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A Literature Review on the Measurement Methods of Digital Economy

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Abstract

With the rapid development of the digital economy, measuring the digital economy has become a hot topic in current economic research. Overall, the academic community has established a preliminary framework for measuring the digital economy. However, due to the widespread application of various digital technologies in various aspects and stages of life and production, fully delineating the scale of the digital economy requires specific technical means and methods. Up to now, there is still no unified standard for measuring the digital economy. This article, through a review of relevant research on the definition and measurement methods of the digital economy, provides a comparative commentary on the strengths and weaknesses of 10 international organizations or institutions' proposed indicator systems related to the digital economy, along with their reference value. Additionally, the article presents a conceptual framework and policy recommendations for constructing an indicator system to measure the level of digital economic development using the index method in the future.

Keywords: Digital Economy, Measurement Method, Digital Economy Measurement

Introduction

The digital economy is a novel form of economic development that has emerged rapidly with the advancement of information technology. It is grounded in digital technologies, encompassing various aspects such as digital production, digital transactions, and digital innovation. The digital economy represents not only a transformation in economic forms but also serves as the engine for restructuring the global economic landscape. In this digital era, the rapid dissemination of information, widespread application of big data, and the rise of artificial intelligence provide robust impetus for the formation and advancement of the digital economy. With the ascent of the digital economy, nations and regions worldwide are undergoing profound changes in economic structures. Traditional industries are undergoing digital transformation, emerging industries are gaining prominence, and the iterative advancements and innovations in digital technologies are redefining the ways of production, distribution, and consumption. Consequently, there is an urgent need for a comprehensive

and in-depth understanding of the characteristics, scale, and impact of the digital economy to better address the new changes in the global economy.

Given the rapid development and deep integration of the digital economy across various industries, measuring its impact is crucial for understanding the overall economic situation (BEA, 2018; [1]Strassner & Nicholson, 2020). The International Monetary Fund's (IMF) 5th Statistical Forum on Measuring the Digital Economy highlighted that existing macroeconomic statistics are inadequate in capturing the added value brought about by digital and digitized products and activities, particularly in the backdrop of slow GDP growth (IMF, 2017; [2]Zhang, 2017). However, due to the key role of data resources in the digital economy and its involvement across industries and geographical boundaries, there is a certain intersectionality with the statistical criteria and industry classification systems of traditional economies. This makes it challenging to accurately measure the size and impact of the digital economy, further hindering a comprehensive understanding of the macroeconomic situation and the formulation of relevant policies. Therefore, there is an urgent need to expedite scientific evaluations and measurements of the level of digital economic development to objectively reflect the impact of the digital economy on socio-economic development.

Through a review of existing literature, we aim to understand the current research methods, trends, controversies, and unresolved issues in the measurement of the digital economy. This will help identify research gaps and guide future development directions.

Literature Review

The concept of the digital economy has been continuously enriched since its inception. With the progress of society and the development of the era, digital technology sustains its "life" through constant reform and innovation. The evolving nature of digital technology also determines that the digital economy is not static; it is a dynamically developing entity. The term "digital economy" undergoes changes in tandem with the evolving landscape of digital technology, making it challenging to establish a uniform definition. Liu (2001) suggests that the digital economy specifically encompasses e-commerce and the information technology industry. Brynjolfsson and Brian (2002) consider the digital economy as a digital infrastructure based on informatisation. Kim (2006), on the other hand, states that the digital economy is a form of economy that specifically refers to the transaction of goods and services in digital form. Kang (2008) refers to the sum of economic activities based on digital technology as the digital economy. The Edgerton Institute (2017) considers the digital economy to be the economic output that results from digital inputs such as digital devices, which is a clearer conceptual category than, for example, economic formations. Li (2017), on the other hand, argues that the digital economy is an economic form of production by means of digital technology. Cai (2018) argues that the digital economy is a new type of economic form resulting from the incorporation of digital elements (or information elements) in the process of digital transformation of traditional industries. US Bureau of Economic Analysis (BEA) (2018) Understanding the digital economy as the internet and related information and communications technology (ICT) sector. The China Communications Research Institute (CCRI) points out in its White Paper (2020) that the digital economy is a new economic form that carries the rapid development of the contemporary economy. OECD (2020) presents a comprehensive concept of the digital economy, indicating that the digital economy encompasses all economic activities that rely on digital technologies, digital infrastructure, digital services, and data, either as digital inputs or activities significantly enhanced through the use of digital inputs.

