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Analysis of Regional Differences and Influencing Factors of China's Digital Economy Development

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Abstract. With the emergence of the digital wave, the problem of regional imbalance in the development of China's digital economy remains serious. The purpose of this research is to scientifically construct a system of indicators of China's digital economy development level and to dissect the spatial and temporal evolution characteristics of China's digital economy development. The hypothesis is that the larger the comprehensive index of digital economy development level, the higher the level of digital economy development, the larger the Gini coefficient, the more obvious the difference in digital economy development level. The innovation is the construction of an evaluation index system for digital economy development level, the measurement of China's digital economy development level, and the analysis of the differences between the three regions. The theoretical significance is that it enriches the evaluation index system of China's digital economy development level and provides theoretical support. The practical significance is that it promotes the realization of high-quality economic and social development in China. The results of the research show that overall, the level of China's digital economy development is steadily increasing, but the phenomenon of inter-regional differences is evident, while the degree of variation is gradually decreasing. In terms of the driving factors, the level of economic development, industrial structure, intellectual property protection and technological development all contribute significantly to the development of the level of the digital economy, while government intervention inhibits the development of the digital economy.

Key words: digital economy development level; regional differences; Gini coefficient; Tobit model; indicator system.

JEL C54, E65

1. Introduction

In the era of economic globalization, the digital economy has become the core engine of economic development, not only in promoting faster growth of gross domestic product (GDP), but also in improving productivity, promoting the transformation of consumption structure, optimizing investment structure, increasing enterprise export scale, Improve the quality of human capital and lead the development of new smart cities. The «White Paper on China's Digital Economy Development and Employment (2020)» released in 2021 pointed out that the scale of China's digital economy in 2020 will reach 39.2 trillion-yuan, accounting for 38.6% of the national GDP %, the status of the digital economy in social and economic development is further highlighted. From the overall level, China's digital economy has developed rapidly, and its growth rate has ranked first in the world for three consecutive years.

However, the development of digital economy faces a series of unbalanced real problems in various regions of China. The

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eastern region is significantly higher than the central and western regions, and the prominent regional imbalance is mainly reflected in the carrying capacity of communication technology and economic and technological foundation, which shows that China The development of the overall level of the digital economy depends more on the regional economic foundation and technological application capabilities.

Therefore, evaluating the degree of regional differences in the development level of China's digital economy and understanding the main reasons for the uneven development of China's digital economy are of great strategic significance for promoting policy formulation for the coordinated development of China's digital economy and narrowing the differences in China's regional economic development.

China is one of the fastest growing digital economies in the world. It is already one of the world leaders in some respects and is likely to strengthen its position further in the coming years. Three of the ten largest Internet-based companies in the world (Tencent, Alibaba and Baidu) are Chinese [1]. Large companies – smartphone maker «Xiaomi» and search engine technology and massively multiplayer online game developer «NetEase» – are also Chinese. in 2016, 64 online platforms were operating in China, almost as many as in the US (63), and they are more innovative, mainly due to government support.

In the era of the digital economy, not only developed countries will benefit, but also many developing countries in a period of accelerated economic development can take advantage of the digital economy's latecomer advantage to narrow the gap between their economic development, which is an important opportunity to achieve a national economic leap forward. The development of the digital economy is an inevitable trend that is guided by a new round of technological and industrial revolutions. The speed of digital technology innovation and iteration is increasing, and it has become the most widely used technology innovation field with the strongest radiation-driven effect and the richest collection of innovative elements.

In recent years, major economies around the world have gradually introduced long-term digital development policies related to the digital economy, hoping to build a new digital-driven economic development system and form a new competitive advantage globally by virtue of their advantages in long-term development in the fields of technology and information. With the evolution and intensification of economic globalization and global competition, the development of the digital economy has gradually become an important part of seizing the opportunities brought about by the new round of technological revolution, achieving positive national development in the future and winning the initiative in international competition [2].

The purpose of this research is to scientifically construct a system of indicators of China's digital economy development level and to dissect the spatial and temporal evolution characteristics of China's digital economy development.

H1: The hypothesis is that the larger the comprehensive index of digital economy development level, the higher the level of digital economy development.

H2: The hypothesis is that the larger the Gini coefficient, the more obvious the difference in digital economy development level.

2. Literature review

A brief overview of digital economy research in China and abroad

The term «Digital Economy» was first coined by the American businessman Tapscott Don (1996), who is recognized as the «father of the world's digital economy» [3]. He discussed the impact of the

Internet on the economy in detail and pointed out that the development of e-commerce will determine the future development trend of the digital economy, but he did not conduct in-depth quantitative research on the digital economy. The digital economy is an important driving force for a more equitable and efficient digital transformation.

According to Huang Jie [4], the digital economy is a new economic form with data resources as the key element, modern information networks as the main carrier, the convergence of information and communication technology applications, and the digital transformation of all factors as an important driving force to promote fairness and efficiency.

Wen Jun [5] believes that the digital economy can drive the expansion of China's economy, and its impact on employment in technology-intensive manufacturing is stronger than that in labor-intensive and capital-intensive industries. China's digital transformation will bring productivity improvements and innovations Speed up.

According to Zhao [6], with the widespread use of the digital economy, on the one hand, each sector has effectively improved its own operational efficiency; on the other hand, it has also provided better, more convenient and higher-end network technology and product services.

According to Yang Wenpu [7], the digital economy, with its characteristics of speed, high penetration and external economies, has become a new driving force for economic growth and may even lead to a third industrial revolution.

The development of the digital economy has given rise to new consumption and business models, changed the way value is created and captured, and has had a profound impact on entrepreneurship at both the theoretical and practical levels [8].

According to Han Pioneer [9], the development of the digital economy has not only accelerated the accumulation of production factors and advanced the process of production in the production sector, making it possible to reduce the cost of matching the supply and demand of innovation factors, but also promoted the upgrading of industrial chains, giving rise to a large number of new products and technologies, and driving the efficiency of innovation upwards.

According to Ding Yulong [10], the digital economy refers to a series of economic activities that use digital knowledge and information as key factors of production, modern information networks as important carriers, and the effective use of ICT as an important driving force for efficiency improvement and economic structural optimization.

According to Tang Yaojia [11], the digital economy has significant supply-side and demand-side economies of scale, which can unlock the full potential of economic growth.

According to Mao Fengfu [12], the digital economy is a more advanced economic form after the agricultural and industrial economies. It is based on network information technology, using data as a factor of production, and through the deep integration of digital technology and the real economy, it continuously improves the digitalization, networking and intelligence of the economy and society, accelerates the reconstruction of the economic development and governance model, and achieves sustainable economic development.

Belozerov S. A. [13] considers that the spread and improvement of digital technologies affect the development of industrial relations, economic structures and education and determine new requirements for communication, computing power, information systems and services.

Guzov Y. N. [14] believes that the biggest innovations in the digital economy are: the emergence of artificial intelligence and

robotics, cryptocurrencies, smart factories, smart cities, smart things, blockchain technology, etc.

Strelkova I. A. [15] argues that in today's business world, the digital economy is understood as a rapidly growing economic sector that is completely reshaping familiar business relationships and existing business models.

Lapidus L. V. [16] believes that the digital economy in a broad sense is «all relationships formed in the process of production, distribution, exchange and consumption based on network technology to meet the needs of daily necessities, which in turn involves new ways of economic management and the formation of the method requires effective national supervision means. The digital economy in the narrow sense is online consumption and transactions on the Internet, which are related to e-commerce and electronic technology. The relationship between Industry 4.0 and the digital economy is part and whole».

