Information Systems and Economics (2025)
Clausius Scientific Press, Canada

DOI: 10.23977/infse.2025.060206
ISSN 2523-6407 Vol. 6 Num. 2

Measurement and Evaluation of the Development Level of China's Digital Economy

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Keywords: Digital Economy Development; Digital Economy Infrastructure

Abstract: This paper aims to measure and evaluate the development level of China's digital economy across 31 provinces from 2015 to 2023, and analyze regional disparities. First, it clarifies the connotation of the digital economy by reviewing relevant studies, which encompasses information and communication technologies, digital applications, and related economic activities. To achieve the research goal, the entropy weight method in STATA is adopted to calculate indicator weights and comprehensive scores. A three-level index system is constructed, covering four primary dimensions: digital economy infrastructure, technological innovation, industrial digital trade and digital industrial trade. The results reveal significant regional differences: eastern provinces (e.g., Beijing, Guangdong) show higher comprehensive scores, followed by central regions (e.g., Chongqing, Sichuan), while western regions (e.g., Ningxia) lag behind, reflecting the "Malthusian effect" and "digital divide". To address these disparities, policy suggestions are proposed, including strengthening digital infrastructure in the west, promoting balanced development in the central region based on local advantages, establishing regional collaborative mechanisms, and enhancing education, digital finance, and technological innovation in underdeveloped areas to foster professional talents and narrow the gap.

1. Introduction

With the continuous popularization of information technology, the advancement degree of digital-based economic systems has become increasingly vigorous. During the period from 2015 to 2023, China has seen the share of digital-based economic systems in its GDP rise from 27.5% to 42.8%. Although the digitalization process in China has been accelerating continuously, there is still a significant gap in the measurement of digital economy indicators at the provincial level. Under this situation, how to measure the advancement degree of digital-based economic systems has become a new research hotspot. This article aims to construct an evaluation system for the advancement degree of digital-based economic systems and deeply analyze the differences in the advancement degree of digital-based economic systems among different regions in China.

2. The connotation of the digital economy

A clear understanding of the connotation of the Digital Economy is the prerequisite for accurately measuring its development level. Brynjolfsson and Kahin [1] hold that the Digital Economy encompasses information and communication technologies, e-commerce, digital delivery services, and software infrastructure, etc. This is more of a refinement from the perspective of the technologies and related applications that enable the advancement degree of digital-based economic systems. When Bukht and Heeks [2]define the Digital Economy, they approach it from both narrow and broad perspectives: in a narrow sense, it refers to various business models based on digital goods and services, including e-business and platform economy, etc.; in a broad sense, it generally refers to the application of information and communication technologies in all economic fields, including Industry 4.0 and algorithm economy, etc. Sandberg et al[3]summarize the Digital Economy as the ABCD model, which is a combination of related technologies such as Artificial Intelligence, Blockchain, Cloud Computing, and Big Data. Chen Xiaohong et al[4] believe that the Digital Economy is a series of new economic and social activities that take digital information as resources, the Internet platform as the carrier, and digital technological innovation as the driving force. The above are the connotations of the Digital Economy.

3. Measurement and Evaluation of the Digital Economic Development Levels of 31 Provinces in China

3.1. Data Sources and Measurement Methods

The data are derived from the National Bureau of Statistics, provincial statistical bureaus, the China Statistical Yearbook, and provincial statistical yearbooks spanning the period from 2015 to 2023. The entropy weight method is adopted to calculate the weights of evaluation indicators, aiming to objectively reflect the significance of each indicator in the comprehensive evaluation and effectively mitigate the impact of subjective judgments on the evaluation outcomes. The essence lies in leveraging the principle of information entropy, where weights are determined based on the data distribution of the indicators themselves, thus ensuring the scientific rationality of the evaluation process.

(1) The indicators chosen in this study are all positive-type indicators, and the normalization procedure for all indicators is presented as follows:

$$x'_{ij} = \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})} \tag{1}$$

Where i representsthe province and j represents the selected indicator.

(2) Calculate theweight of the value of the ith indicator under the jth indicator:

$$P_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{m} x'_{ij}(x'_{ij}>0)} \tag{2}$$

Where m stands for the number of provinces.

(3) Determine the entropy value of the jth indicator:

$$e_j = -k\sum_{i=1}^{n} p_{ij}\ln(p_{ij}), j = 1,\ldots,m \tag{3}$$

Where k is the adjustmentfactor, $k = \frac{1}{ln(m)}$,e_j is the information entropy value, $0 \leq e_j \leq 1$

(4) Determine the redundancy of information entropy (variance):

$$e_j = 1 - e_j, j = 1,\ldots,m \tag{4}$$

Where the greaterthe variability, the lower the entropy value and the greater the impact on the evaluation object.

(5) Calculatethe composite score for each sample:

$$s_i = \sum_{j=1}^{m} w_i x_{ij}, i = 1, \ldots, n \quad (5)$$

3.2. Construction of the Index System

This article constructs a digital economy level index system from four dimensions: digital economy infrastructure construction, industrial innovation, industrial digital trade, and digital industrial trade. The measurement of index weights is shown in Table 1.