As a crucial component of the new economy, the size and scale of the digital economy determine a country's level of economic development and potential. However, due to the pervasive application of various digital technologies in various aspects and stages of life and production, accurately isolating the scale of the digital economy requires specific technical means and methods. This is also a significant reason why current measurement methods cannot comprehensively cover the digital economy domain. In general, methods for measuring the digital economy can be classified into two categories: value-added measurement and indicator measurement.

Firstly, there is the value-added measurement method. BEA conducted statistical analysis of the digital economy within the framework of supply and use in 2018 and 2019. Additionally, they adhered to the statistical methods of BEA satellite accounts. The specific method involves three steps: defining the digital economy; within the supply and use framework, distinguishing products and services based on the definition of the digital economy; identifying the industries that provide these products and services within the supply and use framework, and measuring output, value-added, employment, compensation, etc. BEA starts by focusing on the ICT (Information and Communication Technology) sector and, in conjunction with organizations such as OECD and relevant statistical literature on the digital economy, divides the digital economy into three parts: Infrastructure for digital empowerment; E-commerce; Digital media. When distinguishing digital economy products and services, BEA draws on the definition and data from supply and use tables, references products and services in the North American Industry Classification System, and selects over 200 items for estimating the digital economy. China Academy of Information and Communications Technology (CAICT) in 2017 and China Information Technology 100 (2018) categorize the digital economy into the production part and the application part, corresponding to digital industrialization and industrial digitization, respectively. The calculation for the former follows the approach of identifying the digital sector, while the latter introduces growth models and estimates of ICT capital stock. In addition, Tencent Research Institute (2017), in the calculation of the digital economy index, estimates the scale of the digital economy's value-added through quantitative methods. Since value-added, as an economic indicator, possesses advantages such as comprehensiveness and intuitiveness, and economic growth itself is one of the central goals of socioeconomic development, the scale of value-added in the digital economy, along with its proportion to GDP, attracts more attention from various sectors of society compared to digital economy indices. Furthermore, some scholars, such as Xu & Zhang (2020) have conducted research from the perspective of value-added. The specific approach they adopted is to limit the calculation scope of the digital economy to four aspects: Digital empowerment infrastructure; Digital media; Digital transactions; Digital economic products. Wang & Wang (2019) replaced the original capital stock indicator with the capital services flow indicator.

The second method is the indicator measurement method, which involves comparing the development of the digital economy or specific domains across different regions based on multiple dimensions of indicators. This allows for a relative assessment of the situation (OECD, 2017; ITU, 2015, etc.).

In the preliminary research on the development index of China’s digital economy, this paper primarily focuses on the latter approach. It refers to 12 digital economy indicator systems with high relevance published by international organizations such as the European Union, the U.S. Department of Commerce, the International Telecommunication Union, the World Economic Forum, the Organization for Economic Cooperation and Development (OECD), as

well as domestic institutions like China Academy of Information and Communications Technology (CAICT), CCID Consulting, Shanghai Academy of Social Sciences, and others. The analysis aims to highlight the strengths and weaknesses of each system, providing reference suggestions for the establishment of a digital economy development indicator system.

Evaluation of Indicator Systems for Digital Economy-Related Indexes

This section compares the indices related to the development of the digital economy published by international organisations and some Chinese business organisations, and evaluates the strengths and weaknesses of each.