The digital economy has been a buzzword at global economic and political events in recent years, and has been a major topic at the G20 Hangzhou Summit in 2016, the G20 Hamburg Summit in 2017 and the BRICS Xiamen Summit in 2017 [17].

The current research literature on China's digital economy focuses on the discussion of China's digital economy development strategy and comparative studies with other countries. Most scholars believe that with the deepening of digitalization, the combination of digital technology and traditional industries can realize the rapid and green development of GDP, realize the transformation of consumption structure, improve the quality of human capital, and drive the industrial economy from labor-intensive to technology intensive. However, some scholars believe that the current development of China's digital economy has problems such as unbalanced, insufficient, and uncoordinated development, mainly in the fields of digital infrastructure, digital industry upgrading, information network security, digital technology penetration and deep integration of traditional industries [18].

Zhang Xueling [19] mainly constructed a provincial digital economy development evaluation system from two aspects: the level of regional economic and social development, the foundation and potential of informatization development. Objectively revealed the main factors and regional development characteristics of the digital economy between provinces restricting balanced development.

Some scholars have also studied the differences and causes of regional digital economy in China's Yangtze River Economic Belt and Northeast China. Han [20] used Kernel density estimation and the Dagum Gini coefficient to analyze the unevenness and regional differences of the digital economy in China and the three major regions, and found that there were significant regional differences in the digital economy between provinces. With the acceleration of the globalization process, the digital economy has also become an important driving force for the open economy, so many scholars focus on analyzing the international comparison of the level of the digital economy.

In summary, as China's digital economy is at an early stage of development, few studies have been conducted on China's digital economy, focusing mostly on the qualitative analysis of its connotations and characteristics. In the study of the spatial development of the regional digital economy, scholars have rarely explored and analyzed the spatial pattern of China's digital economy development and the factors influencing the differences. At present, there are problems of unbalanced, insufficient and uncoordinated development of China's digital economy, and there are obvious

regional differences in the digital economy among provinces. The digital economy plays an important role in the coordinated development of China's regional economy. Therefore, measuring the degree of spatial differences in the level of development of China's digital economy and understanding the main causes of spatial differences in the development of China's digital economy are of great significance in promoting the formulation of policies for the coordinated development of China's digital economy and thus reducing the differences in the development of China's regional economy.

The current state of development of China's digital economy

The digital economy is an economic activity in which data in digital form is a key element of production, and the processing of large amounts of data and the analysis of their use has led to significant improvements in the efficiency of the delivery of various types of production, technology, equipment, storage, sales, goods and services compared to traditional forms of economic activity [21].

The digital economy is a system of economic, social and cultural relations based on the use of digital technology. It is sometimes referred to as the internet economy, the new economy or the network economy [22].

The digital economy, as an innovative economic model [23], is the result of the convergence of big data, the Internet and artificial intelligence technologies, among others [24]. It covers all real and non-real economic sectors that involve the use of the Internet, big data and artificial intelligence. The digital economy is gradually gaining weight in China's national economy, becoming a core component of the economic system and an important growth pole and new driving force for China to catch up with developed countries, narrow the gap between the rich and the poor and achieve common prosperity [25–27]. From the present perspective, the construction of China's digital economy is moving forward at a revolutionary pace.

1. Overall level of development of the digital economy

According to the «Global Digital Economy White Paper» published by the China Academy of Information and Communication Technology, the digital economy of 47 countries is estimated to be worth US$32.6 trillion in 2020, accounting for 43.7 % of GDP. At the national level, the US ranks first in the world in terms of digital economy, with US$13.6 trillion. China's digital economy is the second largest in the world at US$5.4 trillion, with a year-on-year growth rate of 9.6 %, ranking first in the world. Germany, Japan and the UK ranked third to fifth in terms of digital economy size, with US$2.54 trillion, US$2.48 trillion and US$1.79 trillion respectively (Figure 1).

In terms of the overall size of China's digital economy, it is growing. According to data (Figure 2), the digital economy will grow from RMB22.6 trillion in 2016 to RMB39.2 trillion in 2020, and its share in GDP will grow from 30.3 % in 2016 to 38.6 % in 2020, both of which are maintaining a stable growth trend. In terms of the global ranking of the total size of the digital economy, China's digital economy has become a core driver of economic growth.

At present, the digital economy is developing at a faster pace in China's provinces and cities [28]. In 2020, 13 provinces and cities in China had a digital economy of more than RMB1 trillion, mainly in the southeast coastal region with a high level of economic development, while Guangdong, Jiangsu and Shandong were the top three provinces in China in terms of digital economy size. In terms of percentage, Beijing and Shanghai's digital economy accounted

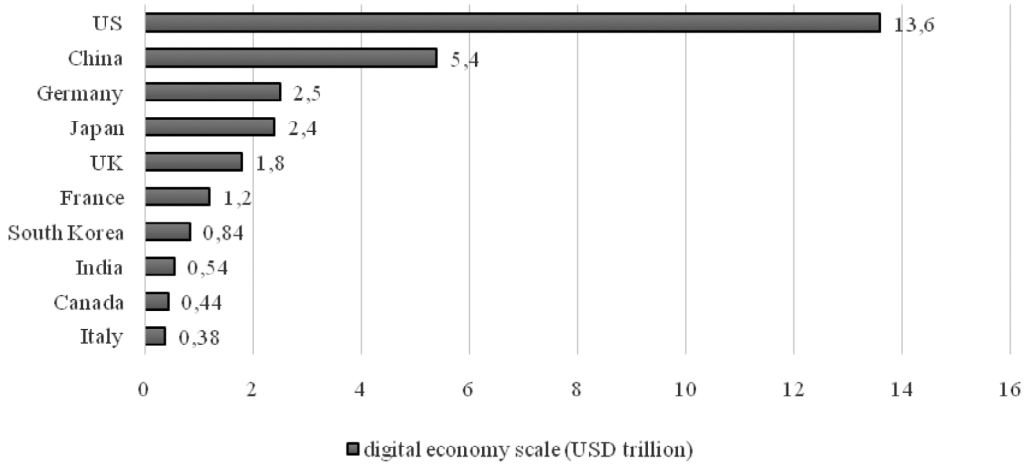

Figure 1. Top 10 global digital economy scale in 2020

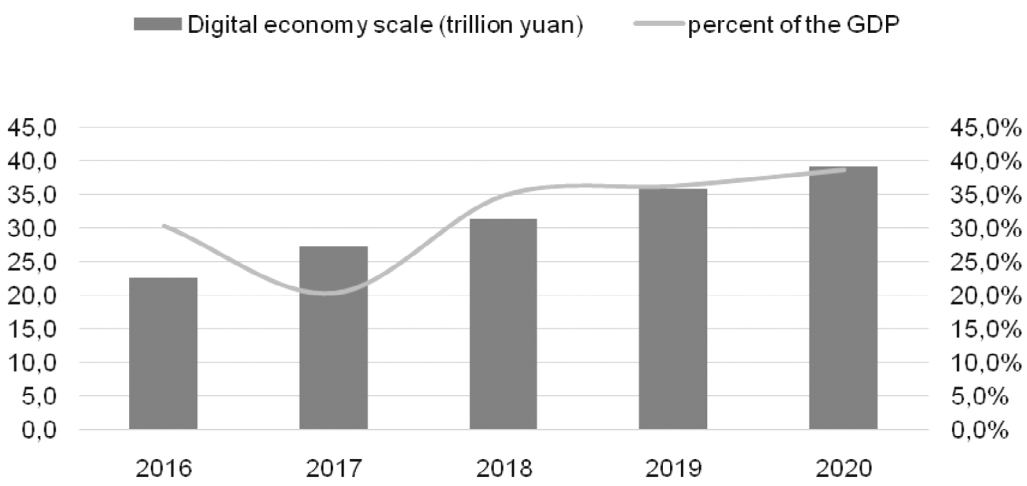

Figure 2. China's digital economy development scale and its proportion in GDP from 2016 to 2020

for more than 50% of GDP, reaching 55.9% and 55.1% respectively, ranking among the top in China, indicating the dominance of Beijing and Shanghai's digital economy in economic development.

