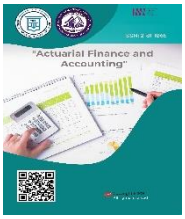

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MEASUREMENT AND PROGRESS OF CHINA'S DIGITAL ECONOMY DEVELOPMENT: MULTI-DIMENSIONAL INDEX SYSTEM AND REGIONAL DIFFERENCES ANALYSIS

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Abstract: With the acceleration of globalization and information technology, China's digital economy continues to expand and become an important engine to promote national economic growth. This paper establishes a multi-dimensional index system covering digital industrialization, industrial digitalization, digital infrastructure and economic environment, and uses the entropy method to measure the comprehensive index of digital economy in each province to reveal its development process and regional differences. The results show that the eastern coastal region is significantly ahead of the central and western regions, and infrastructure and policy support are the key influencing factors. The empirical results of this paper provide data support for further optimizing regional digital economy policies.

Key words: Digital Economy, Entropy Method, Regional Difference, Measurement

II. Introduction

In the modern economic system, digital economy has reshaped the global economic landscape with its radical innovation and wide application scenarios. For China, since its access to the Internet in the 1990s, the digital economy has gone from initial exploration to rapid development, and has been fully exploded in recent years. Although many studies focus on the measurement of digital economy in a single dimension, such as e-commerce and electronic transaction volume, Internet penetration rate and other single indicators to measure the digital economy (Mesenbourg, 2001; [1]Zhang and Shi, 2019[2]). With the deepening of research, most scholars often measure the digital economy from the dimensions of hardware and software infrastructure, e-commerce, enterprise and industry structure, demographic and labor force characteristics, and price behavior of the information economy (De Pablos, P. O.,2023[3]; Ma, Q,2002[4]). However, the systematic

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measurement of these digital economies and the analysis of regional differences still need to be deepened. Therefore, based on the multi-dimensional index system and entropy method, this paper analyzes the development level, process and regional differences of China's digital economy, so as to provide a scientific basis for promoting the balanced development of digital economy.

II. Development process of China's digital economy

The development of China's digital economy can be roughly divided into four stages, each of which has its own characteristics and reflects different historical backgrounds and policy orientations.

2.1 Initial Development (1990s to 2008)

This stage marked the germination and initial development of China's digital economy, mainly due to the introduction and popularization of the Internet. In 1998, Alibaba and other e-commerce platforms were founded, which became an important node in the development of digital economy. [5]According to the China Internet Development Report, the number of Internet users in China was only 620,000 in 1997, but increased to 298 million in 2008. [6]The government has accelerated the growth of Internet companies by relaxing industry access and implementing informatization strategies. Although the impact on the job market is limited, it has laid a foundation for the subsequent development of the digital economy.

2.2 Rapid Growth period (2008 to 2015)

After the global financial crisis, China's digital economy has become an important driver of economic recovery. The introduction of the "Internet Plus" strategy has promoted the digital transformation of various industries. During this stage, e-commerce expanded rapidly and the platform economy rose, bringing a large number of job opportunities. According to the National Bureau of Statistics, as of 2015, the e-commerce industry directly and indirectly created tens of millions of jobs. [7]In addition, the e-commerce transaction volume, which was only 3.96 trillion yuan in 2008, has grown to 16.39 trillion yuan in 2015.[8]

2.3 Full Outbreak Period (2015 to 2020)

During China's 13th Five-Year Plan period, the digital economy has grown into a part of the national strategy. The "new infrastructure" policy has promoted large-scale infrastructure construction, involving 5G, artificial intelligence and other fields. [9]Since then, the "gig economy" fueled by Internet giants has grown significantly, increasing the number of highly skilled and flexible jobs, such as data analytics, food delivery and online

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livestreaming. [10]In 2019, the food delivery sector directly or indirectly created nearly 4 million jobs.[11]

2.4 Post-Pandemic Era (2020-present)

The challenges of COVID-19 have accelerated the in-depth development of the digital economy, especially in the fields of online consumption, remote working and education. By the end of 2020, the size of China's digital economy reached 39.2 trillion yuan, accounting for nearly 40% of GDP (MIIT, 2021). [12]In this stage, intelligent and automated technologies have penetrated into traditional industries, significantly changing the employment structure and becoming an important force for stabilizing employment.