Digital Economy & Society in the EU report and the Digital Economy and Society Index (DESI)

Since 2014, the European Union has been publishing the Digital Economy & Society in the EU report and the Digital Economy and Society Index (DESI). DESI is a composite index that depicts the level of digital economic development in EU member states. The index is calculated by the EU based on 31 sub-indicators across five main aspects: broadband access, human capital, internet usage, digital technology adoption, and the degree of digitization of public services. The synthesis method for this index follows the OECD's Building Composite Indicators: Methodology and User Guide, ensuring a high level of theoretical rigor, scientific validity, and sustainability. DESI not only considers the impact of the digital economy on society but also serves as a crucial window for analyzing the digital economic and social development levels, mutual comparisons, and summarizing development experiences among EU member states. Another significant advantage of this indicator system is that a substantial portion of the data comes from specialized statistical surveys such as the EU Household ICT Survey and Business ICT Survey, providing ample research accumulation and data support. However, DEIS may be subject to subjectivity in indicator selection, leading to potential overemphasis on certain aspects and overlooking other essential factors, which could affect the objectivity of the overall assessment. The reliability of DEIS is constrained by the quality and sources of the data used, potentially resulting in issues of inaccuracy, incompleteness, or unreliability. Additionally, due to lagging data, the index might not offer the most up-to-date information on digital economic and social development, affecting policymakers' ability to make timely decisions.

Digital Economy Indicator System (DEIS)

As one of the early institutions to delve into digital economy research, the Organisation for Economic Co-operation and Development (OECD) has demonstrated a longstanding commitment with its official publications such as Internet Economy Outlook (later renamed Digital Economy Outlook in 2017) and Measuring the Digital Economy: A New Perspective. These publications provide continuous tracking and forward-looking studies on the digital economy. The OECD employs a dual-method approach to measure the digital economy. In "Measuring the Digital Economy," a comparative method is primarily utilized. The constructed digital economy indicator system encompasses 38 internationally comparable indicators. However, this approach does not involve the selection of a fixed sample of countries for comprehensive data collection. Furthermore, it does not aggregate into an overall indicator and lacks a comparative evaluation of the digital economic development across various countries globally.

Network Readiness Index (NRI)

The World Economic Forum (WEF) has been publishing the Network Readiness Index (NRI) since 2002, with a focus on analyzing the rankings, major experiences, and practices of leading countries and regions in global informatization. The NRI is considered authoritative in the international assessment of the information field. Although it includes a considerable number of tertiary indicators (53 in total), the primary and secondary indicators are concise and scientifically chosen.

In terms of driving mechanisms, the NRI asserts that information readiness, application scenarios, and the overall environment collectively constitute the driving forces for development, leading to economic and social impacts. Compared to other indices, the NRI emphasizes information technology, considering information capabilities as a prerequisite for developing the digital economy. Therefore, its selected indicators and mechanisms for economic impact in the information field are valuable references.

However, it's important to note that the NRI primarily focuses on global competitiveness, and its attention may be more concentrated on developed countries and regions. As a result, the evaluation of network readiness in some developing countries may be relatively limited. Additionally, since the NRI is released every two years, its data may be somewhat outdated, making it challenging to provide real-time information on the latest trends in digital economy and technology development. This limitation could impact policymakers seeking to formulate up-to-date policies based on the most recent information.

ICT Development Index (IDI)

The International Telecommunication Union (ITU) ICT Development Index (IDI) indicator system, released by the International Telecommunication Union since 1995, has accumulated extensive research and expertise. In 2017, the evaluation covered 176 economies worldwide and has been widely adopted by governments and various sectors. IDI focuses on 11 indicators related to ICT access, usage, and skills, allowing for comparisons among different countries and periods.

Although IDI measures fewer aspects related to the economy, it provides comprehensive assessments of infrastructure development, industry applications, and human capital in the field of information and communication technology. IDI holds significant experiential value in evaluating the digital economy, particularly in assessing the industry positioning, indicator selection, and reference value establishment in the information technology domain.