2. Digital industrialization development

The continued optimization of the structure of the digital economy has contributed to the steady development of digital industrialization [29]. In 2020, the scale of digital industrialization will reach RMB7.5 trillion, accounting for 7.3% of GDP. From the perspective of digital industrialization, China has entered a transition period from focusing on digital product production and digital consumer market cultivation to focusing on digital technology research, data factor value release and digital industry cluster development.

3. Penetration of the digital economy into the industry

The digital economy plays an important role in the process of industrial modernization [30]. In 2020, the digital economy in services, industry and agriculture

will account for 40.7%, 21.0% and 8.9% of the industry's value added respectively, an increase of 11.1%, 4.2% and 2.7% respectively from 2015, with China's agriculture having a weaker need for digital transformation and services being the fastest growing area of industry digitization (Figure 3).

In particular, the digital economy is deeply integrated with education, medical and catering industries. In 2020, the user scale of online payment, online shopping and online live streaming will grow more significantly, with 850 million, 780 million and 620 million people respectively. Major countries and regions around the world have introduced strategic plans related to the digital economy, which has penetrated into all areas of production and life, and its ability to effectively improve the efficiency of economic operations, boost the transformation of traditional industries to high-tech industries, and provide a guarantee for the global economy to achieve high-quality development.

Overall, the development trend of China's digital economy is stable, and the digital economy is leading the transformation and upgrading of traditional industries at an accelerating pace. At present, Chinese companies such as Huawei and Xiaomi are using the digital economy to integrate innovative technologies to build high-end brands and have successfully taken their place in global development.

3. Research methodology

3.1. Research methods

Entropy method [31, 32]. The entropy method has the advantage of objective assignment, which is used in this paper to measure the level of development of the digital economy.

Calculate the weight of the *i-th* evaluation indicator under the *j-th* indicator P_{ij} as:

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}, \quad i = 1, 2, ..., n. \qquad (1)$$

Calculate the entropy value E_j of the *j*-th evaluation indicator as:

$$E_j = \frac{1}{Ln(m)} \sum_{i=1}^{m} p_{ij} Ln\left(p_{ij}\right), \quad j = 1, 2, ..., n. \qquad (2)$$

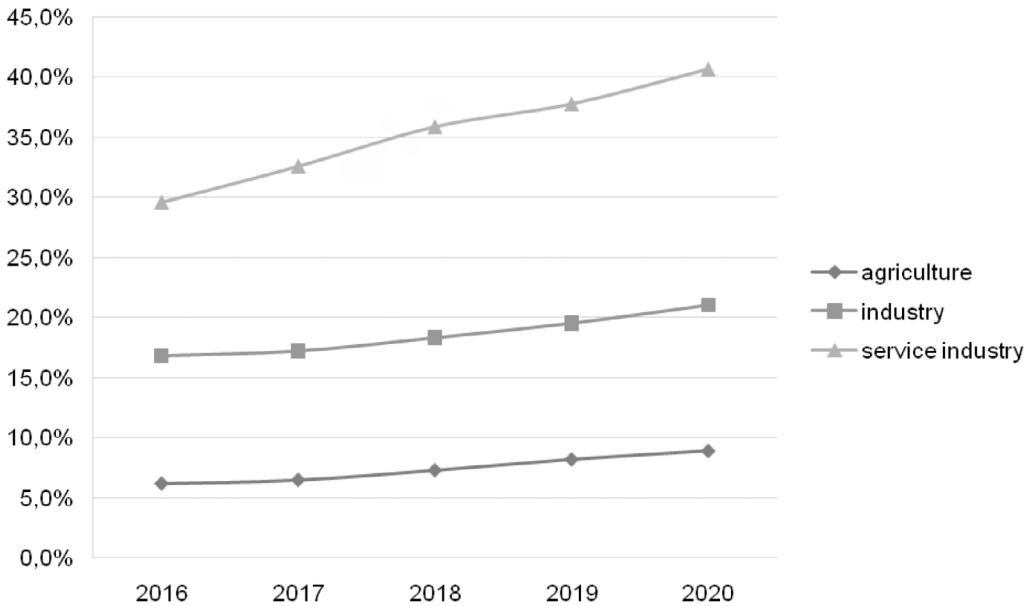

Figure 3. China's digital economy penetration rate from 2016 to 2020

Calculate the weight of the *j*-th evaluation indicator ω_j as:

$$\omega_j = \frac{1-E_j}{\sum_{j=1}^{n}\left(1-E_j\right)}, \quad j=1,2,...,n. \quad (3)$$

Calculation of the level of development of the digital economy by region:

$$Z_I = \sum_{j=1}^{n} \omega_j y_{ij}, \quad j=1,2,...,n. \quad (4)$$

The formula calculates a score between 0 and 1. It should be noted that if the value of an indicator is exactly equal to the maximum or minimum value, its normalized value is 1 or 0.

Dagum Gini coefficient and its decomposition. This paper uses the Gini coefficient decomposition method proposed by Dagum [33, 34] to identify regional differences in the digital economy and their sources. In this paper, regional differences are decomposed into three main components: intra-regional differences, inter-regional differences and hyper-variance density. The Gini coefficient is defined by the following equation:

$$\frac{\sum_{i=1}^{k}\sum_{h=1}^{k}\sum_{j=1}^{n_i}\sum_{r=1}^{n_h}\left|y_{ij}-y_{hr}\right|}{2n^2\mu}. \quad (5)$$

In equation (1), G is the overall Gini coefficient, which represents the relative difference in the digital economy levels of all provinces and municipalities, with larger G indicating larger differences. Where n is the total number of provinces, *k* is the total number of regions (*k* = *3*, East, Central and West respectively), y_{ij} is the digital economy level of *j* provinces in region *i*, and μ is the average digital economy water of all provinces.

