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Digital Economy Development, Green Economy Efficiency and Social Equity Performance Coupling Coordination Research

-- Empirical Analysis based on the Yangtze River Economic Belt

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Abstract

Digital economy is the new driving force of economic development. It is of great practical significance to study the coupling relationship between digital economy and the efficiency of green economy and the performance of social equity to promote the strategy of high-quality development. In this paper, firstly, the super-efficiency SBM-Undesirable model and location entropy were used to measure the performance of green economy and social equity in the Yangtze River Economic Belt during 2010-2021, and then the influence of digital economy development on both of them was studied. Based on this, the dynamic evolution law of the three coupling degrees is explored with the coupling degree model and panel Tobit model, and the driving influence of digital economy on the three coupling degrees is analyzed. The results show that the prosperity of digital economy has a positive impact on the efficiency of green economy and the performance of social equity. The coupling coordination degree of the three shows a steady improvement trend, but the coordination degree of the middle and upper reaches is still to be improved compared with that of the lower reaches. In the study of driving factors, it can be seen that the three indicators that have a great influence on the digital economy, namely, the length of long-distance cable lines, the revenue of software industry and the total amount of data trading centers, all have a positive promoting effect on the coupling degree. The conclusions of the study have certain guiding significance for the high-quality development of the Yangtze River Economic Belt, and can provide reference for the related coordinated development of other regions.

Keywords

Digital Economy; Green Economy Efficiency; Social Equity Performance; Coupling Coordination.

1. Introduction

With the high quality development strategy and the proposal of the double carbon policy, our country has gradually transformed from the principle of efficiency first to pay equal attention to efficiency and equity, and strives to solve the main contradiction in the current society, namely "the contradiction between the people's ever-growing needs for a better life and unbalanced and inadequate development". Therefore, it is of great practical significance to study the coupling relationship between the efficiency of green economy and the performance of social justice. The two can optimize the overall situation and promote the high-quality development of the region through interaction. In November 2022, the Seventh Yangtze River Economic Belt Development Forum was held with the theme of how to promote the high-quality development of the Yangtze River Economic Belt, aiming to solve the problems of unbalanced and uncoordinated development of the Yangtze River Economic Belt. With high-quality development as the goal, it is necessary to break the traditional single economy-

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oriented model of high input, high pollution and high emissions, incorporate environmental protection and resource allocation into the analysis, and improve the coupling degree of green economic efficiency and social equity performance.

At the same time, with the iterative update of the new generation of information technologies such as the Internet, big data and artificial intelligence, the digital economy is becoming a key force in reshaping the global economic structure. Therefore, whether and how the development of digital economy can affect the efficiency of green economy and the performance of social equity is worth pondering. Some scholars believe that the networking and sharing characteristics of the digital economy are conducive to accelerating the speed of knowledge spillover and information interaction in the innovation network, reducing resource mismatch, and realizing the intensive integration and efficient utilization of production factors, so as to improve efficiency and equity. [1]However, some scholars believe that there are typical regional differences in the development of digital economy, and the digital divide will cause efficiency and fairness to decline instead of rising. [2]So how does the digital economy affect the efficiency of the green economy and the performance of social equity, and how do the three interact? Therefore, this paper takes the impact of the development of digital economy on the performance of green economy efficiency and social equity in the Yangtze River Economic Belt as the starting point, and further analyzes the synergistic coupling mechanism of digital economy, green economy efficiency and social equity performance and identifies its driving factors, so as to provide a scientific basis for the deep integration and synergy of digital economy and green balanced development. It also provides scientific reference and theoretical basis for promoting the policy formulation of high-quality development of provinces (municipalities) in the Yangtze River Economic Belt.

2. Literature Review

The literature closely related to this study can be divided into three aspects. First, the impact of the development of digital economy on the efficiency of green economy. Yin Tianbao et al. (2023)[3] believe that the development of digital economy has a significant positive spatial spillover effect on the efficiency of green economy, and there is significant heterogeneity in geographical location, scale and resource type. Zhu Jiexi et al. (2023) [4]suggest that the increase of regional innovation output and the optimization of capital factor allocation efficiency are important intermediary channels for digital economy to empower urban green development. Kong Lingzhang et al. (2022) [5]believe that the development of digital economy can improve the efficiency of green economy by promoting the upgrading of industrial structure and technological innovation.

