

Research on Measurement and Index System Design of Digital Economy Development

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Abstract

In recent years, digital economy has attracted more and more attention from Chinese researchers, and there are a lot of relevant research results. However, the research on digital economy and its measurement index evaluation system lags behind that of foreign countries. Therefore, the paper constructs the comprehensive evaluation system of digital economy development from three dimensions of digital economy infrastructure, digital economy development and application, digital economy innovation strength, and analyzes the development status and existing problems of digital economy, and puts forward countermeasures and suggestions for the development of digital economy.

Keywords: Digital economy; Measure; The evaluation index

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I. Introduction

In recent years, with the development of new Internet technologies represented by big data and cloud computing, people are getting closer and closer to the digital economy. With the development of China's digital economy, the research on digital economy and its related fields is becoming a hot issue in the academic circle.

The essence of digital economy is an economic form marked by Internet and informationization. Among them, the Internet of Things, artificial intelligence, and productivity are the key to industrial empowerment, total factor productivity improvement and Smart manufacturing in China. With the formal arrival of the digital era, digital economy has become one of the most core growth poles in the entire national economy. It is demonstrating its power and momentum at an unprecedented scale and speed.

According to the White Paper on The Development of China's Digital Economy (2021), in 2005, the added value of China's digital economy industry was only 2.6 trillion yuan. In 2020, China's digital economy totaled 39.2 trillion-yuan, accounting for 38.6% of GDP. The growth rate of digital economy is more than three times that of GDP. In particular, the digital economy has played a crucial role in the collection of hospital case information and nucleic acid information, the collection and release of epidemic prevention and control information by the government, and the daily life of people living at home during the COVID-19 outbreak in the past two years. There is no doubt that digital economy has turned into one of the most critical growth points of the national economy and will become an important starting point to achieve high-quality economic development under the background of the major domestic cycle in the future.

In 2017, the Chinese government first proposed the concept of "digital economy" in its work report, and in 2018, it proposed the construction of "digital China". Since then, guidelines and policies related to "digital economy" have appeared in government work reports for three consecutive years, which shows that the digital economy has received a high level of national attention. In this paper, based on the summary of domestic and foreign research results on the development of digital economy and index evaluation system, the establishment of digital economy index evaluation system, to provide suggestions for the further development of digital economy.

II. Review of Literature

2.1 Foreign research status

The concept of Digital Economy was put forward in 1996 by Don Tapscott, who is regarded as the father of Digital Economy^[1].

As for the definition of digital economy, the emerging Digital Economy research report issued by the US Department of Commerce in 1998 summarized the characteristics of digital economy as follows: Internet is the infrastructure, information technology is the leading technology, information industry is the leading and pillar industry, and e-commerce is the engine of economic growth. Beomsoo (2002) pointed out that the essence of digital economy activities is *commodities and services are traded in the form of information*^[2]. In 2016, the

G20 digital initiative economic development and cooperation of the digital business, to use digital as a key factor of knowledge and information, with modern information network as the important carrier, with the effective use of information communication technology as an important driver of efficiency improvement and optimization of economic structure of a series of economic activities.

Foreign research on digital economy and its measurement index evaluation system started earlier and has more diversified perspectives. Pagoropoulos (2017) believes that digital technology enables the formation of a variety of product and service systems with considerable economic, environmental and social benefits^[3]; Sidorov (2020) proposed a comprehensive index model for the development level of digital economy in different scale regions based on functional network^[4]; Sorescu(2021) argue that the digital economy consists of transactions generated by countless online connections between people, businesses, machines and data^[5].

As for the influence of digital economy on the development of other industries, Meso (2006) conducted a comprehensive analysis of the data of high, low- and middle-income countries and believed that the construction of digital infrastructure had a positive effect on improving economic level to some extent, but such promotion was conditional on appropriate infrastructure development and service industry growth. For most developing countries, they have limited resources and high opportunity costs^[6]; Salahuddin (2016) argues in research literature that the development of the Internet and Internet technology can improve agricultural production efficiency and digital economy can promote agricultural economic development^[7].