III. Measurement of the digital economy

In order to scientifically evaluate and analyze the development level of China's digital economy, this paper constructs a multi-dimensional index system, and uses the entropy method to analyze the comprehensive index of each region. This method can objectively reflect the differences and advantages of each region in the development of digital economy.

3.1 Multi-dimensional indicator system

The specific indicators are shown in Table 1. Digital economy results for D.

Table 1 Indicator system of digital economy

The secondary indicators	Tertiary indicators	unit	Target direction	Representative symbol
Industrial digital D1	E-commerce sales	(100 million yuan)	Positive	X1
	Number of computers used per 100 people	(units)	Forward	X2
	Number of enterprises with e-commerce transaction activity	(number)	Forward direction	X3
Digital industrialization D2	Total amount of telecommunications services	(100 million yuan)	Positive	X4
	Software revenue	(100 million yuan)	Positive	X5
	Courier business revenue	(RMB '000)	Forward direction	X6
Digital infrastructure construction D3	Optical fiber cable line length	(km)	Forward	X7
	Mobile phone switch capacity	(ten thousand	Forward direction	X8

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		households)		
	Number of domain names	(ten thousand)	Forward	X9
Digital economy environment D4	Technology market turnover	(RMB '000)	positive	X10
	Number of students in school	(people)	Forward direction	X11
	Number of patent applications granted	(pieces)	Forward direction	X12

3.2 Application of entropy method

In order to scientifically construct the comprehensive index of digital economy, this paper uses the panel entropy method to measure the digital economy level of each province in China in the past ten years. The specific methods are as follows:

Step 1: Data normalization

In order to eliminate the differences in the dimensions of different indicators, the normalization formula is used:

$$x'_{ijk} = \frac{x_{ijk} - x_{min,k}}{x_{max,k} - x_{min,k}}$$

Where, and represent the minimum and maximum values of the KTH indicator in all years and regions, respectively. $x_{min,k}x_{max,k}$This step converts all the data to the interval [0,1].

Step 2: Calculate the proportion of each indicator

On the basis of normalization, calculate the proportion of index k in year i and region j:

$$p_{ijk} = \frac{x''_{ijk}}{\sum_i \sum_j x''_{ijk}}$$

The proportion reflects the relative indicator level of each region in each yearp_{ijk}

Step 3: Calculate the entropy of the indicators

The entropy value is used to measure the amount of information of each index, and the smaller the entropy value is, the greater the contribution of the index to the composite index is. The entropy value of the KTH index is calculated as follows:

$$e_k = -\frac{1}{\ln(rn)} \sum_i \sum_j p_{ijk} \ln(p_{ijk})$$

Step 4: Calculate the difference coefficients of the indicators

According to the entropy value, calculate the difference coefficient of the KTH index:g_k

$$g_k = 1 - e_k$$

The larger the coefficient of difference is, the more significant the difference between regions and years is, and the greater the impact on the composite index is.

Step 5: Calculate the index weight

The difference coefficient of each indicator is normalized to obtain the weight of the KTH indicatorw_k:

$$w_k = \frac{g_k}{\sum_k g_k}$$

Step 6: Calculate the comprehensive evaluation index

The weight of each indicator is used to calculate the composite index of digital economy:

$$M_{ij} = \sum_k w_k x''_{ijk}$$

This composite index can fully reflect the development differences of digital economy in different regions.

The operating weights of entropy method in this study are shown in Table 2:

Table 2 Entropy method of Digital Economy Entropy method operation

W	value	W	value
w1	0.1009828	w7	0.0412880
w2	0.0292512	w8	0.0350614
w3	0.0738836	w9	0.0901314
w4	0.0825308	w10	0.1306253
w5	0.1413913	w11	0.0311516
w6	0.1378254	w12	0.1058774

IV. Development status and regional differences of China's digital economy

4.1 Development status of China's digital economy

According to the result of the entropy value method, the Chinese provinces and cities in recent 10 years from 2014 to 2023 the number of economic indicators averaged as shown in table 3, change trend as shown in figure 1:

Table 3 The average value of digital economy in China's provinces in the past ten years