Second, the impact of the development of digital economy on the performance of social equity. Bai Xuejie et al. (2023)[6] indicated that the digital economy was conducive to improving the per capita income level of all regions and narrowing the income gap among regions, and the impact showed that the low income group was better than the middle income group than the high income group, and increasing individual employment opportunities and improving household income level were important channels for the digital economy to alleviate income inequality. Ye Azhong et al. (2023) [7]found that the development of digital economy can significantly affect the degree of resource mismatch in the region and surrounding areas, but the impact effect has obvious regional heterogeneity, and indirectly affects resource allocation through stimulating foreign direct investment, consolidating financial deepening and improving employment activity.

The third is the study on the interaction between green economic efficiency and social equity performance. Qi Wei et al. (2021)[8] believe that improving efficiency is a prerequisite for promoting fairness, and efficiency is an important material condition for realizing fairness.

Efficiency contains fairness, and fairness exists in efficiency. Zhou Pingxuan (2014)[9] believes that the improvement of efficiency will promote the realization of a higher level of equity, and the realization of equity itself reflects the promotion of efficiency, and equity and efficiency are an interactive and co-directional driving relationship. However, Zhang Daiqian (2007)[10] believes that efficiency and fairness are a pair of eternal contradictions, which can not be determined by the social system, but the inevitable product of economic development to a certain stage. Policies that promote efficiency are often unfair, and policies that promote equity tend to create greater distortions and inhibitions in the economy.

Some scholars call the relationship between efficiency and fairness "Goldbach conjecture" in the history of economic theory, which has always been the subject of debate in the economic field. At present, the literature on the interaction mechanism of economic efficiency and social justice is relatively rare in foreign countries, while the literature on the relationship between the two focuses on the relationship between efficiency, justice and harmonious society, and there are some differences on the understanding of the interaction mechanism. As for putting digital economy, economic efficiency and social equity into the same framework, quantitative evaluation of the coordination relationship between the three is even less. Based on the above literature analysis, this paper first utilizes ultra-efficient SBM-Undesirable model and location entropy to measure the performance of green economy efficiency and social equity, and then analyzes the impact of digital economy development on them. In this context, the system coupling degree model and panel Tobit model are used to analyze the dynamic evolution of the three coupling degrees and their driving factors, providing theoretical basis and policy inspiration for the Chinese government to grasp the development opportunities of the digital economy and achieve the common prosperity goal of both efficiency and equity.

3. Research Methods and Data Sources

3.1. Principal Component Analysis

At present, there is no unified standard for measuring the development level of digital economy. This paper constructs the evaluation index system of digital economy development by combing the literature and drawing on the ideas of Xia Ming, Zhou Wenyong, Zhu Jixi and Bao Yu, etc.[11, 12], as shown in Table 1.

Table 1. Digital economy development comprehensive index evaluation index system

Digital economy	infrastructure	Number of broadband Internet access ports
		Length of long distance optical cable line
		Government Website Development Index
	People's livelihood service	Total volume of telecommunication service
		Total express business
		Software revenue
		Computer, communications and other electronic equipment manufacturing business income
	Market size	Total number of mobile phone subscribers
		Number of listed companies with e-commerce business
		Total number of data trading centers

In order to reduce the multicollinearity between explanatory variables and make the evaluation results more accurate, this paper adopts the principal component analysis method to measure the comprehensive development index of digital economy. The number of evaluation objects and evaluation indicators is set as n and j respectively, and the sample matrix X composed of the index values of n samples is as follows:$X_i = \{X_{i1}, X_{i2}, \ldots, X_{ij}\}(i = 1,2,\ldots,n; j = 1,2,\ldots,j)$.

First, the standard matrix Z is obtained after the data is standardized, and the correlation coefficient matrix R of the sample is obtained for Z. Secondly, the characteristic equation of the sample correlation coefficient matrix R is obtained, and p eigenvalues are obtained:

$$\alpha_1 \geq \alpha_2 \geq \ldots \geq \alpha_p \geq 0$$

Thirdly, the cumulative contribution rate of the first m principal components is as follows:

$$G_{(m)} = \frac{\sum_{j=1}^{m} \alpha_j}{\sum_{j=1}^{p} \alpha_j} \tag{1}$$

Finally, the score of the sample on each principal component is calculated, and the comprehensive evaluation function is constructed:

$$Y = \beta_1 y_1 + \beta_2 y_2 + \ldots + \beta_m y_m \tag{2}$$

Among them, β_i is the variance contribution rate of each principal component y, and y_i is the score of the i principal component. Cluster analysis is conducted on these scores and the ranking is determined to obtain the evaluation index of comprehensive development of digital economy.