2.2 Related Research in China

The concept of digital economy has been attached importance to by Chinese scholars since it was put forward. Zhao Xisan (2017) believes that digital economy has three connotations: digital economy is a new economic and social form; The digital economy can be viewed as a networked digital infrastructure; Digital economy is regarded as a technological economy paradigm^[8]. Li Fuyi (2018) believes that digital economy is a process that records the transition from an industrialized society to an information-based society. Meanwhile, digital economy will change with the continuous evolution of economic structure and social system^[9]. Zhang Liangliang (2018) points out that digital economy takes digital knowledge and information as the core factor of production and uses information technology, Internet technology and digital products as the base point, carrier, and service of economy^[10].

In China, the influence of digital economy development on China's traditional industry is mainly emphasized. Yin Haodong et al. (2020) pointed out that under the current development and application of digital technology, e-commerce can be developed through the Internet to break through the weakness of traditional agricultural economy and promote agricultural development^[11]. Wen Tao et al. (2020) point out that digital economy can empower agricultural production, improve agricultural production efficiency, and labor production efficiency^[12]. Nie Yuanyuan et al. (2021) believe that the increasing popularity of Internet information technology, profound changes have taken place in people's consumption structure, consumption mode and consumption habit, and digital economy is a key variable driving consumption upgrading^[13]. Chen Liang et al. (2021) believe that the integration of modern communication technology and traditional industry has evolved a new mode of circulation industry and improved its efficiency^[14]. Jiao Shuaitao and Sun Qiubi (2021) focus on representative industries and industrial fields, establish a comprehensive index evaluation system of digital economy development containing several indicators from five perspectives including digital literacy and digital transformation, and study the spatial spillover effect of digital economy development on consumption upgrading^[15].

Under the new development pattern, the digital economy influence every aspect of national economic development has gradually become the hot issue of domestic scholars research, digital economy in our country, the rise of late, and the digital economy and its measure index evaluation system of research lags behind that of foreign countries, the study of digital economy is mainly focused on how to build the evaluation system on the economic development of the digital indicators.

III. Digital Economy Development Index Design

3.1 Measurement of digital economy

Digital economy is an economic form in which human beings recognize, select, filter, store and use big data to guide and realize rapid optimal allocation and regeneration of resources and achieve high-quality economic development. At the technical level, it includes emerging technologies such as big data, cloud computing, Internet of Things, blockchain, artificial intelligence and 5G communications.

The essence of digital economy lies in informatization. Information technology is a social and economic process from industrial economy to information economy caused by the revolution of production tools such as computer and Internet. Specifically speaking, informatization includes the industrialization of information technology, the informatization of traditional industries, the informatization of infrastructure, the informatization of life style and so on.

Information industrialization and industrial informatization, that is, the production and application of information are the two key aspects. Information production requires the development of a series of high-tech information technologies and industries, involving not only the manufacturing of micro-electronic products, communication equipment and facilities, computer hardware and software, network equipment and other fields, but also the collection, processing and storage of information and data. This process is digital industrialization, which is mainly reflected in the added value of information industry, including basic telecommunications, electronic information product manufacturing, software and information service industry, and Internet industry. Industrial digitalization, that is, the application of information technology in the economic field is mainly manifested in the transformation and upgrading of traditional industries such as agriculture, industry and service industry with information technology, or its contribution to other industries.

In the broad sense, all digital transaction forms belong to the digital economy, and in the narrow sense, only the digital industry belongs to the digital economy. This paper adopts the broad definition method to study, and thinks that the digital economy can be measured from the four dimensions of development environment, digital industrialization, industrial digitalization and digital governance. The development environment can be examined from the perspective of digital infrastructure, innovation-driven investment in scientific research funds, etc. Digital industrialization mainly considers information transmission and technology application. Industrial digitization mainly involves intelligent manufacturing and digital life, while digital governance mainly inspects the e-government development of the government.