Province	D	D1	D2	D3	D4
ANHUI	12.8197	3.3102	1.9359	3.7226	3.8510
BEIJING	36.9953	9.6981	9.8665	6.5054	10.9253
CHONGQING	8.2014	2.6055	1.9519	1.9399	1.7041
FUJIAN	15.8443	3.0870	3.4073	7.1051	2.2449
GANSU	3.8001	0.8372	0.5869	1.3584	1.0177
GUANGDONG	52.6071	12.1760	18.1601	10.4953	11.7757
GUANGXI	7.8122	1.4702	1.4118	3.2458	1.6844
GUIZHOU	6.5421	1.4629	1.2504	2.5568	1.2720
HAINAN	2.7158	1.4965	0.3527	0.6094	0.2572
HEBEI	11.4370	1.9037	2.4204	4.1947	2.9182
HEILINGJIANG	5.7396	1.2635	0.7319	2.2877	1.4565
HENAN	13.9008	2.4097	2.6802	4.8471	3.9638
HUBEI	14.3232	2.9368	2.6712	3.6850	5.0302
HUNAN	11.8774	2.4994	1.9540	4.0721	3.3519
JIANGSU	33.0400	6.6929	10.5054	7.0845	8.7571
JIANGXI	8.0490	1.8269	1.1761	2.8259	2.2201
JILIN	4.5309	1.0414	0.9161	1.3498	1.2237

LIAONING	9.6401	2.1609	2.4275	2.5624	2.4893
NEIMENGGU	4.5317	1.4689	0.6567	1.7692	0.6368
NINGXIA	1.5188	0.8823	0.2018	0.2519	0.1828
QINGHAI	1.5668	1.0934	0.1444	0.2269	0.1020
SHANDONG	25.1799	6.7044	6.4087	5.4411	6.6257
SHANGHAI	25.0961	8.1539	9.6824	2.8418	4.4180
SHANGXI	11.0897	2.0759	2.4586	2.2817	4.2735
SHANXI	5.5529	1.2927	0.8243	2.2357	1.2003
SICHUANG	18.1151	3.3146	4.3424	6.1591	4.2990
TIANJING	7.6508	2.3945	1.8775	0.7393	2.6395
XINJIANG	4.0193	1.0168	0.6394	1.8064	0.5567
YUNNAN	7.0398	1.7777	1.3356	2.6626	1.2640
ZHEJIANG	28.6289	6.8539	9.2622	6.2315	6.2813