3.2. Super-efficiency SBM-Undesirable Model

Although the traditional data enveloping model can evaluate the relative effectiveness of DMU, because the model itself is based on radial Angle and does not consider the relaxation variables, the efficiency evaluation results are inevitably biased from the reality. The SBM model overcomes the defect that the traditional DEA model cannot measure the relaxation variables, and improves the reliability of efficiency evaluation by using non-radial method. When Undesirable outputs are considered in the SBM model, SBM-Undesirable model can be obtained. The superefficient DEA model can solve the efficiency comparison problem among multiple relatively efficient DMU, and further distinguish the DMU at the efficiency front. Combining the above models, super-efficient SBM-Undesirable model is obtained. In this paper, ultra-efficient SBM-Undesirable model is adopted to measure green economy efficiency, which can effectively solve the problems of relaxation of input-output variables and undesirable output during the development process, so as to enable a more scientific assessment of the green economy efficiency of the Yangtze River Economic Belt. The specific formula is as follows:

$$\min \rho = \frac{1 + \frac{1}{m}\sum_{i=1}^{m} \frac{s_i^x}{x_{ki}^t}}{1 - \frac{1}{n+r}\left(\sum_{\theta=1}^{n} \frac{s_\theta^y}{y_{k\theta}^t} + \sum_{\mu=1}^{r} \frac{s_\mu^b}{b_{k\mu}^t}\right)} \tag{3}$$

$$\text{s.t.}\begin{cases}\sum_{j=1,j\neq k}^{n1} z_j^t x_{ji} - s_i^x \le x_{ki}^t \\ \sum_{j=1,j\neq k}^{n1} z_j^t y_{j\theta} + s_\theta^y \ge y_{k\theta}^t \\ \sum_{j=1,j\neq k}^{n1} z_j^t b_{j\mu} - s_\mu^b \le b_{k\mu}^t \\ 1-\frac{1}{n+r}\left(\sum_{\theta=1}^{n}\frac{s_\theta^y}{y_{k\theta}^t}+\sum_{\mu=1}^{r}\frac{s_\mu^b}{b_{k\mu}^t}\right)>0 \\ z_j^t, s_i^x, s_\theta^y, s_\mu^b \ge 0\end{cases} \tag{4}$$

Where: ρ is the target efficiency value; m, n and r represent the number of input, expected output and unexpected output, respectively. $x_{ki}^t, y_{k\theta}^t, b_{k\mu}^t$ represents the i input factor, θ expected output and μnon-expected output factor of the k DMU in the t period. $s_i^x, s_\theta^y, s_\mu^b$ is the relaxation variable of input factor, expected output and unexpected output respectively, and $z_j^t$is the weight vector of decision unit. When ρ<1, the closer the value of ρ is to 1, the higher the green economic efficiency is. When there is an optimal solution ρ=1, it indicates that the green economy efficiency reaches the optimal.

Based on the super-efficiency SBM-Undesirable model, this paper constructs an input-output index system of green economic efficiency in the Yangtze River Economic Belt. Input index includes: labor input, capital input, energy input. Specifically, labor input is expressed by the number of employed persons in urban units; Capital input is expressed by the total investment in fixed assets of the whole society; Energy input is the total energy consumption of each region. The expected output index includes: economic benefit, social benefit and environmental benefit. Economic benefits are expressed by the real GDP of each province; Social benefits are expressed by the per capita wages of employed persons in urban units; Environmental benefits are expressed by urban per capita green space. For the measurement of undesirable output, this paper mainly considers from the perspective of wastewater and waste gas emissions, and takes the chemical oxygen demand emissions in wastewater and SO_2 emissions in waste gas of each region to represent the undesirable output, which are included in the evaluation model after reciprocal.

3.3. Gini Coefficient and Location Entropy

The Gini coefficient is commonly used as a measure of income distribution in a country or region, and as the methodology has developed, it has also been used to evaluate other resource distributions. Since the distribution of income resources and public infrastructure resources has similar connotations of social equity, Gini coefficient analysis is often adopted in the performance evaluation of social equity of urban public facilities resources, and the calculation formula is as follows:

$$G = 1 - \sum_{k=1}^{n}(P_k - P_{k-1})(R_k + R_{k-1}) \tag{5}$$

Where: G is the Gini coefficient of urban social equity performance. P_k is the cumulative proportion of population,k =1,2... n,$P_0 = 0$,$P_n = 1$.R_k is the cumulative proportion of the public infrastructure point. The closer the value is to 0, the more balanced the spatial distribution of public facilities resources, the higher the social equity performance, and vice versa.