Digital Economy Inde (DEDI)

In July 2017, the China Academy of Information and Communications Technology released the "China Digital Economy Development White Paper (2017)," introducing the Digital Economy Index (DEI) through a comparative approach to observe the national digital economic development. This article focuses on the construction of DEI. Unlike other similar indices, DEI is a composite index comprising leading indicators, coincident indicators, and lagging indicators, serving as a business cycle index. By comparing with the base period, it reflects the economic cyclical conditions in different periods. The advantage of this index, compared to others, lies in its comprehensive consideration of the essential conditions for digital economic development, digital industrialization, industrial digitization, and the impact of the digital economy on the macroeconomic and social aspects. Moreover, it incorporates many indicators with Chinese and contemporary characteristics, making it a relatively comprehensive index. However, its shortcomings include an imperfect theoretical framework

and unclear logical connections and scientific basis between indicators. Some indicators may be current hotspots but lack sustainable observability and representativeness over the long term.

Digital Economic Development Index (DEDI)

In November 2017, CCID Consulting released the "2017 China Digital Economy Index (DEDI)" white paper. The report, based on the analysis of the development and characteristics of the digital economy, classified it into basic, resource-based, technology-based, integration-based, and service-based types. The evaluation covered all 31 provincial-level administrative regions in China. DEDI considered both the assessment of provinces nationwide and the evaluation of sub-indices in five dimensions of the digital economy. It utilized user data from internet enterprises to reflect the penetration of the digital economy in the service sector, demonstrating a certain level of innovation. However, a common drawback of such indices is the instability of data sources and the lack of international comparability.

Global Digital Economy Competitiveness Index(GDECI)

The "Global Digital Economy Competitiveness Index (2017)" was first released in December 2017. The report categorized the digital economy into the main industry section and the integrated application section. This index primarily adopts a comparative approach, collecting and analyzing digital economic development data from over 120 countries worldwide to form a comprehensive and multidimensional evaluation. The index constructs a global digital economy competitiveness analysis model with four dimensions: digital facilities, digital industry, digital innovation, and digital governance. Among these, digital facilities, digital industry, and digital innovation serve as the three pillars of a country's digital economy competitiveness, while digital governance ensures the healthy operation of this system. Compared to other index systems, the competitiveness index emphasizes the role of governance. On an operational level, it uses statistics and survey data such as the United Nations E-Government Survey to examine levels of government services, data openness, and conducts forward-looking and comprehensive research on digital governance. It provides certain reference value for China's establishment of a digital economic development index. However, potential drawbacks include the instability of data sources in published reports, varying degrees of missing information for different countries, and susceptibility to human factors during the calculation process. Additionally, many indicators may have varying degrees of relevance when applied to evaluations at the provincial or municipal levels.

“Internet +” Digital Economy Index

Since 2015, Tencent, in collaboration with institutions like JD.com and Didi, has compiled comprehensive data covering Tencent's core platforms, including WeChat, payment services, urban services, and more. This data, along with industry data from companies such as JD.com, Didi, and Ctrip, is used to create the "Internet+" Digital Index for China. The index adopts a comparative approach and is divided into four sub-indices: Infrastructure, Industry, Innovation and Entrepreneurship, and Smart Livelihood. It encompasses 14 primary indicators and 135 secondary indicators, covering 17 major sub-industries in social networking, news, video, cloud computing, and the three industrial sectors. It also includes areas like innovation and entrepreneurship based on mobile internet and smart livelihood, providing a comprehensive overview of the implementation of the "Internet+" digital economy in 351 cities across 31 provinces (autonomous regions and municipalities) in China.

Advantages of the Tencent "Internet+" Digital Index include its detailed sub-indices, covering a wide range of industries, and rich data resources. It provides a nuanced assessment of various aspects of the "Internet+" digital economy. The industry coverage is extensive, encompassing social networking, news, video, cloud computing, and 17 major sub-industries related to the three industrial sectors. It also includes areas like innovation and entrepreneurship based on mobile internet and smart livelihood, presenting a comprehensive picture of the digital economy in different domains. The data resources are abundant, as the index, led by internet companies, has access to dynamic updates, aiding in accurate and timely reflection of market vitality and digital economic development.

However, limitations of the index include data constraints, as the data may be restricted by the market share and business types of the relevant enterprises, potentially not fully representing the overall level of the digital economy. Macro-level aspects are missing, as there is a lack of coverage for macro-level topics such as information infrastructure and the digital transformation of traditional manufacturing industries. The index is company-led, and the involvement of internet companies in formulating the index may introduce biases related to business interests and data selection, affecting the objectivity of the index.

