in Table 10.

Table 10. Coupling degree C, coordination index T, and coupling coordination degree value D

area	degree of coupling C	Coordination index T	Coupling coordination degree D
Shanghai Municipality	0.9799	0.6090	0.7725
Jiangsu Province	0.9804	0.6387	0.7913
Zhejiang Province	0.9827	0.5254	0.7185
Anhui Province	0.9849	0.2820	0.5270
Jiangxi Province	0.8858	0.1955	0.4161
Hubei province	0.9758	0.2552	0.4990
Hunan Province	0.9599	0.2412	0.4812
Chongqing City	0.9356	0.2431	0.4769
Sichuan Province	0.9578	0.3266	0.5593
Yunnan Province	0.9244	0.1500	0.3724
Guizhou Province	0.9755	0.1531	0.3864

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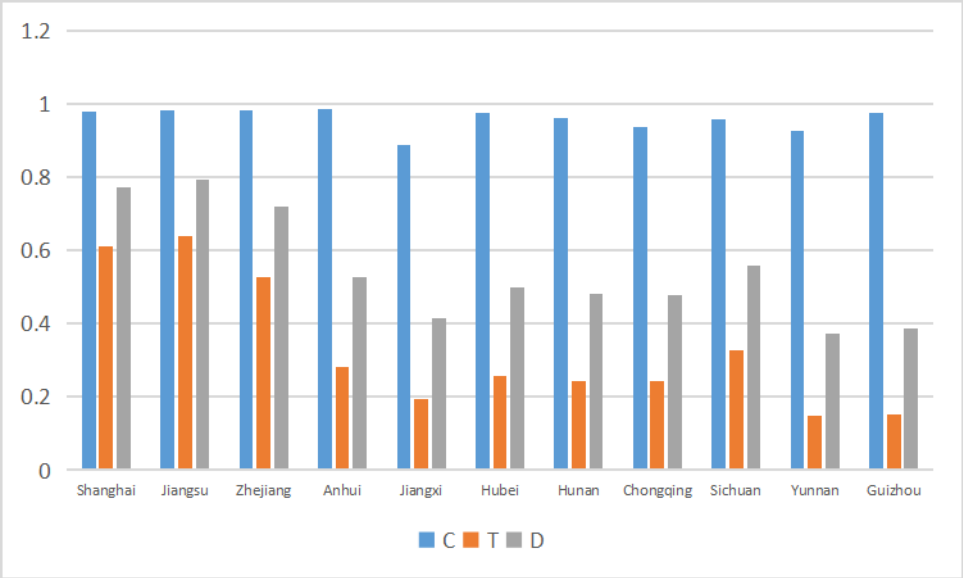

Figure 2. Coupling and coordination degree of digital economy, green technology innovation and high-quality economic development along the Yangtze River Economic Belt in 2021

As can be seen from table 10 and figure 2, the Yangtze river economic belt 11 provincial coupling degree between (0.8~1), the 2021 the Yangtze river economic belt of provincial digital economy-green technology innovation-economic development of high quality between three systems are in high coupling level stage, that the Yangtze river economic belt of provincial digital economy, green technology innovation and economic development between high quality effect, influence each other. In terms of coupling coordination degree, Jiangsu, Shanghai and Zhejiang are in the intermediate coordination stage (0.7~0.8), and the three systems show good mutual promotion; Anhui and Sichuan are in the weak coordination stage (0.5~0.6), and the three systems barely promote each other; Hubei, Hunan and Chongqing are in the near stage (0.4~0.5), the three systems; Yunnan and Guizhou are in the slight imbalance stage (0.3~0.4), and the relationship between the three systems is slightly mutual inhibition.

4.3. Disorder factor analysis

4.3.1. Analysis of obstacle factors of first-level indicators

The radar chart of the primary indicators of digital economy, green technology innovation and high-quality economic development of the Yangtze River Economic Belt in 2021 is shown in Table 11 and Figure 3.

