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Digital Economy: Development and Future

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Digital Economy: Development and Future

Abstract

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Keywords

digital economy, big data, intelligent algorithms, computing platforms

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Digital Economy: Development and Future

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Abstract: The digital economy has become a significant force in reorganizing global factor resources, reshaping global economic structure and global competitive landscape. This article starts with the basic issues of digital economy, outlines three key components of digital economy, which are big data, intelligent algorithms, and computing platforms. Then it reviews the development of international digital economies and the current status of China's digital economy, and summarizes the advantages and challenges of developing a digital economy in China. Finally, based on the 14th Five-Year Plan for National Economic and Social Development and the Long-Range Objectives through the Year 2035, according to challenges and shortcomings of China's development of digital economy, six suggestions of policies to promote, optimize, and strengthen China's digital economy have been proposed, including data openness and protection, issues of key technologies, training programs for big data talents, livelihood services for citizens, social credit system and international collaborations. **DOI:** 0.16418/j.issn.1000-3045. 20211217002-en

Keywords: digital economy; big data; intelligent algorithms; computing platforms

China's digital economy has made remarkable achievements since the 18th National Congress of the Communist Party of China (CPC). New technologies such as big data, artificial intelligence, and cloud computing have experienced accelerated innovation and have been increasingly integrated into all fields and the whole process of economic and social development. China has become a great country in digital economy with obvious scale advantages and local leading industries. General Secretary Xi Jinping has repeatedly talked about the issues related to the digital economy ①, which has provided ideological and action guidance for China' digital economy to advance from being big to being strong.

Digital economy has been booming around the world in the new era. The wide application of digital technologies has profoundly impacted the transformation and upgrading of traditional industries and has given birth to new industries, new formats, and new models. The intertwined impact of the profound changes unseen in a century and the COVID-19 pandemic has exposed the shortcomings of China in the development of digital economy, especially in data governance, key technologies, people's livelihood, and social services. Focusing on the development and future of digital economy, this paper starts with the basic issues of digital economy and outlines three key components (big data, intelligent algorithms, and computing platforms) of digital economy. Then it reviews the development of international digital economies and the current status of China's digital economy, and summarizes the advantages and challenges of developing a digital economy in China. Finally, based on the 14th Five-Year Plan for National Economic and Social Development and the Long-Range Objectives through the Year 2035 (hereinafter referred to as the 14th Five-Year Plan and the Long-Range Objectives through the Year 2035), six suggestions of policies to promote, optimize, and strengthen China's digital economy have been proposed, including data openness and protection, issues of key technologies, training programs for big data talents, livelihood services for citizens, social credit reporting system and international collaborations. It is further proposed to inject the concept of "digital" into Chinese culture and creatively cultivate the big data culture with Chinese characteristics, thus building Digital China, a leading digital economy in the world as soon as possible.

1 Basic issues of digital economy

1.1 Definition

There is currently no unified definition of digital economy at home and abroad. In this regard, the paper gives a comprehensive definition: the digital economy is an emerging economic form with the three main components: big data,

① Xi Jinping: Implementing the national big data strategy to accelerate the construction of Digital China. (2017-12-09)[2021-12-17]. http://www.xinhuanet.com/2017-12/09/c_1122084706.htm. During the 34th collective study of the Political Bureau of the CPC Central Committee, Xi Jinping emphasized to master the development trends and rules of digital economy and promote the healthy development of China's digital economy. (2021-10-19)[2021-12-17]. http://www. news.cn/politics/leaders/2021-10/19/c_1127973979.htm.

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intelligent algorithms, and computing platforms. Intelligent algorithms are used to store, process, and analyze big data on computing platforms for discovering knowledge, so as to serve the allocation optimization, transformation, and upgrading of resources in industries and promote the high-quality development of economy. The above three key components are indispensable for the digital economy. Without big data, digital economy is like cooking without rice; without intelligent algorithms, digital economy cannot create value; without computing platforms, digital economy will no longer exist.

In general, digital economy can be introduced from digital industrialization and industrial digitization. Digital industrialization refers to the process of industry generation with digital technologies, which provides basic technologies, products, services, and solutions for the overall progress of digital economy. Examples of digital industrialization include artificial intelligence, cloud computing, and other emerging industries in recent years. Industrial digitization refers to the upgrading of traditional industries with digital technologies, mainly the improvement of production quantity and production efficiency brought by the application of digital technologies. Examples of industrial digitization include the adoption of automatic production line by traditional automobile production enterprises.