Digital Economy Index (CDEI)

In May 2017, the Caixin Insight, among other institutions, released the China Digital Economy Index (CDEI). CDEI utilizes a comparative approach, focusing primarily on the digital economy's ability to enhance overall societal efficiency. It includes four main components: production capacity, integration level, digital spillover capacity, and the entire society's utilization capacity.

CDEI, initiated by the media, shares innovative and prominent features with Tencent's "Internet+" Digital Economy Index. It possesses strong characteristics of the times and can reflect the current market dynamics and the development status of key areas. However, there are certain limitations associated with the CDEI. The theoretical foundation of its indicators may be subject to debate, and the enterprise data captured may not necessarily provide an objective reflection of the macro-level situation of China's digital economy.

Digital Economy Index (DEI)

In April 2017, the "China City Digital Economy Index White Paper (2017)" was first released. It is the inaugural assessment system specifically designed to evaluate the development level of the digital economy in Chinese cities. The index employs a comparative approach, combining current popular technology applications and urban development conditions. It evaluates the digital economy development levels of various Chinese cities from the perspectives of urban information infrastructure, urban services, urban governance, and industrial integration. The first assessment covered 40 cities nationwide.

The characteristics of this index include its alignment with national and local policies, consideration of hot topics in digital applications, and a focus on the implementation effectiveness of technological innovation at the application level. However, due to significant regional differences in China and the diverse development characteristics of cities, the method of cross-regional comparison requires further refinement to tailor the assessment to the specific conditions of each city's digital economic development.

Table 1
Comparison of different systems of indicators related to the digital economy

Name	Publisher	Main indicators	Advantages	Disadvantage
DESI (Digital Economy and Society Index)	EU	Broadband access, human capital, internet usage, digital technology application, and the degree of digitization of public services	Building on the preliminary achievements of the OECD and taking into account the impact of the digital economy on society, this study incorporates data support.	Lack of objectivity in indicator selection; Data lag.
Digital Economy Indicator System	OECD	Investing in intelligent infrastructure, Innovation capability, empowering society, ICT promotes economic growth and increases employment opportunities	Adopting a comparative approach, the constructed digital economic indicator system encompasses elements with international comparability.	Lack of standardized Data collection; Absence of global comparative analysis
NRI (Network Readiness Index)	WEF	Environment, readiness, application, impact	Comprehensive analysis; focus on the field of information technology countries and regions in global informatization; high Authority.	Limited coverage; Lack of timeliness
IDI(ICT Development Index)	ITU	ICT Access, ICT Usage,ICT Skills	Comprehensive measurement of information and communication technology (ICT) includes infrastructure development, industrial applications, and human capital assessment in the related fields.	Limited measurement of economic-related content
DEI (Digital Economy Index)	China Academy of Information and Communications Technology	For the Business Cycle Index, it includes three categories: leading indicators, coincident indicators, and lagging indicators. By comparing with the base period, it reflects the economic conditions in different periods.	Comprehensive consideration of digital Economic development; Selection of indicators with Chinese characteristics	The theoretical framework is not sufficiently robust, and further consideration is needed regarding its sustainability and representativen-ess.
DEDI (Digital Economic Development Index)	CCID Consulting China	Foundational, resource-based, technological, integrated, and service-oriented.	Possesses a certain degree of innovativeness.	The data source is not necessarily stable and lacks international comparability.
GDECI (Global Digital Econo	Shanghai Academy of	A global digital economy competitiveness analysis model consisting of four dimensions: digital infrastructure, digital	Emphasis on governance role ; Selection of authoritative data sources	Data source stability; country differences and data gap