The Dagum decomposition method is then used to derive: the intra-subgroup Gini coefficient G_{jj} and the contribution of intra-subgroup variation to the total G_w in Equation (2) and Equation (3); the inter-subgroup Gini coefficient G_{jh} and the contribution of inter-subgroup variation to the total G_{nb} in Equation (4) and Equation (5); and finally, the contribution of hyper-variance density G_t in Equation (6).

$$G_{ij} = \frac{1}{2\overline{y_j}n_j^2}\left(\sum_{i=1}^{n_i}\sum_{r=1}^{n_j}\left|y_{ij}-y_{hr}\right|\right), \quad (6)$$

$$G_w = \sum_{i=1}^{n_j} G_{jj}P_jS_j, \quad (7)$$

$$G_{jh} = \sum_{i=1}^{n_j}\sum_{r=1}^{n_h}\left|y_{ij}-y_{hr}\right| \Big/ n_j n_h\left(\overline{y_j}+\overline{y_h}\right), \quad (8)$$

$$G_{nb} = \sum_{j=1}^{k}\sum_{h=1}^{j-1} G_{jh}\left(P_jS_h+P_hS_j\right)D_{jh}, \quad (9)$$

$$G_t = \sum_{j=1}^{k}\sum_{h=1}^{j-1} G_{jh}\left(P_jS_h+P_hS_j\right)\left(1-D_{jh}\right). \quad (10)$$

P_j and S_j in Equation (3) and Equation (5) satisfy $=\frac{n_j}{j}$ and $=\frac{n_j y_j}{n_y}$, respectively. Specifically, y_{ji} in the above equation represents the level of digital economy of the *i-th* province and city in region *j*, and so on. Y_{ji} is the sum of the digital economy levels of all provinces and cities in region *j*, and so on. For D_{jh} the digital economy interaction between region j and region h is represented. The specific formula is as follows.

$$D_{jh} = \frac{d_{jh}-P_{jh}}{d_{jh}+P_{jh}}, \quad (11)$$

$$d_{jh} = \int_0^{\infty} dF_j(y)\int_0^{y}(y-x)\,dF_h(x), \quad (12)$$

$$d_{jh} = \int_0^{\infty} dF_h(y)\int_0^{y}(y-x)\,dF_j(x). \quad (13)$$

The d_{jh} of equation (8) is the difference in digital economic development between regions, specifically the mathematical expectation of the sum of the sample values for y_{ji}-y_{hr}>0. Similarly, pjh of equation (9) is the mathematical expectation of the sum of the sample values y_{hr}-y_{ji}>0. Finally, the contribution of intra-regional differences to the overall Gini coefficient is G_w; the contribution of inter-regional differences to the overall Gini coefficient is G_{nb}; and the contribution of hypervariable density to the overall Gini coefficient is G_t. The relationship between the three is $G = G_w + G_{nb} + G_t$.

The Tobit model [35, 36]. As this paper uses the entropy method to measure the level of development of the digital economy, it is limited to a range of 0–1. The Tobit model, which addresses the restricted dependent variable, is used to quantify the impact of the digital economy, as the following regression model is used:

$$Y_{it} = \begin{cases} Y_{it}^* = \alpha_0 + \sum_{i=1}^{n} \beta_i X_{it} + \mu_i Y_{it}^* > 0 \\ 0, \ Y_{it}^* \le 0 \end{cases}. \quad (14)$$

In Equation (10), Y_{it} is the level of digital economy development in province i at time t, x_{it} represents a set of influencing factors, α_0 and β_i represent the coefficients of the constant and independent variables respectively, and μ_i is the independent random error term and $\mu_i \sim (0, \sigma^2)$.

3.2. Indicator construction and data sources

According to previous scholarly research, there are two main types of evaluation of the digital economy, namely the single indicator approach and the composite indicator approach. Single indicator method uses a single indicator, the Digital Financial Inclusion Index, to measure the level of development of the digital economy. Composite indicator method uses a comprehensive indicator approach to measure the digital economy in three dimensions: informatization, Internet and digital transactions.

Compared with the single indicator method, this paper suggests that the composite indicator method can contain more information and more accurately reflect the level of development of the digital economy. In addition, there is no consensus in the existing literature on the indicators for measuring the level of development of the digital economy, nor is there an official document that defines the evaluation system of the digital economy. In view of this, the evaluation indicators of the digital economy in this paper are mainly based on the principles of accessibility, reliability and scientificity.

In terms of data sources, this paper uses panel data for 30 provinces and cities from 2013 to 2019 (including Tibet, Hong Kong, Macao and Taiwan, which are not included in the data). The evaluation indicators in the table and the driver indicators below are derived from the China Statistical Yearbook, the China Science and Technology Yearbook and provincial and municipal yearbooks from 2014 to 2020 (Table 1).

4. 4. Analysis of the results

4.1. Digital economy development level measurement results

The results of the DEDCI (Digital Economy Development Index) for 2011–2020, as measured by the entropy method described above (Table 2), show significant spatial and temporal heterogeneity in the level of development of the digital economy.

Table 2 shows that the average value of China's digital economy has increased from 0.128 to 0.799, with an average annual growth rate of 27 % and a significant increase in the development level by province. Specifically, in 2020, Jiangxi, Hunan, Guangxi and Sichuan are leading the way in terms of digital economy development,

Table 1. **Indicators for evaluating the level of development of the digital economy**

Indicators		Variables	Unit	Properties
Digital Economy Facilities	Network Foundations	Number of Internet domains	10,000 families	Positive
		Number of Internet broadband access subscribers	10,000 families	Positive
	Mobile Basics	Mobile phone penetration	%	Positive
		Number of mobile phone subscribers at the end of the year	10,000 families	Positive
	Data Infrastructure	Length of long-distance fibre optic cable routes	10,000m	Positive
Digital applications	Personal Applications	Total telecoms business	billionyuan	Positive
		Software product revenue size	billionyuan	Positive
		Size of information services revenue	billionyuan	Positive
	Corporate Applications	Number of businesses with e-commerce trading activities	indivual	Positive
		Number of manufacturing enterprises in the electronic information industry	indivual	Positive
Digitalisation of industry	Digitalisation of agriculture	Proportion of administrative villages with Internet broadband service	%	Positive

Table 2. **Measuring the level of development of China's digital economy by province, 2011–2020**

Provinces	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual average growth rate (%)
Beijing	0.067	0.102	0.198	0.298	0.371	0.419	0.501	0.565	0.724	0.846	35
Tianjin	0.100	0.150	0.180	0.250	0.412	0.461	0.408	0.507	0.705	0.846	29
Hebei	0.049	0.075	0.115	0.287	0.400	0.568	0.593	0.646	0.783	0.689	40
Shanxi1	0.104	0.124	0.140	0.187	0.308	0.355	0.402	0.565	0.667	0.864	27
Inner Mongolia	0.228	0.294	0.337	0.401	0.453	0.549	0.504	0.558	0.646	0.722	14
Liaoning	0.305	0.353	0.406	0.529	0.655	0.491	0.500	0.491	0.589	0.654	10
Jilin	0.236	0.254	0.251	0.276	0.391	0.473	0.561	0.619	0.532	0.569	11
Heilongjiang	0.208	0.208	0.280	0.432	0.550	0.529	0.589	0.508	0.536	0.552	13