1.2 The first key component: big data

In 2013, the 462nd symposium of Xiangshan Science Conference gave the Chinese definition of big data ②: big data is a data set with diverse sources and types, large volume, complexity, and potential value, which is difficult to be processed and analyzed within the expected time. Big data as a new strategic resource in the digital age and an important factor driving innovation is changing human production and lifestyle. The types of big data are diverse, covering almost all the aspects of social life, including health, gene, communication, meteorology, credit, and social contact. Big data mainly has three sources: government, enterprises, and open source.

The emergence and popularization of big data have profoundly changed all walks of life. The scientific analysis based on big data can not only provide effective support for decision-making activities but also creatively change people's production and lifestyle. Upon the outbreak of COVID-19 in early 2020, the teams of Chinese Academy of Sciences, Chinese Center for Disease Control and Prevention, and Hong Kong Baptist University constructed a social contact-based heterogeneous data analysis model for the social occasions of 7 age groups and 4 types of places. They then used the model to analyze the COVID-19 case data of 6 cities including Wuhan, which revealed the potential patterns and uncertainty risks of epidemic spreading. Furthermore, they developed a variety of plans for resumption of work and production according to the expected growth of gross domestic product (GDP) of these cities in that year [1]. The results are rapidly reported in the form of policy suggestions, which provides support for the decision-making on resumption of work and production later. This is a typical case of performing scientific analysis and assisting government's decision-making based on big data of health and social contact.

The origin of the analysis of big data can be traced back to 1783 when the British statistician Richard Price established the prediction model of life insurance and national debt by collecting and analyzing the inheritance tax data [2]. The history of big data analysis can be roughly divided into three overlapping periods. (1) Since 300 years ago, statistical methods have mainly been used to analyze data and obtain descriptive conclusions. (2) Since the concept of artificial intelligence was first put forward at Dartmouth Conference in 1956, data processing, mining, and knowledge discovery through machine learning have gradually become the mainstream. (3) In the past 20 years, the studies about the methods for unstructured data such as texts and images have been increasing, which has enriched the method system of big data analysis and promoted the advancement of related disciplines.

Despite the three periods, big data analysis always follows three basic principles. (1) Decision-making process. Given the goal of a data analysis problem, intelligent algorithms can be used to mine knowledge from normalized data and then the knowledge can be applied to decision-making. (2) Principle of machine learning. A mathematical model can be established with the training set and verified with the test set, which can be used to analyze the new data. According to different specific scenarios, the model needs repeated training and learning to ensure its accuracy. (3) Intelligent knowledge discovery. The first-order problem of data analysis is to obtain rough knowledge through data mining, and the second-order problem is to identify rough knowledge through the subjective knowledge of decision-makers and generate intelligent knowledge, which is then used to support decision-making.

However, there are still three major challenges in the development of big data analysis. (1) The structuring of unstructured data. It remains to be solved how to transform unstructured data such as texts and images into structured data through data fusion, and then use the existing structured data mining methods for analysis. (2) The complexity and uncertainty of data. It remains to be solved how to comprehensively restore and show the complexity and uncertainty of big data in different scenarios. (3) The relationship between data heterogeneity and decision-making heterogeneity. The

② The scientific principles and development prospects of data science and big data: A review of the 462nd symposium of Xiangshan Science Conference. (2013-05-29)[2021-12-17]. http://www.xssc.ac.cn/waiwangNew/index.html#/xsscNew/meetingdetailsNew/527/jkxq.

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heterogeneity of data leads to the heterogeneity of decision-making, so we need to find out how to use the relationship between data heterogeneity and decision-making heterogeneity to discover the effective decision support according to local conditions.

We should have a scientific understanding of big data analysis. Big data represents a large sample rather than the whole, and a large sample is more universal than a small sample. Big data analysis should seek accuracy from roughness and mine causality from correlation for prediction.