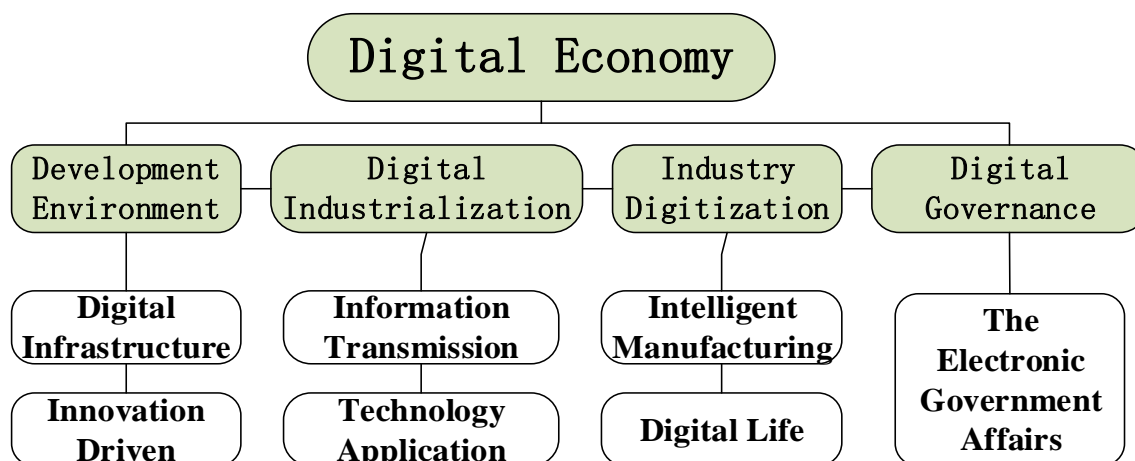


Figure 1: Measurement dimensions of digital economy

3.2 Construction of digital economy index system

This paper draws lessons from Guo Sijia (2021)^[16] and Ge Heping (2021)^[17] et al., to construct an indicator system for the development of digital economy. The selected indicators refer to The Yearbook of High-tech Industry, China Information Yearbook, China Science and Technology Yearbook, China Statistics Yearbook, etc. The specific indicators selected in this study are divided into first-level indicators and second-level indicators. The first level indicators are digital economy infrastructure, digital economy development and application, and digital economy innovation. The second level indicators of digital economy infrastructure are optical cable length (X1), mobile phone penetration rate (X2), and Internet broadband access ports (X3). There are four secondary indicators for the development and application of digital economy, including the level of online mobile payment (X4), the turnover of technology market (X5), the number of employments in information service industry (X6), and the number of government websites (X7). There are two secondary indicators of digital economy innovation, namely the number of patent applications (X8) and the average number of students in institutions of higher learning (X9), as shown in Table 1.

Table 1 : Index system of digital economy development

First-level indicator	The secondary indicators
Digital economy infrastructure	optical cable length(X1)
	Mobile Phone Penetration rate (X2)
	Number of Internet Broadband Access Ports (X3)
Digital economy development& application	Online Mobile Payment Level (X4)
	Technology Market Turnover (X5)
	Employment in Information Services (X6)
	Number of Government Websites (X7)
Digital economy innovation	Number of Patent Applications (X8)
	Average Number of Students in Institutions of Higher Learning per 10,000 People (X9)

3.3 Data standardization processing

3.3.1 Initial value transformation of data

As the index system of digital economy constructed above has different dimensions and orders of magnitude, most of them show an increasing trend. Therefore, it is necessary to carry out the initial value transformation of the basic data and convert it into a comparable sequence. The method is as follows:

$$X_{ij}' = \frac{X_{ij}}{X_{il}} \quad (1)$$

In Formula 1, X_{ij}' is the initial value of the i index in the j th year, X_{ij} is the original data, X_{il} is the value of the i index in the l year. Formula 1 is used to calculate the initial valued transformation matrix A of all indicators.

3.3.2 Entropy method is used to determine index weight

Compared with subjective assignment method, entropy method can objectively evaluate the relative importance of each index by eliminating the human interference factors, and is widely used in the objective weight assignment in social and economic fields. In this study, the advantages of entropy method are utilized to assign entropy weight to each indicator, and the steps are as follows:

Firstly, the information entropy of each index X_{ij}' is calculated according to Formula 2 and Formula 3.

$$P_{ij} = \frac{X_{ij}'}{\sum_{j=1}^n X_{ij}'} \quad (2)$$

In Formula 2, n represents the number of years. P_{ij} represents the proportion of the i index in the j th year,

$$H_i = -k \sum_{j=1}^n p_{ij}' \ln p_{ij}', \quad k = \frac{1}{\ln(n)} \quad (3)$$

In Formula 3, H_i represents the information entropy of the i index. Secondly, the weight of each index is calculated according to Formula 4.

$$W_i = \frac{g_i}{\sum_{i=1}^m g_i} \quad (4)$$

In Formula 4, m represents the number of indicators. W_i is the entropy weight of index i , g_i is the difference coefficient of index i , $g_i = 1 - H_i$.