End of table 2

Provinces	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual average growth rate (%)
Shanghai	0.146	0.185	0.213	0.322	0.438	0.420	0.399	0.493	0.680	0.846	23
Jiangsu	0.260	0.288	0.228	0.277	0.306	0.402	0.404	0.551	0.662	0.819	15
Zhejiang	0.127	0.222	0.209	0.254	0.383	0.490	0.435	0.547	0.680	0.792	25
Anhui	0.162	0.183	0.113	0.206	0.316	0.387	0.432	0.570	0.756	0.848	25
Fujian	0.157	0.217	0.227	0.221	0.354	0.460	0.529	0.614	0.732	0.697	20
Jiangxi	0.058	0.105	0.113	0.199	0.372	0.346	0.474	0.588	0.738	0.901	39
Shandong	0.072	0.105	0.205	0.287	0.394	0.552	0.545	0.760	0.767	0.838	34
Henan	0.165	0.190	0.227	0.340	0.394	0.487	0.515	0.652	0.707	0.808	20
Hubei	0.121	0.164	0.183	0.233	0.349	0.431	0.454	0.640	0.795	0.874	25
Hunan	0.047	0.077	0.105	0.218	0.308	0.452	0.484	0.577	0.732	0.907	42
Guangdong	0.111	0.157	0.164	0.239	0.346	0.407	0.431	0.618	0.773	0.851	27
Guangxi	0.085	0.111	0.137	0.196	0.232	0.308	0.340	0.474	0.739	0.910	31
Hainan	0.097	0.127	0.171	0.228	0.355	0.421	0.454	0.666	0.803	0.648	25
Chongqing	0.174	0.210	0.250	0.209	0.298	0.438	0.497	0.580	0.697	0.817	20
Sichuan	0.041	0.071	0.142	0.227	0.356	0.493	0.542	0.608	0.774	0.904	44
Guizhou	0.115	0.130	0.155	0.240	0.288	0.440	0.488	0.598	0.717	0.822	25
Yunnan	0.121	0.146	0.124	0.249	0.329	0.378	0.442	0.567	0.724	0.839	27
Tibet	0.081	0.102	0.086	0.202	0.260	0.367	0.344	0.401	0.515	0.786	34
Shanxi2	0.080	0.125	0.149	0.217	0.340	0.465	0.509	0.682	0.834	0.888	32
Gansu	0.116	0.083	0.149	0.202	0.344	0.512	0.508	0.615	0.742	0.827	29
Qinghai	0.066	0.122	0.133	0.220	0.443	0.567	0.443	0.552	0.707	0.841	38
Ningxia	0.110	0.135	0.129	0.303	0.379	0.494	0.579	0.683	0.792	0.843	30
Xinjiang	0.165	0.205	0.261	0.387	0.377	0.504	0.387	0.584	0.693	0.727	20
National average of DEDCI	0.128	0.162	0.186	0.269	0.371	0.454	0.474	0.583	0.708	0.799	27

while Beijing, Hebei, Shandong, Tibet, Shaanxi and Qinghai have the highest average annual growth rates, all exceeding 30%, and are still catching up in terms of digital economy development. However, it is undeniable that the inter-provincial gap is still more pronounced, but there is a clear trend of catching up.

The more economically developed provinces are, the higher the level of

development of the digital economy and the greater the contribution of the digital economy to the economy. From a micro perspective, the digital economy is rapidly changing the economic activities of the market and stimulating market dynamics. From a macro perspective, the digital economy is highly permeable to industry and is important for industrial transformation and upgrading.

The heterogeneity of digital economy development among provinces shows that there is still much room for development in regions with a low level of DEDCI. It is still a priority to improve the level of digital economy development in relatively backward regions, to narrow the gap between regional digital economy development levels and to avoid the widening of the «digital divide».

4.2. Regional differences in the level of development of the digital economy and their sources

Overall differences and differences within each region. As shown in Figure 4, the overall differences in the level of development of the digital economy across the country between 2011 and 2020 are gradually decreasing, and the overall development is showing a convergence trend.

However, when analyzed in terms of the three major regions, there are significant differences in the variation between the eastern, central and western regions. The overall difference in the level of digital economy in the eastern region is declining, in line with the national trend. However, while the central and western regions experience fluctuating trends, the overall Gini coefficient value is decreasing. This indicates that the overall difference in the level of the digital economy between the central and western regions is decreasing and that the degree of imbalance is diminishing.

In terms of the degree of disparity, the Gini coefficient in the central region tends to decrease before increasing, with the greatest overall disparity in the center compared to the east and west. The western region is decreasing its internal differences, while the eastern region forms the most unbalanced region, overtaking the central region.

Differences between regions. As shown in Figure 5, vertically, the Gini coefficient is decreasing from 2011 to 2018, while it is increasing from 2018 to 2020. The difference in digital economy levels

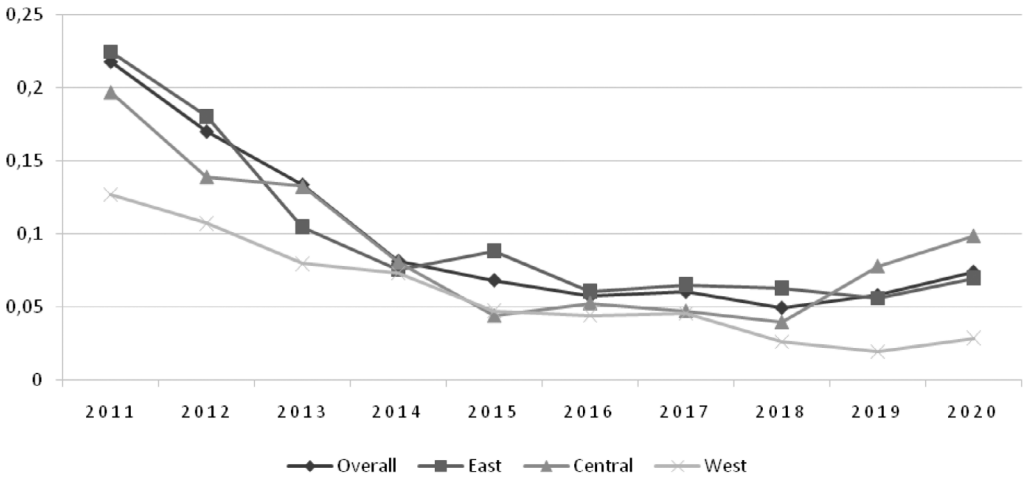

Figure 4. Gini Coefficient Trends of the Digital Economy in China as a Whole and by regions from 2011 to 2020

between East-Central and East-West is gradually decreasing.

Horizontally, the East-West curve is at the highest end of the curve, indicating that the gap between the digital economy in the East and the West is the largest, while the East-Central curve is at the middle of the curve, indicating that the gap between the digital economy in the East and the Central is in the middle, and the Central-West curve is at the lowest end of the curve, indicating that the gap between the digital economy in the Central and the West is in the middle. The East-Central curve is at the middle of the curve, indicating that the gap between the East and Central regions is in the middle, while the West-Central curve is at the lowest end, indicating that the gap between the Central and West regions is the lowest.

On the one hand, this is due to the strong economic base and technological advantages of the eastern region, as well as its relatively advantageous geographical location, which the western and central regions do not possess, thus resulting in a larger gap in the overall level of the digital economy between the east-central and east-west regions. In addition, the western region is more backward than the central region, so the difference between the east and west regions is the greatest.

On the other hand, due to the small difference in the overall level of development between the central and western regions, the Gini coefficient value is the lowest in the central-western region and the overall difference between the regions is not significant.

Sources of regional variation and contribution. As shown in Figure 6, in terms of contribution size, the intra-regional contribution, inter-regional contribution and hyper-variance density contribution showed a decreasing trend from 2011 to 2018 and an increasing trend from 2018 to 2020, but the intra-regional contribution showed a decreasing trend from 2019 to 2020 with less volatility.