By comparing the spatial distribution of resources with the spatial distribution of population, location entropy can make up for the deficiency that the Gini coefficient can only reflect the overall trend change in the region to a certain extent, and reveal the specific problems existing in the urban industrial layout. Based on the ratio between the per capita park green space service coverage of permanent residents in each province (city) and the per capita park green space service coverage of permanent residents in the study area, this paper analyzes the spatial pattern of social equity performance of urban park green space, and the calculation formula is as follows:

$$LQ_j = (M_j/D_j)/(M/D) \quad (6)$$

Where :LQ_j is the location entropy of J-space unit; M_j is the number of POI points of public infrastructure in J-space unit; D_j is the number of population in J-space unit; M is the number of POI points of public infrastructure within the research scope; D is the total population in the study area. According to the location entropy, each spatial unit is divided into several levels, which can effectively screen out the very high and very low spatial units.

With the development of digital economy as the background, this paper constructs a social equity performance evaluation system from the perspective of public infrastructure distribution. POI data of public service facilities in provinces (cities) (from Baidu map interest points) are used as research indicators.

3.4. Data Sources

According to the geographical distribution along the Yangtze River basin, the Yangtze River Economic Belt is spatially divided into three parts: upper reaches, middle reaches and lower reaches. The upstream covers Chongqing, Sichuan, Guizhou and Yunnan provinces. The middle reaches cover Jiangxi, Hubei and Hunan provinces. Downstream covers Shanghai, Jiangsu, Zhejiang and Anhui 4 provinces (cities). The data of all economic and social statistical indicators come from China Statistical Yearbook, China Social Statistical Yearbook, China Energy Statistical Yearbook, China Environmental Statistical Yearbook and wind database. For the missing index data of some years, the mean value method and the sequential method are used to supplement it. Since this paper considers 11 provinces (municipalities) to be equally important, all kinds of data in the upper, middle and lower reaches are respectively represented by the mean value of data in each province (municipality).

4. Empirical Analysis

4.1. Calculation Results and Analysis of Green Economy Efficiency

Using the super-efficiency SBM-Undesirable model, the green economy efficiency of each year is calculated, as shown in the average change trend of green economy efficiency of the Yangtze River Economic Belt during 2010-2021.

Figure 1 fully indicates that the green economic efficiency of the Yangtze River Economic Belt from 2010 to 2021 shows a fluctuating upward trend on the whole, but there is a distribution pattern of "higher downstream and lower upstream" green economic efficiency. From the perspective of sub-regions (upper, middle and lower reaches), there is regional heterogeneity of green economic efficiency in China at this stage, among which the green economic efficiency in the lower reaches has a large increase, and there is a trend of increasing gap with the middle and upper reaches.

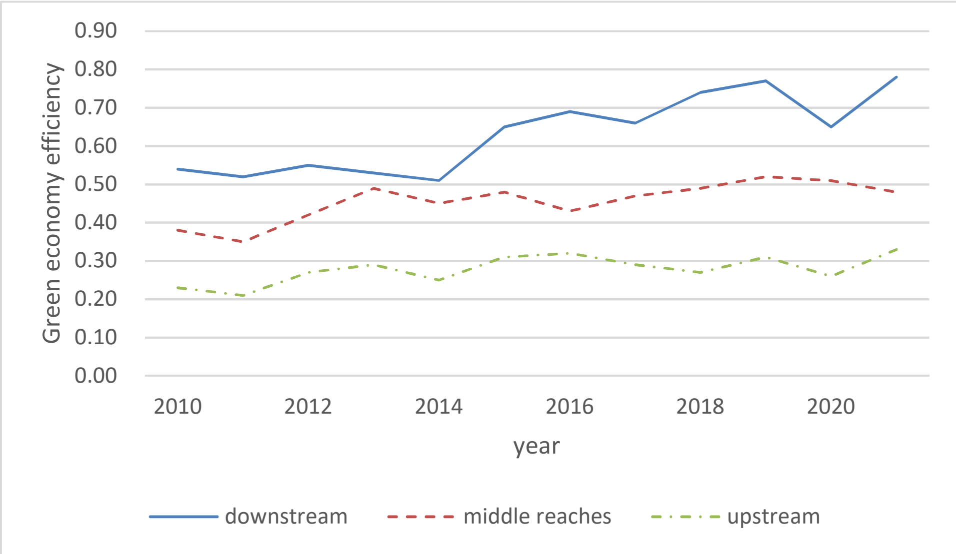

Figure 1. Sequential evolution characteristics of green economy efficiency in the Yangtze River Economic Belt