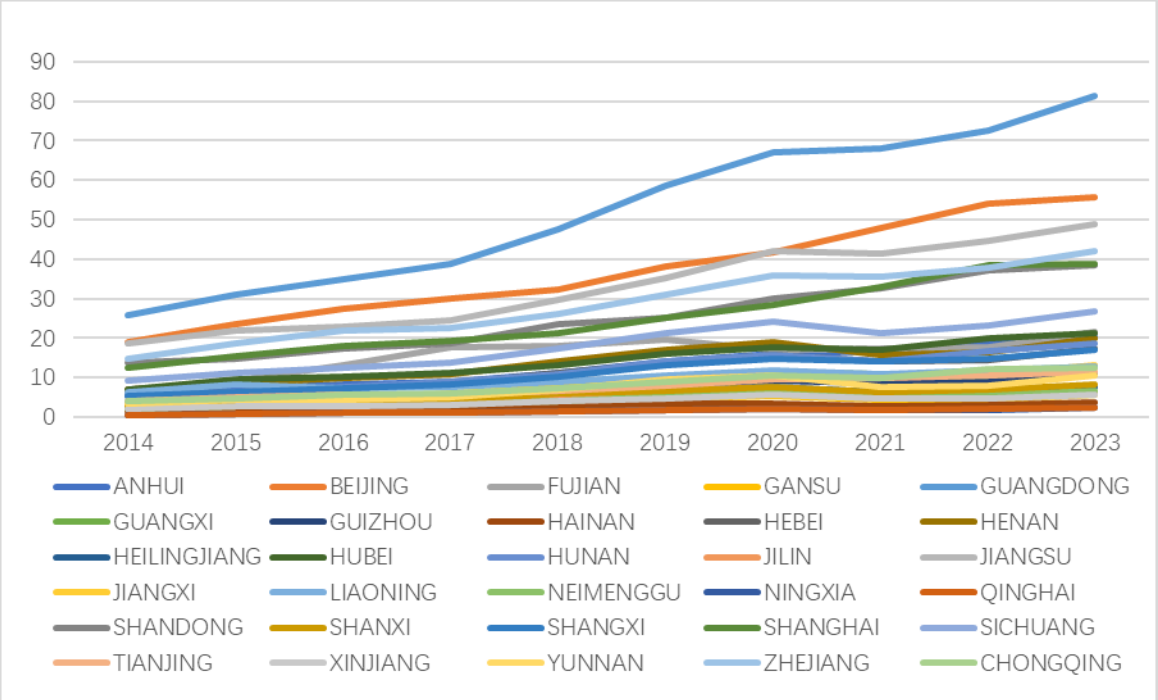

Figure 2 provincial digital economy composite index (D) the time trend

4.1 Regional difference analysis

According to the analysis, there are obvious regional imbalances in the development of digital economy in China, and the eastern coastal regions are significantly ahead of the central and western regions. For example, provinces and cities such as Guangdong, Beijing and Jiangsu lead the country in terms of digital infrastructure and market size, while inland provinces such as Gansu and Ningxia lag behind in terms of development level.

Eastern Region: The region has formed a favorable environment for the development of digital economy with advantages such as developed economy, high degree of openness, complete infrastructure and favorable policies. A large number of technical talents gather in these regions, which makes them highly competitive in digital industry innovation and industrial upgrading.

Central Region: Despite the increase in policy support and infrastructure investment in recent years, the development of digital economy in this region is relatively slow due to the limited market size and insufficient digitalization of enterprises.

Western region: The lagging infrastructure construction, low market development, and talent gap with the eastern region make the influence of digital economy relatively weak. However, in recent years, the state's attention to and investment in the development of the western region is gradually improving the situation.

4.2 Driving Factors

The study shows that the key factors affecting the level of regional digital economy development mainly include:

(1) Technical infrastructure: the construction degree of optical fiber network and mobile communication base station directly affects the transmission efficiency of digital information.

(2) Policy support: including supporting policies for digital industrialization and incentive measures for independent innovation, they play an important role in creating a good economic environment for the region.

(3) Market environment: the degree of market openness and the formation of consumers' digital habits are closely related to the consumption driving force of digital economy.

The data show that the advantages of the eastern region mainly come from the leading edge in these fields. It is crucial for the central and western regions to expand the influence of digital economy through continuous policy adjustment and infrastructure improvement.

V. Conclusions and recommendations

Through the research on the development status of digital economy in different regions of China, this paper reveals the regional differences in the development of digital economy in China, and provides data support, so as to provide reference for the government and enterprises in decision-making.

5.1 Research Conclusions

The main conclusions of this study are as follows:

(1) Obvious regional imbalance: the development level of digital economy in the eastern coastal region is significantly higher than that in the central and western regions, reflecting the concentration of economic, technological and policy resources.

(2) Infrastructure and policy drive: the improvement of information infrastructure and continuous policy support are important driving forces for the development of regional digital economy, especially in the eastern region, but the central and western regions need to be further strengthened in this respect.

(3) The influence of technology and talents: the regions with strong technological innovation ability and significant talent agglomeration effect show greater vitality and resilience in digital economy development.

5.2 Measures for improvement

In view of the research conclusions, this paper puts forward the following policy recommendations:

(1) Strengthen infrastructure construction: The central and western regions should increase investment in information infrastructure, especially the construction of 5G network and optical fiber broadband, so as to break infrastructure bottlenecks and improve **communication** coverage and speed.

(2) Implementing differentiated policies: The government should implement targeted policies based on the specific conditions of different regions. The eastern region can focus on technological innovation and international promotion; The central and western regions should further attract investment and talents to guide the digital transformation of industries.

(3) Promote education and skills training: vigorously develop digital education and vocational training to enhance the adaptability of the labor market, so that more people can share the opportunities and achievements brought by the digital economy.

(4) Optimize the market environment: optimize and guarantee the market environment for innovative enterprises by simplifying enterprise registration procedures, strengthening intellectual property protection and other measures, and promote the sustainable development of the digital economy.

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