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Table 11. Primary of level level level barrier analysis

area	project	Index ranking		
		1	2	3
Shanghai Municipality	obstruction factor	A_1	B_1	A_3
	Disorder degree	19.25%	14.60%	11.89%
Jiangsu Province	obstruction factor	A_1	C_5	C_3
	Disorder degree	18.23%	16.59%	13.59%
Zhejiang Province	obstruction factor	C_5	A_1	B_4
	Disorder degree	16.36%	15.19%	14.26%
Anhui Province	obstruction factor	A_1	B_4	C_5
	Disorder degree	15.22%	13.45%	11.74%
Jiangxi Province	obstruction factor	A_1	C_5	C_3
	Disorder degree	18.23%	16.59%	13.59%
Hubei province	obstruction factor	A_1	B_4	C_5
	Disorder degree	16.02%	13.12%	12.42%
Hunan Province	obstruction factor	A_1	B_4	C_5
	Disorder degree	15.05%	12.93%	12.12%
Chongqing City	obstruction factor	A_1	B_4	A_3
	Disorder degree	16.17%	13.60%	12.43%
Sichuan Province	obstruction factor	B_4	C_5	A_3
	Disorder degree	14.01%	13.25%	11.50%
Yunnan Province	obstruction factor	A_1	A_3	B_4
	Disorder degree	14.69%	12.43%	12.42%
Guizhou Province	obstruction factor	A_3	A_1	B_4
	Disorder degree	12.71%	12.61%	12.23%

As can be seen from Table 11 and Figure 3, the barriers of Anhui, Jiangxi, Hubei, Hunan, Chongqing, Yunnan and Guizhou have similar shapes and can be classified to the main infrastructure except Guizhou ()), and the barriers are between (14%~17%); secondly, green technology innovation spreads () at around 12.5%; the main obstacle factor of Shanghai are digital infrastructure (19.25%) and green technology innovation investment (14.60%). The main obstacle factors in Zhejiang are open development (, 16.36%) and digital infrastructure (, 15.19%), while the main obstacle factors in Sichuan are the diffusion of green technology innovation (, 14.01%) and open development (, 13.25%). In general, the main barriers to the coordinated development of all provinces are digital infrastructure, open development and the diffusion of green technology innovation.A_3($A_1B_4A_1B_1C_5A_1B_4C_5$

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Figure 3. Radar map of digital economy, green technology innovation and high-quality economic development obstacles in all provinces and cities along the Yangtze River Economic Belt

4.3.2. Analysis of secondary indicators

This study lists the top five secondary indicators. As shown in Table 12, on the whole, the provincial secondary indicators include the proportion of foreign investment in GDP, in addition, the top five secondary indicators of Hunan, Chongqing, Sichuan, Yunnan, Guizhou, Zhejiang and Anhui include telephone penetration rate, software business revenue and software business exports, and the total investment of foreign-invested enterprises. It can be

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seen that the importance of digital infrastructure, the diffusion of green technology innovation and open development to the comprehensive development of the three systems.

Table 12. Analysis of secondary index barrier factors

area	project	Index ranking				
		1	2	3	4	5
Shanghai Municipality	obstruction factor	X4	X10	X23	X2	X5
	Disorder degree	9.19%	8.50%	8.39%	7.29%	7.24%
Jiangsu Province	obstruction factor	X1	X35	X30	X18	X34
	Disorder degree	10.50%	9.61%	7.35%	7.31%	6.98%
Zhejiang Province	obstruction factor	X23	X35	X34	X1	X22
	Disorder degree	9.02%	8.80%	7.56%	5.75%	5.24%
Anhui Province	obstruction factor	X23	X1	X35	X6	X34
	Disorder degree	8.43%	7.11%	6.24%	6.02%	5.50%
Jiangxi Province	obstruction factor	X23	X1	X35	X6	X22
	Disorder degree	7.68%	6.35%	6.27%	5.71%	5.18%
Hubei province	obstruction factor	X23	X1	X35	X34	X22
	Disorder degree	8.13%	6.98%	6.91%	5.51%	5.24%
Hunan Province	obstruction factor	X23	X35	X1	X6	X34
	Disorder degree	7.80%	6.63%	6.49%	5.57%	5.49%
Chongqing City	obstruction factor	X23	X35	X22	X1	X6
	Disorder degree	8.02%	6.76%	5.58%	4.88%	4.84%
Sichuan Province	obstruction factor	X23	X35	X22	X1	X34
	Disorder degree	8.24%	7.72%	5.77%	5.58%	5.54%
Yunnan Province	obstruction factor	X23	X35	X1	X6	X22
	Disorder degree	7.30%	6.00%	5.80%	5.47%	5.12%
Guizhou Province	obstruction factor	X23	X35	X1	X6	X34
	Disorder degree	7.36%	5.72%	5.57%	5.33%	5.01%