4.2. Measurement Results and Analysis of Social Equity Performance

Table 2 shows the Gini coefficient and location entropy of provinces (cities) in the Yangtze River Economic Belt in 2010, 2014, 2018 and 2021, based on which the social equity performance is evaluated.

Table 2. Gini coefficient and location entropy of provinces (cities)

		2010		2014		2018		2021	
region	Province (city)	Gini	Lo en	Gini	Lo en	Gini	Lo en	Gini	Lo en
downstream	Shanghai	0.30	1.31	0.29	1.30	0.29	1.33	0.27	1.34
	Jiangsu	0.37	1.63	0.38	1.65	0.38	1.65	0.36	1.66
	Zhejiang	0.37	1.52	0.37	1.49	0.39	1.53	0.36	1.55
	Anhui	0.40	1.29	0.38	1.25	0.37	1.28	0.37	1.31
Middle reaches	Jiangxi	0.39	0.97	0.38	0.99	0.38	0.97	0.38	1.02
	Hubei	0.39	0.97	0.39	1.01	0.39	0.96	0.38	1.04
	Hunan	0.42	1.14	0.43	1.15	0.42	1.20	0.41	1.18
upstream	Chongqing	0.43	0.75	0.42	0.75	0.44	0.78	0.43	0.77
	Sichuan	0.39	0.68	0.39	0.67	0.39	0.65	0.38	0.70
	Guizhou	0.48	0.45	0.48	0.47	0.48	0.48	0.48	0.49
	Yunnan	0.45	0.48	0.43	0.47	0.47	0.48	0.43	0.49

Note: Gini=Gini coefficient,Lo en=Location entropy.

As can be seen from Table 2, the spatial distribution of public infrastructure in provinces (municipalities) in the Yangtze River Economic Belt from 2010 to 2021 is relatively fair, and the social equity performance of all provinces maintains a good upward trend. It shows that since the new era, along with economic development, infrastructure has been gradually improved, social governance has been continuously strengthened, and social equity has been guaranteed and promoted.

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From the comparison of provinces, there are some differences in the performance of social equity in different regions, and the fairness of the spatial layout of public infrastructure in the downstream region is higher than that in the middle and upstream region. According to the results of location entropy, most of the regions are in the middle section, and there is no obvious polarization. As for a small number of outliers, they reflect some problems in equity, which can specifically show the unfairness caused by the lack of public infrastructure and the mismatch between facilities and population in space.

4.3. The Impact of the Development of Digital Economy on the Two

With green economy efficiency and social equity performance as explained variables, digital Economy Comprehensive Development Evaluation Index as explanatory variable, urbanization rate, technological innovation, investment level and environmental regulation as control variables, Among them, the urbanization rate, technological innovation, investment level and environmental regulation are respectively expressed by the proportion of urban population to total population, the proportion of scientific and technological expenditure to total financial expenditure, the proportion of total fixed asset investment to GDP and the completed investment in industrial pollution control.

When OLS is used to estimate panel data, it is first necessary to determine whether the fixed effects model or the random effects model should be used. The result of Hausman test with Stata showed that the P-value was less than 0.01, and the null hypothesis of random effects was rejected, so the fixed effects panel model was adopted. Then, the annual dummy variable is added to investigate whether there is an individual time effect. The result shows that the P value is less than 0.01, so the original hypothesis of "no time effect" is strongly rejected and the model is believed to have a time effect. Therefore, two-way fixed effect model is chosen.

Table 3. Regression results of panel model

variable	Green economy efficiency	Social equity performance
_cons	1.098^{***}	0.558^{***}
ln(dige)	0.147^{***}	0.029^{***}
ln(urbr)	0.121^{**}	-0.069^{*}
ln(teci)	0.083^{**}	0.067^{**}
ln(inve)	0.050^{**}	0.023^{**}
ln(envr)	0.164^{**}	0.086^{*}
R^2	0.932	0.919

Note: ***, ** and * are statistically significant at 1%, 5% and 10%, respectively.