my Competitiveness Index)	Social Sciences	industry, digital innovation, and digital governance.		
"Internet +" Digital Economy Index	Tencent	Basic sub-index, industrial sub-index, innovation and entrepreneurship sub-index, smart livelihood sub-index	Detailed sub-indices; wide industry coverage; rich data resources	Limited Data Scope; Macro-level omissions; Corporate dominance
CDEI (China Digital Economy Index)	Institutions such as Caixin Think Tank	Digital economy industry Index, digital economy integration index, digital economy spillover index, digital economy infrastructure index.	Possessing contemporary features, it can reflect the current market dynamics and the development status of key areas.	Weak theoretical foundation; The representativeness of enterprise data remains to be proven.
DEI (Digital Economy Index)	H3C Group	Urban information infrastructure, urban services, urban governance, and industrial integration.	The initial assessment of the digital economic development level at the city level; Investigated the status of hot digital applications, with a focus on the practical effectiveness of technology innovation at the application level	The method of horizontal comparison requires further refinement

Conclusion and Discussion

Conclusion

(1) Each indicator system has its strengths and unique features. In the research results of international institutions, there are valuable insights from the perspective of defining the concept of the digital economy and constructing theoretical frameworks. The U.S. Department of Commerce has conducted research on the definition, theory, scope, and measurement steps of the digital economy, providing valuable references. From the viewpoint of constructing indicator systems, the European Union's Digital Economy and Society Index is particularly objective and comprehensive, especially in terms of data acquisition. The EU has a solid research foundation with a wealth of relevant surveys and statistical studies, and its long-term, large-scale survey and statistical work mechanism is worth learning from. Regarding the scientific design and sustainability of indices, the World Economic Forum's Network Readiness Index and the International Telecommunication Union's ICT Development Index have undergone long-term testing, especially in the mature calculation and international comparison of information infrastructure and information industries.

(2) China's existing indicator systems have very distinct characteristics. Firstly, they are relatively new in time. The seven domestic digital economy indices discussed in this paper were all first released in 2017. This indicates the varying degrees of attention and rapid response from different institutions, enterprises, and regions to national strategies and the overall trend of digital economic development in China. However, it also suggests that China started measuring digital economic development relatively late. Secondly, there is a strong diversity among these indices. The measurement methods of international organizations are

relatively standardized, focusing on aspects such as the foundation, application, and impact of the digital economy. In contrast, China's seven indices each have their own characteristics, reflecting the differences in the focus and conceptual approaches of different institutions and roles towards the digital economy. Thirdly, there is a significant emphasis on innovative big data applications, especially in indicator systems designed and led by enterprises. These systems demonstrate greater diversity in data sources.

This study significantly contributes to the existing knowledge by providing a comprehensive review of relevant research on the definition and measurement methods of the digital economy. By comparing the strengths and weaknesses of indicator systems proposed by 10 international organizations or institutions, this research offers valuable insights into the current landscape of measuring the digital economy. Moreover, the conceptual framework and policy recommendations presented in this study pave the way for future research endeavors in constructing an indicator system to measure the level of digital economic development. This research not only fills the gap in the literature by synthesizing existing knowledge but also offers practical guidance for policymakers and researchers to accurately assess and track the progress of the digital economy. As digital technologies continue to reshape various aspects of life and production, the findings of this study hold significant implications for understanding and navigating the complexities of the digital economy in contemporary society.

Discussion

In summary, to effectively advance research on digital economic development, the author proposes the following recommendations:

(1) Enhance theoretical research on the measurement and evaluation of the digital economy: The measurement of the digital economy should be built upon a rigorous theoretical framework to ensure authoritative policy influence and academic value.

(2) Explore the establishment of cross-departmental working mechanisms and expedite relevant statistical surveys on the digital economy: Construct cross-departmental and cross-level organizations for index research, surveys, and evaluations. Systematically develop frameworks for key indicator statistical surveys, ensuring the long-term collection of primary and core data to guarantee data quality reflecting the real situation and avoiding the impact of factors such as unstable data sources.

(3) Innovate data sources under the premise of data quality and controllable origins: While multiple digital economic indices make extensive use of existing statistical data, they also incorporate industry data reflecting market vitality and internet big data obtained through web scraping. However, further research is needed to balance these factors while maintaining international comparability of the indices. Additionally, this study did not delve into measurement methods proposed by scholars or groups for digital economic development indices. Subsequent research can continue to explore this aspect further.

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