3.3.3 Calculation of digital Economic development Index

According to the entropy weight of each index and the value after the initial value change, the corresponding classification index and comprehensive index are calculated according to Formula 5.

$$I_j = \frac{\sum X_{ij}' W_i}{\sum W_i} \quad (5)$$

In Formula 5, I_j is the exponent for the j th year.

IV. The Current Situation and Existing Problems of Digital Economy Development

Through the design of the index system, this study analyzes and evaluates the development of China's digital economy, and analyzes the status quo and existing problems of the development of digital economy as follows.

4.1 The current situation of digital economy development

At present, the development of digital economy mainly presents the following characteristics:

First, the total amount of new infrastructure construction in China is still relatively short, and the construction level is relatively backward, especially in the high-tech areas such as the Internet of Things, cloud services and blockchain. Moreover, there is a large regional gap in the level of new infrastructure construction in China, and the digitalization and informatization process between urban and rural areas and between eastern and western regions is not balanced.

Second, the new digital industry develops rapidly and the digitalization degree of the industry is relatively high. At present, the intensity of industrial agglomeration in China is high, and its products have higher competitiveness. In addition, Internet technologies such as big data, cloud computing and artificial intelligence are increasingly connected with agriculture, manufacturing and other real economic fields, and are increasingly connected with the service industry. Smart tourism and network economy have made great progress.

Third, information has significantly improved the level of the people. At present, great progress has been made in the construction of smart cities in China, the digital transformation of medical services is progressing day by day, the construction of cultural and educational resources sharing mechanism between urban and rural areas is vigorously promoted, and the informatization degree of towns and townships is constantly rising.

Fourthly, the digital integration construction of service-oriented government has achieved considerable results. At present, China's government affairs open a considerable amount of information, the level of government digital services continue to improve, the government service platform is basically interconnected.

4.2 Problems existing in the development of digital economy

4.2.1 Information security problems

While the digital economy brings convenience to people, it also brings some risks, including the information security of the Internet. Network information security is a worldwide threat and challenge, there is no geographical and economic restrictions. In the past, information security problems are generally focused on defense, but now it has been associated with big data network problems. In today's digital economy era, the industrial control system of enterprises or the system of financial companies, all links are interconnected, and there is the possibility of hacker attack, but there are no measures for this aspect at home and abroad, to ensure security. The establishment of information security mechanism requires the same cooperation and win-win cooperation among all countries. Based on cooperation, the problem of information security is solved from the national strategic level.

4.2.2 Lack of high-end talents in digital technology

The lack of digital technical talents is an obstacle to the development of Chinese enterprises, thus hindering the process of digitization in China. The digital industry needs to integrate with the traditional primary, secondary and tertiary industries, and has higher requirements for talents. It requires talent not only to master digital skills, but also to understand the theory of traditional industries. In such a premise, digital industry integration development, the urgent need for professional talent team. The lack of digital talents poses a huge challenge to China's long-term internationalization strategy. High-end technology and mass innovation are important measures for domestic enterprises to become bigger and stronger, go abroad and face the world. Therefore, the reserve of digital technical talents and the attraction of talents are important foundations for domestic enterprises to improve their international competitiveness in the field of data.

4.2.3 The foundation of digital economy development is weak

China's digitalization started late and the digital level is low, which directly leads to many high-end control systems and software are still monopolized by foreign countries. How to achieve innovation in core technology is the focus of development. The outward dependence of domestic digital technology is high, and the transition from "Made in China" to "made in China" is difficult. Development of nearly a third of the core materials is slow, and most of the chips in advanced devices and more than half of the processors and chips in digital terminals are dependent on others. The independent innovation ability of important information technology is an important prerequisite for the steady development of digital economy. Long-term dependence on foreign imports will make the supply of digital consumption and its derivatives unsustainable.