It can be seen from the analysis results in Table 3 that digital economy has a positive impact on both green economy efficiency and social equity performance. The possible explanation is that the prosperity of the digital economy makes the internal and external exchanges in the region more convenient, and the infrastructure is increasingly perfect, which accelerates the transformation and upgrading of traditional industries, improves the efficiency of resource utilization, and reduces the unexpected output. Moreover, in the era of digital economy, advanced data processing technology and data centers have greatly improved the matching efficiency of supply and demand, and reduced the mismatch of resources by breaking the barriers of factor flow, which makes the performance of social equity grow rapidly.

Among the control variables, technological innovation, investment level and environmental regulation have significant positive effects on green economic efficiency and social equity performance. Fixed asset investment and scientific and technological innovation are conducive to the construction and improvement of digital infrastructure, so that regions can make full use

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of the digital economy to enable green and coordinated development. The urbanization rate has a positive effect on the green economic efficiency of the Yangtze River Economic Belt. However, it has a negative effect on the performance of social equity, indicating that the digital divide may occur in the development process of the digital economy, leading to the widening of the income gap between urban and rural residents, and the inequality of opportunities in employment, education and health care for urban and rural residents is becoming increasingly obvious.

4.4. The Dynamic Evolution of the Coupling Degree between the Efficiency of Digital Economy, Green Economy and Social Equity Performance

Coupling comes from the concept of physics and refers to the phenomenon that two or more intrinsically connected systems affect each other and even unite through interaction. The combination of coordination and development and integration, through the harmonious symbiosis between the elements to achieve complementary advantages and common good trend.

Coupling degree model:

$$C = 3\left[\frac{S_1 S_2 S_3}{(S_1 + S_2 + S_3)^2}\right]^{\frac{1}{3}} \tag{7}$$

Since the efficiency of digital economy, green economy and social equity performance are different in their respective development, there may be a situation where the calculated coupling degree is high while the development level is low and similar. Therefore, the coupling coordination degree model is constructed:

$$T = \alpha S_1 + \beta S_2 + \gamma S_3 \tag{8}$$

$$D = \sqrt{CT} \tag{9}$$

Where, C is the coupling degree, which measures the coupling effect between the efficiency of digital economy, green economy and social equity performance. D is the coupling coordination degree, reflecting the coupling coordination level of digital economy, green economy efficiency and social equity performance; T is the coordination degree index, quantified as the coordinated development degree of digital economy, green economy efficiency and social equity performance; S_1, S_2, S_3 is the calculated digital economy comprehensive development evaluation index, green economy efficiency and social equity performance comprehensive index; α, β, γ is the undetermined coefficient. Considering that the efficiency of digital economy and green economy has A certain correlation with the performance of social equity, and the three are gradually playing an equally important role at this stage, $\alpha = \beta = \gamma = 1/3$ is set.

After the coupling degree is obtained, in order to facilitate the description and analysis, the coupling degree is discussed in segments, and the median segmentation method is commonly used. By referring to the existing research results, the interval of coupling coordination degree is allocated and the coordination level of different levels is determined, and Table 4 is obtained as follows.

Table 4. Table of coupling types by region

	2010		2014		2018		2021	
region	deg	type	deg	type	deg	type	deg	type
downstream	0.64	Prim	0.70	Inter	0.79	Inter	0.83	Good
Middle reaches	0.55	Forced	0.58	Forced	0.66	Prim	0.71	Inter
upstream	0.47	Border	0.51	Forced	0.59	Forced	0.67	Prim

Note: deg=Coupling degree,type=Coupling type,

Prim=Primary coordination,Inter=Intermediate coordination,

Good=Good coordination,Forced=Forced coordination,

Border=Borderline disorder.

The coupling coordination degree can reflect the coordination status of the three systems of digital economy, green economy efficiency and social equity performance in the Yangtze River Economic Belt. As can be seen from Table 4, the coupling degree of provinces (cities) in the Yangtze River Economic Belt has been increasing year by year, and will reach a state of primary coordination or even better by 2021.

4.5. Analysis of Coefficient of Variation

In order to more clearly explore the differences in coupling degrees of various regions of the Yangtze River Economic Belt, the difference values are calculated based on the upper, middle and lower reaches and the coefficient of variation formula, as shown in Figure 2. Among them, the smaller the coefficient of variation means that the coupling degree gap between provinces in a certain region has a decreasing trend.