The inter-regional contribution refers to the contribution of the differences in digital levels between East, Central and West to the differences in overall digital economy levels; the intra-regional contribution refers to the contribution of the differences within East, Central and West to the differences in overall digital economy levels; and the contribution of hyper-variable density is the contribution of the cross-over between the regions to the overall differences. Specifically, the contribution of hypervariable density is the

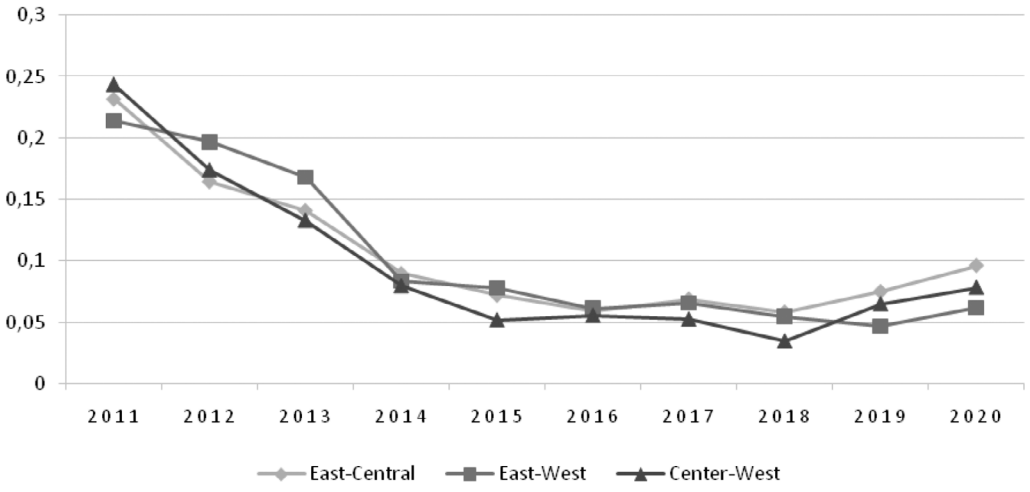

Figure 5. Trends in the evolution of the Gini coefficient between regions

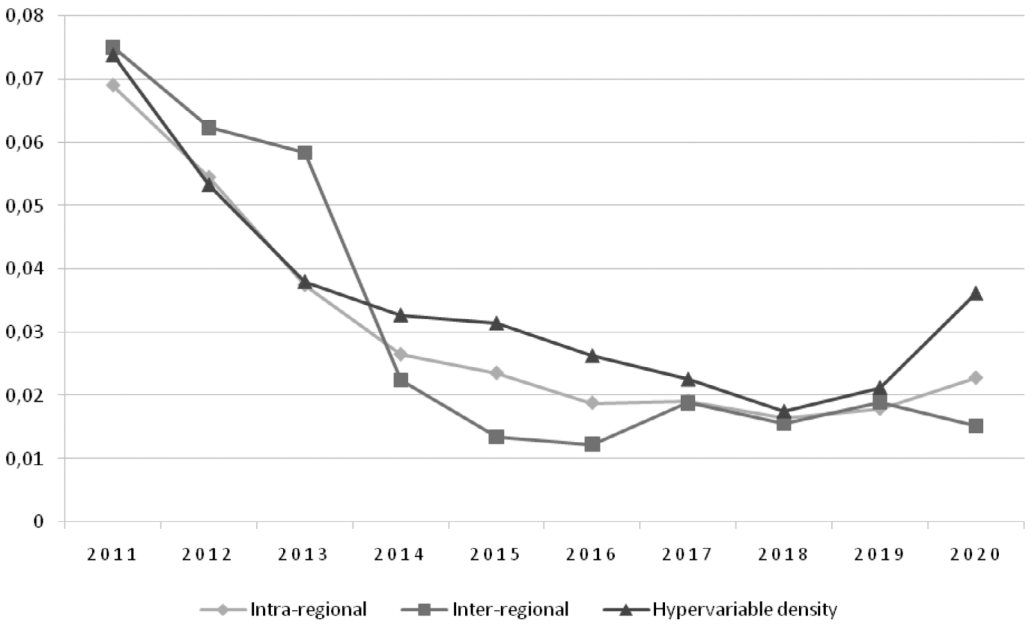

Figure 6. Sources and Contributions of Differences in the Development of Digital Economy Levels

largest, which indicates that the overall difference in the national digital economy is mainly caused by the difference in the level of digital economy among the eastern, central and western regions.

However, the trend of inter-regional contribution rate, intra-regional contribution rate and super-variable density contribution rate are converging and show a decreasing trend followed by an increasing trend. Therefore, from 2010 to 2020, the development of the digital economy in each region of the country is characterized by fluctuations.

4.3. Analysis of the drivers of the digital economy

The variables are selected. In this paper, a panel Tobit model is used to examine the drivers of the digital economy based on a combination of measures of the level of the digital economy and analysis of regional differences in the digital economy. In this paper, the level of digital economy development (*dge*) is the explanatory variable and the explanatory variables are:

(1) The level of economic development (*GDP*) expressed as deflated GDP.

(2) Industrial structure (*ind*) characterised by the share of value added of the tertiary sector in the value added of the secondary sector.

(3) Government intervention (*gov*) measured by government fiscal expenditure as a share of GDP.

(4) Intellectual property protection (*kgp*) characterised by the share of technology market transactions in GDP.

(5) Science and technology development (*tiv*) characterised by the ratio of science and technology expenditure to GDP.

Based on the above analysis, the baseline model can be further refined as:

$$Y_{it}=\alpha_0+\beta_1 gdp_{it}+\beta_2 ind_{it}+\beta_3 gov_{it}+ \\ +\beta_4 kgp_{it}+\beta_5 tiv_{it}. \quad (15)$$

Where Y_{it} is the explanatory variable, i. e. the digital economy index for each province in China; α_0 is the constant term; and β represents the parameter to be estimated. The regression results of the empirical model are shown in Table 3.

Table 3. **Empirical Model Regression Results**

Variables	Coefficient	Standard deviation	z Testing	P value
GDP	0.0484248	0.0054363	8.91	0.000
Ind	0.1050095	0.0104992	10	0.000
gov	-0.0595639	0.0704252	-0.85	0.398
kgp	0.3742951	0.3024838	1.24	0.216
tiv	1.979645	1.897498	1.04	0.297
cons	-0.1053401	0.0254007	-4.15	0.000

The regression analysis of the Tobit model shows that economic development is positively correlated with the level of development of the digital economy and passes the 1% significance level test. This result indicates that economic development in each province is conducive to the improvement of the digital economy and is a direct driver of the increase in the level of the digital economy.

On the one hand, the rapid economic development can increase the research on new technologies and industries, which in turn can promote the improvement of the digital economy; on the other hand, the rapid economic development makes people's needs increasing and the need to build a digital economy more urgent, which will prompt the current society to develop the digital economy.

Industrial structure is positively correlated with the level of development of the digital economy, and the coefficient is significant at the 1% level. This indicates that a good industrial structure can promote the development of the digital economy and is an important engine for the development of the digital economy. The current industrial structure is moving in the direction of technological upgrading, mainly reflecting the trend of high-tech industries as the leading industry, basic manufacturing as the foundation, and the overall development of the service industry. Accordingly, the development of the digital economy is reflected in the course of industrial structure optimization, and the optimization and upgrading of the industrial structure is conducive to the development of the digital economy.

There is a negative relationship between government intervention and the level of development of the digital economy. Currently, the development of the digital economy is jointly driven by the market and the government, etc. Government intervention affects the balance of the market structure to a certain extent and inhibits the long-term development of the digital economy.

The relationship between intellectual property protection and the level of development of the digital economy is positive, both passing the significance test of at least 10%. This indicates that improving the level of IPR protection can help improve the level of the digital economy. On the one hand, IPR protection is a key factor in stimulating the development of innovation in the digital economy; on the other hand, focusing on IPR protection can strengthen the awareness of property rights in the digital economy and create a harmonious atmosphere for building the digital economy.

The relationship between science and technology development and the digital economy is positive and passes the 10% significance test. This indicates that technological development contributes to the development of the digital economy. On the

one hand, technological development is a prerequisite for the development of the digital economy and can directly influence the innovative development of digital technology; on the other hand, technological development can promote the effective concentration of innovation resources, cultivate an innovation-driven atmosphere and drive the development of the digital economy.