In addition, enterprises need to realize the digitization of all links from production to sales, and ensure the smooth flow of data in all links. For example, some enterprises use advanced digital technology and equipment, but the backward management system, resulting in the realization of some information dislocation. Therefore, enterprises also need to innovate management systems to ensure that management systems can keep pace with digital technology and equipment.

V. Countermeasures and suggestions

Through the analysis of the current situation and problems, this paper puts forward suggestions for the development of digital economy from the following three perspectives:

5.1 Strengthen infrastructure development for the new digital economy

The new digital economy infrastructure mainly includes three aspects: information, convergence, and innovation.

First, we will step up efforts to build new digital infrastructure such as 5G and the Internet of Things, accelerate the intelligent upgrading of traditional infrastructure, and accelerate the development of new service platforms supported by modern information technologies such as the Internet, big data, artificial intelligence and 5G, as well as a smart infrastructure system that is stable, efficient and environmentally friendly; To deepen the implementation of policies and guidelines for digital new infrastructure, to create cloud computing centers with top computing power, to improve technology and upgrade hardware, to enhance the operation efficiency of servers, and to give full play to the growth benefits contained in large databases; Accelerate the informatization process of the real economy, promote its mutual influence and integration with the digital economy, enrich the practice scenes of the digital economy in all aspects of production and life, enhance the digital integration ability of the whole chain between industries, and improve the digital development level of the three industries.

Second, we will further promote the coordinated development mechanism among regions, continuously increase the number of new infrastructure facilities in towns, townships and the central and western regions, increase the number of 5G base stations in the central and western regions and township areas, increase the total number of optical cable construction, and increase the access rate of Internet ports, so that people across the

country can share in the fruits of digital economy development. We will guide these regions to develop digital consumption modes such as livestreaming e-commerce and social e-commerce. At the same time, improve the logistics network system, expand the coverage of express logistics points, improve the efficiency of logistics distribution.

5.2 Enterprises should improve their independent innovation capability

The most important point of developing digital economy is innovation. Only by mastering core science and technology can we promote the continuous development of digital economy. Faced with the double cycle pattern, the global industrial chain, supply chain and innovation chain are accelerating reconstruction, the key to the development of digital economy lies in core technology. It is a top priority for enterprises to improve their capacity for independent innovation.

First, the corresponding enterprise independent research and development in the field of innovation, and actively guide to maintain consolidate corporate technological competition and cooperation between the link, to perfect the government, colleges and universities, scientific research institutions and enterprises as the main body of administration production system, strengthen the industry chain and cross alignment of innovation chain, improve the scientific research achievements conversion rate, actively carry out important research of advanced technology.

Second, enterprises should enhance the awareness of innovation, continue to carry out core technology research and development in related fields, improve the innovation ability of consumer products and services, constantly create higher quality supply, and effectively meet the high-end demand of consumers.

5.3 The government shall improve the governance mechanism and establish a harmonious and efficient environment

The government should formulate relevant policies, make overall plans and coordination, improve the governance mechanism of the digital economy, improve governance efficiency, encourage, and guide relevant enterprises to integrate with industrial upgrading, strengthen the supervision of the digital consumption field, and strive to create a healthy, harmonious, and efficient environment for the development of the digital economy. The government should play a leading role in the process of digital economy boosting industrial upgrading, consider efficiency and fairness, increase fiscal expenditure on infrastructure construction of digital economy and other new economic forms of business, and increase support for independent technological innovation of enterprises.

VI. Conclusions

Digital economy is the agricultural economy, industrial economy after the more advanced stage, it was based on the digital information and knowledge as the key factors of production, with modern information network as the main carrier, with information and communication technology integration application, total factor important impetus for digital transformation, promote tolerance, innovation, efficiency and sustainable development of the new economic form. In short, for the digital economy, data is the element, network is the carrier, convergence transformation is the driving force. To better promote the development of digital economy, we need to pay attention to relevant fields, carry out research and comprehensively promote them.

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