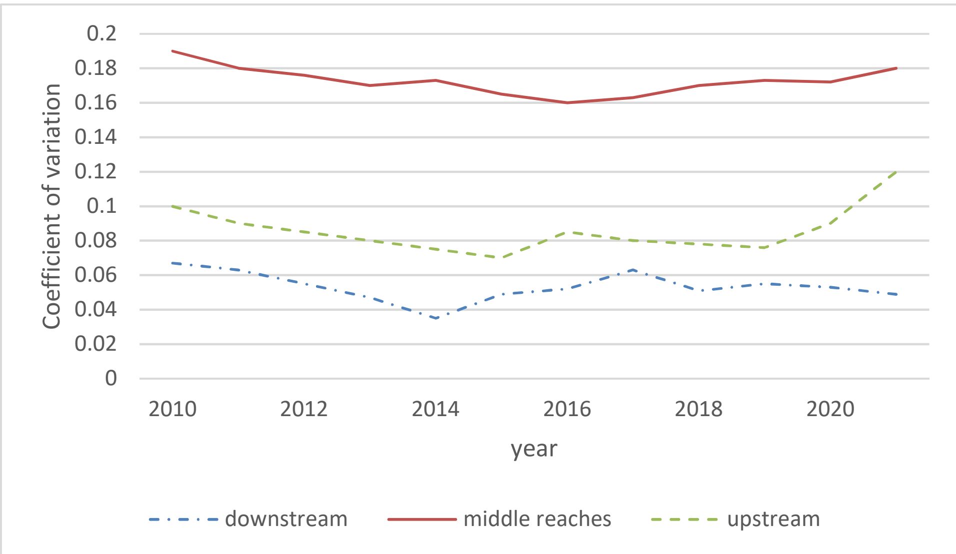

Figure 2. Trend chart of coefficient of variation

As can be seen from Figure 2, the coefficient of variation in the downstream region has the characteristics of fluctuation and decline, indicating that the coupling degree development among provinces (cities) in the region gradually tends to be balanced. The coefficient of variation values in the middle and upper reaches of the Yangtze River Economic Belt decreased first and then increased, and were higher than those in the lower reaches, indicating that the coupling degree of digital economy, green economy efficiency and social equity performance of provinces (cities) in the Yangtze River Economic Belt is characterized by regional heterogeneity imbalance. On the one hand, it may be because of the uneven economic conditions and infrastructure in different places, which makes the development of digital economy greatly different. The downstream economic center has a strong driving effect on the surrounding areas, while the economic center and spillover effect in the middle and upstream regions are weaker than the downstream. On the other hand, the downstream region, with its strong location advantages, rich resource conditions and strong economic strength, can quickly adapt to the development of the digital economy and make full use of the advantages brought by its development. On the contrary, the middle and upper reaches cannot keep up with the development of the digital economy due to the impact of economy, resources and policies, and the digital divide between regions leads to the disconnection between the development of the middle and upper reaches and the downstream regions.

5. Driving Factor Analysis

5.1. Tobit Model

Since the coupling degree is between 0 and 1 and is a restricted dependent variable, the traditional least square method will lead to estimation bias. Therefore, in order to solve this problem, the Tobit model is adopted to empirically analyze the factors influencing the coupling degree of digital economy, green economy efficiency and social equity performance of provinces (municipalities) in the Yangtze River Economic Belt, and the following specific models are established:

$$y_{it} = \begin{cases} \alpha x_{it} + \varepsilon_{it}, when\ \alpha x_{it} + \varepsilon_{it} > 0 \\ 0, \quad other \end{cases} \tag{10}$$

Among them, the explained variable y_{it} is the coupling degree of the three in the t year of the i province of the Yangtze River Economic Belt; x_{it} is the independent variable and α is the parameter to be estimated; $\varepsilon_{it} \sim N(0, \sigma^2)$.

5.2. Variable Selection

In order to further explore how the development of digital economy drives the coupling degree of the three, three factors with greater weight are selected from the above digital economy indicator system, namely, the length of long-distance optical cable lines, software industry income and the total amount of data trading centers. Stata software is used to build a panel Tobit model to explore the strength of each factor's influence on the coupling degree.