5. Discussion

China's digital economy will grow at the highest rate in the world by 2020, and the size of the digital economy will reach US$5.4 trillion, ranking second in the world. However, compared with the United States and other developed countries, China's digital economy still has major shortcomings, which are reflected in the following aspects:

China's digital economy is developing with great regional disparities, and there is a «digital economy divide» and a huge imbalance in regional development. China's digital economy is developing rapidly, but it is still at a low level and has significant internal differences. The development pattern of the digital economy is consistent with that of the real economy, showing a gradient from east to west, but some provinces and regions show differences in digital economy development.

Insufficient digital infrastructure. First, China's total digital infrastructure is insufficient. 5G has now become an important strategic focus for digital infrastructure development. The number of 5G network users in China exceeds 160 million, and 5G is being built at a relatively fast pace, but 5G coverage still needs to be improved. Second, China's digital infrastructure development is uneven across the region. As of March 2020, there were 904 million Internet users in China, of which 71.8% were in urban areas and 28.2% were in rural areas. The «digital divide» between urban and rural areas exists mainly because of the backward digital infrastructure in rural areas.

The integration of traditional industries with digital technology is low. Digital technology can accelerate the digital and intelligent development of traditional industries, effectively improve production efficiency and reduce operating costs. Digital transformation can promote intelligent and networked manufacturing, achieve green, intelligent and innovative production, improve product and service quality, and accelerate the transformation of old and new industrial dynamics. At the same time, traditional industries provide important scenarios for the application, innovation and improvement of digital technologies, and the two complement each other. At present, the degree of integration between traditional industries and digital technology in China is relatively low, mainly in the following areas: First, the degree of integration between agriculture and digital technology is low. The second is the low level of integration between manufacturing and digital technology. The manufacturing industry is the key to economic prosperity, but China's manufacturing sector is large but not strong. Digital technology is an important driver of quality and efficiency change in manufacturing enterprises. Promoting the integration of manufacturing and digital technology is the key to achieving high-quality economic development. Thirdly, the integration of the service sector with digital technology is low. Digitalization of the service sector can effectively improve service quality and realize service diversification and personalization.

Lack of digital talent. The huge talent gap in the digital field has slowed down the process of restructuring digital resources, and the serious lack of digital talent has become a bottleneck that restricts the development of the digital economy. First, the ability to attract top talent is insufficient.

The Global Digital Talent Development Annual Report 2020 shows that European cities and the US are more attractive to global digital talent, while China is severely under-attractive to digital talent. Second, the number of digital professionals is insufficient. China's digital industry is still in the exploratory stage, and there is a shortage of digital professionals in the country's talent structure.

Residents' digital literacy needs to be improved. Digital literacy is the ability and attitude of people to use digital means in their social life. The digital economy is developing rapidly, and for individuals, the ability to improve their digital literacy determines whether they can better adapt to the information age. If China is to focus on developing a digital economy, it must improve the digital literacy of its residents.

6. Policy recommendations

Based on the findings of the study, the thesis argues that the development of China's digital economy can be further promoted in the following ways.

First, we should continue to increase investment in digital infrastructure and accelerate the development of new infrastructure. It is clear from the research results that digital infrastructure is the main reason for regional differences in digital economic development, but the digital infrastructure in most regions is still not perfect, and infrastructure is the foundation of digital economic development.

Secondly, regional cooperation should be strengthened to achieve resource sharing. Therefore, regional cooperation and sharing of resources and technologies is one of the important ways to reduce regional differences in digital economy development.

Thirdly, we should improve digital economy policies, provide policy support and improve the development environment. The development of the digital economy requires national and regional policy support. It is important to meet the policy needs of the digital economy, improve the environment for the development of the digital economy, provide good environmental support for the development of the digital economy, and further promote the development of the digital economy in lagging regions, so as to narrow regional differences in the development of the digital economy across the country.

Fourthly, innovation is driven by technological innovation. The digital economy is an internet-based economy, and its development cannot be achieved without the support of technology. Innovation in digital economy-related technologies and technological advances can further break down geographical restrictions, strengthen regional cooperation and narrow regional differences in digital economy development.

Fifth, it is necessary to improve the digital literacy of residents. With the deepening of digital industrialization and digitization of industries, improving the digital literacy of residents is extremely important to promote the rapid and high-quality development of China's digital economy. The government should strengthen publicity on digital technology and the digital economy to raise residents' awareness of «digital». Relevant government departments should promote online courses offered by education and training institutions and some enterprises to provide convenient services for residents to learn anytime and anywhere, build a good learning environment, promote the digitization of lifelong education, and provide training in digital skills such as data analysis, data security, industrial software and software programming. In addition, the government should improve public facilities and services and integrate digital technologies as much as possible to create a strong «digital» atmosphere. Strengthen digital education in the community and bridge the 'last mile' of digital

education. Integrate digital education into the basic education system. Learning to use digital services is one of the most basic elements of digital literacy and having digital skills will be key to improving digital literacy in the future. This is why digital literacy should be integrated into the compulsory education system to develop students' knowledge of 'digital'. Promote the digital transformation of urban libraries. In the digital age, the digitalization of urban public libraries is conducive to the digitalization of the city as a whole, and to the social value of libraries.

Sixth, accelerating the digital transformation and upgrading of industries. To achieve the «overtaking» of the digital economy, it is necessary to accelerate the digital transformation and upgrading of existing industrial clusters, which can be carried out in the following ways:

1) Establishing a digital platform for agriculture. As China is a large agricultural country, the establishment of a digital platform for agriculture is of great significance in improving the process of agricultural marketisation and accelerating agricultural modernization. It will also provide an efficient and accurate platform for agricultural producers, operators and regulators to interact with each other, establish a corresponding digital supply chain system and promote the construction of e-commerce for agricultural products. The establishment of a digital platform to promote agricultural modernization will not only improve the efficiency of agricultural production, but also effectively expand the scale of China's digital economy.

2) Continuously promote the digitalization of the manufacturing industry. As the competition in the manufacturing economy is intensifying around the world, the development of the manufacturing economy needs to further promote the integration of new digital technologies with the real economy and the transformation from traditional manufacturing to «smart manufacturing». Governments should provide subsidies for the purchase of new digital equipment. New digital equipment is the basis for research and development, and government subsidies can help to promote digital upgrading in traditional enterprises. The Chinese manufacturing industry should implement targeted digital development measures, and the government should introduce relevant and inclusive policies to jointly promote collaborative innovation between industry, academia and research. At the same time, the manufacturing industry should make use of digital technologies such as the Internet of Things and big data, and be equipped with an efficient data platform, so as to achieve digital transformation and upgrading.

3) Promote the construction of service-based consumer products. The development of digital technology has reduced transaction costs, improved service levels, facilitated data creation and sharing, and achieved information interoperability between the service industry and consumers, providing more room for development of digitalization and innovation in the service industry. With the development of digitization, consumers' demand for digital scenarios and digital platform transaction services is growing, but the digitization of China's service industry today is small in scale and scattered in layout, with less attention paid to the upgrading of residential and public consumption. The government should take a holistic approach to develop digitally relevant consumer markets and application scenarios, further shifting the focus of developing the digital economy to the provision and consumption of digital products and services. This will require the service market to accelerate the digital transformation process and promote the integration of the service sector with the digital economy.

Seventhly, development strategies should be tailored to local conditions.