5. Conclusions and policy recommendations

5.1. Conclusion

This study constructed the comprehensive evaluation index system of digital economy, green technology innovation and high quality economic development. Firstly, using the entropy method to calculate the comprehensive development level of the three subsystems of the provinces of the Yangtze River Economic Belt in 2021, then establish the coupling coordination model to measure the coupling coordination degree of the three systems, and finally introduce the main factors affecting the coordinated development. This study leads to the following conclusions:

5.1.1. From the perspective of the comprehensive development level

In 2021, the comprehensive development level of digital economy, green technology innovation and high-quality economic development in most of the provinces in the Yangtze River Economic Belt will be relatively low. Development level of digital economy: Jiangsu and Zhejiang are developing well, while the development level of digital economy in other provinces is low. Green technology innovation and high quality economic development level: the distribution trend is roughly the same but generally low, from the figure on the axis, are "down-rise-down-

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up-down" trend, the development of Jiangxi, Yunnan and Guizhou province, the worst, digital economy development level and economic development level are at a low level (less than 0.2).

5.1.2. In terms of the coupling and coordination degree

Coupling degree: a high degree and interaction among the digital economy, green technology innovation and high-quality economic development in the provinces of the Yangtze River Economic Belt. Coupled coordination: Jiangsu, Shanghai, Zhejiang, Anhui and Sichuan systems; Hubei, Hunan and Chongqing systems; slight mutual inhibition between Yunnan and Guizhou systems.

5.1.3. In terms of barriers

The main obstacle factors restricting the coordinated development of all provinces are digital infrastructure, open development and green technology innovation diffusion; including the proportion of foreign investment in GDP, telephone penetration rate, software revenue and software export volume.

5.2. Suggestions

5.2.1. Strengthen the construction of digital infrastructure

From the analysis of the analysis of this study, both level and secondary index of the main obstacle factor, the Yangtze river economic belt provincial digital infrastructure has a larger proportion, in the digital economy, should further intensify efforts to popularize telephone, Internet broadband and long-distance cable construction, especially in Yunnan, Guizhou, Sichuan and other remote areas, improve the level of development of digital economy.

5.2.2. Attach importance to opening up and foreign trade transactions to achieve high-quality economic development

Through this paper, it is found that whether it is green technology innovation or high-quality economic development, the diffusion of green technology innovation and open development involving opening to the outside world all play a large weight in the provinces of the Yangtze River Economic Belt. Therefore, we should accelerate green technology innovation to enable high-quality economic development, strengthen research on green innovation technology, reduce the problem of heavy pollution in the world, achieve sustainable development, give full play to the characteristics of various regions to attract a large number of foreign investment, pay attention to the quality control of import and export, and increase the import and export volume.

5.2.3. We will strengthen green technological innovation and high-quality economic development

From the perspective of the comprehensive development level of the three systems, the level of green technology innovation and high-quality economic development in each province is lower than that of digital economy. Since the three systems are a coupled system, the development level of each subsystem is closely related to the coordinated development of the three systems. Therefore, the Yangtze River Economic Belt should increase the investment and diffusion of green technology innovation and improve the level of green technology innovation and development; pay attention to the coordinated development of all provinces to improve the level of high-quality economic development.

5.2.4. Ensure the coordinated and balanced development of the digital economy, green technology innovation and high-quality economic development

From the results of the study, digital economy, green technology innovation and economic quality development coupling degree is much higher than the coupling coordination, as a coupling system, its sustainable development ultimately depends on the coordination between the Yangtze river economic belt provinces and cities should according to the local

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characteristics and advantages, pay attention to collaboration, strengthen foreign exchanges, build the government as the leading factor, the market as the main body, digital economy and green technology innovation of coordinated development of regional development strategy, promote the development of economy with high quality.

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