5.3. Regression Results

Table 5. Regression results of Tobit model

Explanatory variable	Coupling degree
constant	0.043**
Length of long distance optical cable line	0.178*
Software revenue	0.054**
Total number of data trading centers	0.088**

The regression results show that the regression coefficients of long-distance cable line length, software industry income and total data transaction center on coupling degree are all positive, indicating that with the improvement of the overall layout of digital construction and the digital penetration of traditional industries, the efficiency of digital economy, green economy and social equity performance are mutually dependent and complementary, and jointly promote the high-quality development of the region.

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6. Robustness Test

In order to check the stability of the regression results, the robustness test was carried out by piecewise regression method. The Fifth Plenary Session of the 18th CPC Central Committee proposed the implementation of the network power strategy and the national big data strategy to expand the network economy space, which shows that the country attaches more and more importance to the development of the digital economy. Taking the time of the Fifth Plenary Session of the 18th CPC Central Committee as a node, this paper divides the time into two stages for regression: 2010-2015 and 2016-2021. The regression results are shown in Table 6 and Table 7. (Note: ***, ** and * are statistically significant at 1%, 5% and 10%, respectively).

Table 6. Robustness test results

	Green economy efficiency		Social equity performance	
variable	2010-2015	2016-2021	2010-2015	2016-2021
_cons	−0.012***	0.197***	0.365***	−0.039***
ln(dige)	0.085***	0.172**	0.007***	0.010***
ln(urbr)	0.061**	0.193*	−0.121**	−0.074**
ln(teci)	0.077**	0.091**	0.050**	0.121**
ln(inve)	0.033**	0.064**	0.011**	0.015**
ln(envr)	0.110**	0.173**	0.076*	0.092*
R^2	0.874	0.886	0.719	0.831

Table 7. Robustness test results

	Coupling degree	
Explanatory variable	2010-2015	2016-2021
Constant	0.112**	0.043**
Length of long distance optical cable line	0.134**	0.199**
Software revenue	0.041**	0.100**
Total number of data trading centers	0.077*	0.108**

The stability of the results can be seen from Table 6 and Table 7, thus confirming the correctness of the conclusions in this paper.

7. Conclusion and Recommendations

The main conclusions of this paper are as follows: From 2010 to 2021, the green economy efficiency and social equity performance of provinces (municipalities) in the Yangtze River Economic Belt show a trend of fluctuation and rise on the whole, and the development of digital economy plays a positive role in promoting the two. In terms of regional comparison, there are still significant differences in green economic efficiency and social equity performance in the middle and upper reaches compared with the lower reaches, and there is room for improvement. The coupling degree of digital economy, green economy efficiency and social equity performance has the characteristics of regional heterogeneity imbalance, and the overall performance is "high downstream and low upstream". In the further analysis of the driving impact of digital economy on the coupling degree, it is concluded that the three indicators that have a greater impact on the digital economy, namely, the length of long-distance cable lines, software industry income and the total amount of data trading centers, have a positive impact on the coupling degree. According to the conclusion, this paper can get the following enlightenment:

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In order to promote the high-quality development of provinces in the Yangtze River Economic Belt and narrow the gap between provinces and urban and rural areas caused by the development of digital economy, we need to optimize the industrial and economic growth structure, firmly adhere to the concept of sustainable development, and enhance the development efficiency of green economy through efficient use of resources and technological innovation and progress. At the same time, it is necessary to improve infrastructure construction, accelerate the reform of the distribution system, and achieve equal emphasis on economic development and social equity.

Be alert to the risk of digital divide. Although the digital economy can promote economic growth, it will affect social equity through monopolies, digital divide and other channels. Especially at the urban and rural level, provinces (cities) should not blindly pursue the expansion of urban scale and the improvement of digital facilities, but should put the improvement of quality and function in the first place, appropriate aggregation, reasonable planning, and promote the integration of urban layout and function. At the same time, it is necessary to cater to the policy and vigorously promote the rural revitalization strategy, narrow the gap between urban and rural residents' income and public service level, and achieve stable and coordinated development between urban and rural areas.

Due to the influence of geographical location, resource endowment and national policies, there is still a certain gap in the coupling degree between the middle and upstream regions and the downstream regions. It is necessary to speed up the construction of digital infrastructure, make full use of the advantages brought by the rise of digital economy, give play to the radiation effect between regions, so as to enhance the mutual exchanges between different regions, and realize the sharing of ideas, resources and technologies to a certain extent. Make green harmony, fairness and stability become the main theme of development.

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