According to the results of the study, the development of the data economy is uneven, and the level of development of the digital economy varies greatly from region to region, and the resources and strengths of each region are also different. To promote the development of the digital economy in the region, it is necessary to formulate a development strategy that is in line with the actual situation of the region, based on the overall national guidelines.

Eighth, build digital industry clusters with high quality. With major industries and product lines as the guide, we will cultivate digital industry clusters with world competitiveness and influence. We will build cloud computing industrial parks, big data industrial parks and Internet of Things industrial parks according to local conditions, and attract multinational headquarters, R&D centres and productive service companies to move in, creating clusters of cloud computing, big data and other digital industries. In regions with a solid manufacturing base and high level of intelligence, build smart manufacturing demonstration bases with advanced big data technology and superior product intelligence. Cultivate digital economy innovation-driven incubators, creator spaces and special towns, and enhance the capacity of digital economy clusters. Take industrial parks, development zones and industrial clusters as carriers to build digital operation service platforms, promote the integration of software and hardware, and enhance the level of intelligent control in parks.

Ninth, building a sharing system for high-quality development of the digital economy. By making use of the cloud computing capabilities of digital resources and big data resources, we can better understand user experience in a data-driven mode and provide more humane and personalized services. At the same time, we should pay more attention to the security and reliability of the development of the digital economy, build a whole-chain and whole-cycle security system, reasonably and effectively control the misuse of data, and effectively safeguard national information security, the rights and interests of enterprise data, and the privacy of individuals.

Tenth, promote international cooperation in digital technology and standards. Digital technology is the basis for the development of the global digital economy. We should give full play to the policy leadership role of the government, cooperate closely with countries in the development of technology in the areas of network information, artificial intelligence, big data and cloud computing, establish international incubation bases for digital technology innovation and entrepreneurship, promote information sharing and cooperative research and development in digital technology hardware and software among countries under the G20 framework, and promote the formulation of unified international digital technology standards. The G20 will also promote the development of unified international digital technology standards.

Eleventh, improve the level of regional openness and promote the steady development of the digital economy. As the global digital game intensifies, the country should actively participate in global digital governance, promote and lead a new model of Asia-Pacific-India-Pacific digital cooperation and governance, and smooth the international market cycle of the digital economy. We should actively develop digital economy cooperation with other countries, form a more open, secure and diversified digital trade pattern, explore high-level international rules for digital trade, and establish a bottom-line mindset while promoting the export of China's digital products and services, strengthen the protection of data security, and actively promote the prosperous development of China's digital trade.

Twelfth, promoting regional balance in the digital economy and sharing the «digital dividend». At present, China's digital economy is characterized by uneven regional development, with a gradual weakening from east to west. To promote the balanced development of the digital economy, it is crucial to radiate from the priority development regions to the backward development regions. The first is to accelerate the construction of digital economy infrastructure. We should strengthen the construction of 5G base stations, big data centres and other information and communication infrastructure in the central and western regions, and continuously reduce their usage and operating costs, so as to create basic conditions for the development of digital industries. Secondly, we should improve the construction of the digital economy industry docking platform. We will explore a regional coordinated development model for the digital economy, strengthen inter-regional industry matching and transfer, build regional digital economy industry chains, and create digital economy industry clusters with special characteristics, so as to drive backward regions to enjoy the «digital dividend» and contribute to China's economic development.

Thirteenthly, differentiated policies should be implemented in response to regional differences. Taking into account the uneven development of China's regional digital economy, policy resources should be reasonably regulated. The government should give full play to the effective intervention of government finance in the central and western regions, where the digital economy is at a lower level, and tilt the limited policy resources towards the central and western regions to accelerate the digital infrastructure construction in the central and western regions, improve the labour force level in the central and western regions, and promote the economic growth in the central and western regions, so as to guide the rapid development of the digital economy in the central and western regions, narrow the «digital divide» between the regions in China, and achieve the balanced development of the digital economy. This will guide the rapid development of the digital economy in the central and western regions, narrow the «digital divide» between regions in China and achieve balanced development of the digital economy.

7. Conclusion

In conclusion, the development of the digital economy is an important focus of strategic competition among countries around the world, and an in-depth study of the problems and countermeasures for the development of China's digital economy has become an important Issue that needs urgent attention from all sectors of society.

This paper takes the regional differences in the development of the digital economy as a perspective and the high-quality development of the digital economy as a grip, and systematically studies the development situation of China's digital economy, the main problems and countermeasures.

The study finds that although China's digital economy is developing rapidly, problems such as the lack of extensive digital applications, the need to improve the level of digitalisation of industries and the low degree of digital industrialisation are still prominent. Regional disparities in the development of China's digital economy are significant, and regional imbalance is a distinctive feature of China's digital economy development.

The findings of this paper are in line with the findings of most scholars at home and abroad. In general, the level of China's digital economy development is rising, and the phenomenon of inter-regional differences is obvious, while the degree of differences is gradually decreasing. In terms of the degree of contribution, the intra- and

inter-regional contributions are on a declining trend but less volatile. In terms of drivers, the level of economic development, industrial structure, intellectual property protection and technological development all contribute significantly to the development of the level of the digital economy, while government intervention inhibits the development of the digital economy.

The development pattern of the digital economy is consistent with that of the real economy, showing a gradient from east to west, but some provinces and regions show differences in their digital economy development. Therefore, the level of development of China's digital economy still needs to be improved and narrowing the gap between regions is an important proposition for China's high-quality economic development.

During the study, we confirmed both hypotheses. First, we confirmed that the larger the comprehensive index of digital economy development level, the higher the level of digital economy development. Second, we confirmed that the larger the Gini coefficient, the more obvious the difference in digital economy development level.

The development of China's digital economy needs to be based on digital infrastructure, to enhance the attractiveness of cities to digital talents, to build digital talent advantages as the core, to improve the digital literacy of residents as the basis for sustainable development, to accelerate the integration of digital technology with the three major industries, and to accelerate the digital transformation and upgrading of existing industrial clusters.

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Анализ региональных различий и факторов, определяющих развитие цифровой экономики Китая

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Аннотация. С появлением цифровой трансформации проблема регионального дисбаланса в развитии цифровой экономики Китая становится еще более актуальной. Целью исследования является теоретическое обоснование системы показателей уровня развития цифровой экономики Китая и анализ пространственно-временных характеристик эволюции развития цифровой экономики Китая. Гипотеза заключается в том, что, во-первых, чем больше комплексный показатель уровня развития цифровой экономики, тем выше уровень развития цифровой экономики; во-вторых, чем больше коэффициент Джини, тем очевиднее разница в уровне развития цифровой экономики. Инновация исследования заключается в построении системы оценочных индексов уровня развития цифровой экономики, измерении уровня развития цифровой экономики Китая и анализе различий между тремя регионами. Теоретическая значимость заключается в том, что исследование обогащает систему оценочных показателей уровня развития цифровой экономики Китая и обеспечивает теоретическую поддержку понимания их различий. Практическая значимость в том, что это способствует реализации сбалансированного экономического и социального развития различных регионов Китая. Результаты исследования показывают, что в целом уровень развития цифровой экономики Китая неуклонно растет, но при этом очевиден феномен межрегиональных различий, а степень вариативности в различиях постепенно снижается. Что касается движущих факторов, то уровень экономического развития, структура промышленности, защита интеллектуальной собственности и технологическое развитие вносят значительный вклад в развитие уровня цифровой экономики, в то время как вмешательство государства сдерживает развитие цифровой экономики.

Ключевые слова: уровень развития цифровой экономики; региональные различия; коэффициент Джини; модель Тобита; система показателей.

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