1.3 The second key component: intelligent algorithms

Intelligent algorithms, the mathematical tools for big data analysis, are widely used in all walks of life. For example, AlphaGo, an intelligent Go program, has defeated professional players many times, demonstrating the super learning ability of intelligent algorithms. For another example, the digital currency, which emerged after the hash function was integrated into the blockchain, has profoundly shaken the financial market. According to the set rules or heuristic methods, intelligent algorithms explore groups through the learning of individuals, which can be roughly classified into two categories: (1) generated through logical learning; (2) generated through the simulation of human and biological consciousness and behavior. The commonly used intelligent algorithms include statistical analysis, association rules, clustering methods, deep learning, mathematical programming, and fuzzy logic. The mathematical ideas vary among intelligent algorithms. For example, the basic idea of the optimization algorithm in mathematical programming is to improve the accuracy of data classification.

1.4 The third key component: computing platforms

Computing platforms are the computing resource for big data storage and analysis, which have two specific forms: (1) centralized computing platforms, such as supercomputing and cloud computing; (2) distributed computing platforms, such as computers and mobile phones. Generally speaking, a computing platform is composed of four parts: whole machine, chip, operating system, and application software. The construction of computing platforms in China is developing rapidly, while it is restricted by the goal of carbon neutrality and carbon peak. According to statistics, the power consumption of data centers accounted for about 2% of the total power consumption of the whole society in China, 2020 and increased at a rate of 12% for eight consecutive years [③]. The carbon emission problem is serious as 70% of the overall power consumption of computing facilities comes from conventional energy. Therefore, when deploying the new computing platforms such as internet data centers, we must consider the large carbon emissions caused by high energy consumption.

It is noteworthy that the "mining" of virtual currency will lead to ultra-high energy consumption. According to the statistics of Cambridge University, the bitcoin mining in the world causes the annual power consumption of about 149.4 TWH [④]. In this regard, in September 2021, 11 departments including the National Development and Reform Commission jointly carried out the rectification of virtual currency "mining" activities. Accordingly, China's share of global bitcoin computing power has been reduced from 44% to 0 [⑤], which indicates that the rectification has effectively contained the abuse and misuse of computing resources and maintained the normal financial order.

2 Development status of international digital economy

2.1 Evolution of digital economy

The term "digital economy" appeared in the early 21st century. However, the economic activities supported by digital technologies originated in the 1950s, the evolution of which has experienced three stages: (1) Technology preparation stage (1950s–2000). The emergence of innovative products such as IBM personal computer and Microsoft operating system provides technical support for the prosperity of digital economy. At the same time, digital services began to develop. For example, based on the data of thousands of banks, First Data Co. of the United States provided services such as credit card issuance, acquiring, payment, and credit scoring. The backbone network built by Level 3 Communications with optical fibers has laid the rudiment of the Internet since then. (2) The rapid development stage (2000–2012). The rapid rise of new business models such as e-commerce, search engine, and social media gave birth to internet technology giants such as Amazon, Google, Facebook, and PayPal, which provided rich data for the digital economy and further expanded the application scenarios. (3) The era of big data and artificial intelligence since 2012. Digital industrialization is accelerated worldwide. For example, the Obama administration of the United States defined big data as new oil in the future and then issued the Big Data Research and Development Initiative and the National

③ The main responsible comrades of the High Technology Department of the National Development and Reform Commission answered reporters' questions on the Implementation Plan of the Computing Hub of the National Integrated Big Data Center Collaborative Innovation System. (2021-05-26)[2021-12-17]. https://www.ndrc.gov.cn/xxgk/jd/jd/202105/t20210526_1280956.html?code=&state=123.

④ Cambridge Center for Alternative Finance. Cambridge Bitcoin Electricity Consumption Index. (2021-12-17). https://ccaf.io/cbeci/index.

⑤ 11 Departments jointly issued a notice to rectify virtual currency "mining" activities. (2021-09-25)[2021-12-17]. http://www.gov.cn/xinwen/2021-09/25/content_5639202.htm.

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Artificial Intelligence Research and Development Strategic Plan to boost big data and artificial intelligence at the national level. Advanced economies such as the United States, Western Europe, and Japan have applied modern information technology to traditional industries and experienced the rapid development of industrial digitization, making data analysis the basic support for business.