Table 1: Three-level indicators ofdigital-based economic systems index system

Level1 Indicators	Secondary Indicators	Thirdly Indicators	Thirdly Indicator weights
Digital economy	Digital economy infrastructure	Domain name count(ten thousand)	0.082
		Mobile internet users (ten thousand)	0.033
		Total quantity of registered web domains(in thousands of kilometers)	0.025
	Technological innovation	Number of employed persons in urban units of information transmission, software and information technology services(in ten thousand people)	0.079
		Count of domestically filed patent applications (items)	0.080
		R&D spending by industrial enterprises of designated size (in ten thousand yuan)	0.082
	Industrial digital trade	Mobile phone switch capacity (in ten thousand users)	0.029
		E-commerce sales (billion yuan)	0.090
		E-commerce purchase volume (billion yuan)	0.096
		The number of enterprises conducting e-commerce transaction (units)	0.068
	Digital industrialization trade	Total volume of telecommunications business (billion yuan)	0.077
		Income from information technology services(in ten thousand yuan)	0.133
		Software industry income (ten thousand yuan)	0.127

3.3. Comprehensive Score of Digital Economic Development in Each Province from 2015 to 2023

Based on the above method, we calculated the comprehensive digital economy scores of each region from 2015 to 2023. Generally speaking, the advancement degree of digital-based economic systems shows obvious regional characteristics. The eastern regions (Beijing, Guangdong, Shanghai, Jiangsu, and Zhejiang) have significantly higher scores, followed by the central regions (Chongqing, Sichuan, Anhui, Shanxi, Hunan, Hubei, and Hainan, etc.), while the western regions (Ningxia, Qinghai, Gansu, etc.) have relatively lower comprehensive scores. However, from a regional perspective, the differences in digital economy development in different dimensions have led to significant regional disparities in overall development. Liu Shuchun [5] believes that the development of China's digital economy shows a trend of polarization, with a clear "Malthusian effect", which has led to a serious digital divide phenomenon. Yan Hui and Sun Lili [6] believe that the "digital divide" phenomenon reflects the serious inequality in the distribution of information and knowledge resources among different regions. This is manifested in the fact that cities with backward infrastructure cannot enjoy the "knowledge dividend" brought about by the development

of the Internet. Jing Wenjun and Sun Baowen[7] believe that this not only restricts the local economic development but also reduces the application and popularization of the Internet and other technologies in these regions. Zheng Xiaobi and Wu Jiahui [8] pointed out thatthe advancement degree of digital-based economic systems in the downstream region of the Yangtze River Economic Belt has a stronger promoting effect on high-quality economic development than that in the upstream and midstream regions. The provinces and cities in the lower, middle and upper reaches of the Yangtze River Economic Belt roughly correspond to the three major regions of China's east, central and west. Li Xu Jing and Lei Na [9] proved from the perspective of spatial spillover effect that the digital economy helps rural revitalization by adjusting the employment structure and improving labor productivity, and conducted a spatial spillover effect analysis for the eastern, central and western regions, concluding that the driving effect of the digital economy on rural revitalization in the eastern region is more obvious. Wang Shangao [10] proposed that the impact of the digital economy on the high-quality development of agriculture has regional and temporal heterogeneity, and overall shows a decreasing trend from the eastern region to the central and western regions. At the same time, less developed regions also lag behind developed regions in terms of development environment and potential. Education, digital finance, and technological innovation.

4. Policy Suggestions

4.1. Strengthen the Construction of Digital Economy Infrastructure in the Western Region

Increase investment indigital-based economic systems infrastructure in the western regions, laying a solid foundation for the advancement degree of digital-based economic systems in these areas, and promoting the wide application and popularization of Internet technologies in the region.

4.2. Promoting the Balanced Development of Digital Economy in the Central Region

Based on the industrial characteristics and resource advantages of each province in the central region, formulate targeted strategies for the advancement degree of digital-based economic systems. At the same time, focus on cultivating and attracting talents related to digital-based economic systems, and improve the talent incentive mechanism.

4.3. Facilitate the Coordinated Growth of digital-based economic systems Across Regions

Establish a regional collaborative framework for digital economy development to strengthen interactions and cooperation among eastern, central, and western regions in the digital economic domain. Encourage developed eastern areas to utilize their strengths in technology, capital, and talent, and promote digital economy development in central and western regions through strategies like industrial relocation, technological dissemination, and human capital cultivation.

4.4. Enhancing the Development Potential of Digital Economy in Underdeveloped Regions

Increase support for education, digital finance and technological innovation in underdeveloped and less developed regions. Strengthen the construction of related disciplines in the field of digital economy to cultivate professional talents who can meet the demands of digital economic development.

5. Conclusion

From the overall score results, the eastern region has developed better, while the western region is relatively worse. The digital economy advancement in the central region is at a medium level. This regional disparity reflects the existence of "Malthusian effect" and "digital divide" in China's digital economy development. Underdeveloped and less developed regions, due to their backward infrastructure, cannot fully enjoy the "knowledge dividends" brought by the development of the Internet, which restricts the local economic development as well as the application and popularization of technologies such as the Internet. The gap with developed regions is very large, which is not conducive to the long-term the advancement degree of digital-based economic systems. To promote the advancement degree of digital-based economic systems, corresponding measures need to be taken for different regions. This includes strengthening the construction of digital economy infrastructure in the western regions, leveraging the industrial characteristics and resource advantages of the central regions to promote balanced development of their digital economies, and emphasizing talent cultivation and introduction. Establishing a regional digital economy cooperation mechanism to promote coordinated development among the eastern, central and western regions is also necessary. At the same time, greater support should be provided to backward regions in terms of education, digital finance and technological innovation, and cultivating relevant professionals to enhance their development potential.

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