2.2 Overview of international digital economies

According to the O*ECD Digital Economy Outlook 2020* [3] released by the Organisation for Economic Co-operation and Development (OECD), the situations of international digital economies can be summarized from three aspects. (1) Data acquisition and use. Thirty-seven OECD member states have promulgated 205 policies on data circulation in the public and private sectors, which directly affect the acquisition and use efficiency of data. Twenty-nine OECD member states have enacted privacy and personal data protection laws, with strong awareness of data security and protection. (2) Digital construction policy. According to a survey of 35 OECD member states in 2019, the top three priority objectives of developing digital economy are to build digital government, develop telecommunications infrastructure, and promote digital technology innovation. Policy orientation is critical for the construction of digital economy. The obstacles of OECD member states in population distribution, budget financing, cross-sectoral coordination, data supervision and opening, and privacy and security restrict the development of their digital economy. (3) Digital technology innovation. One third of the patents owned by OECD member states are related to information and communication technology, whereas this proportion has decreased in the past 10 years. By contrast, the corresponding proportions of China, Russia, and India have increased significantly. From 1999 to 2019, the number of papers focusing on artificial intelligence has quadrupled, and China's contribution to the research and innovation achievements of digital technology has increased rapidly.

2.3 Leadership of international digital economy

The developed countries in Europe and America have built strong digital economies, and we can learn from their experience in the following three aspects. (1) Guidance by laws and policies. From the promulgation of the Information Superhighway by the Clinton administration in 1993 to the renewal of the National Artificial Intelligence Research and Development Strategic Plan in 2019, the United States has successively issued more than 30 laws and policies, which clarified the rights and responsibilities of entities and standardized the development of digital economy. The General Data Protection Regulation promulgated by the European Union in 2018 is the most stringent law for protecting data privacy security in history, which guarantees the security of personal data and information in the digital economy era. The European model with strict protection of privacy and the American model with a high degree of free circulation have produced different development directions of the digital economy, which are important references for China to formulate relevant policies in data opening and protection. (2) Innovation-driven enterprise development. Five companies in the United States, Facebook, Amazon, Apple, Netflix, and Google, have world-leading technologies in social media, online retail, mobile communication, streaming media, and search engine, respectively. These international technology giants always focus on their business and keep innovating the technologies, thereby greatly promoting the leaping development of the digital industry in the United States. (3) Sound market form. With the comprehensive market-oriented system and influential third-party institutions, the United States took the lead in building a relatively complete social credit system. Personal credit reporting agencies such as Experian, Equifax, and TransUnion, as well as corporate and sovereign credit rating agencies such as Standard and Poor's, Moody's, and FitchRatings, have provided sound market consulting services for the trading and circulation links of the digital economy. The establishment of social credit system depends on the development of digital technology and at the same time promotes the industrial digitization in the United States.

3 Development status of China's digital economy

China's digital economy began to officially connect to the Internet in 1994. With the rapid emergence of e-commerce and social media in the first 10 years of the 21st century, China's digital economy has gradually expanded. Since the 18th National Congress, the CPC Central Committee has put forward a series of strategic objectives on developing digital economy. In particular, it added data as a factor of production in the fourth plenary session of the 19th CPC Central Committee and released the comprehensive layout of the digital economy in the 14th Five-Year Plan and the Long-Range Objective through the Year 2035, which will guide China's digital economy towards high-quality development.

3.1 Achievements of China's digital economy

According to the *White Paper on China's Digital Economy Development* (*2021*) [4] by the China Academy of Information and Communications Technology, during the 13th Five-Year Plan period, the scale of China's digital economy increased from the CNY 11 trillion to CNY 39.2 trillion in 2020, accounting for 38.6% of GDP. Digital economy has become the key momentum for the high-quality development of China's economy, the main achievements of which can be summarized in six aspects. (1) Expanding digital industrialization. The scale of new models and new formats of digital industry keeps growing, and the new momenta of industrial development are becoming increasingly strong. In 2020, the

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revenue of China's Internet and related service enterprises above designated size reached CNY 1.3 trillion, with a year-on-year increase of 12.5%. The scale of artificial intelligence industry reached CNY 160.69 billion, with a year-on-year increase of 24.43%. At present, there have been 439 000 AI-related enterprises, and the scale of the computing industry has reached CNY 2 trillion, directly driving the economic output to CNY 1.7 trillion. (2) Accelerated industrial digitalization. The digital transformation of agriculture, manufacturing industry, and service industry has been promoted. In 2020, the digitization rate of production equipment of China's industrial enterprises above designated size reached 49.4%. More than 470 000 enterprises were newly cloudified, and the online retail volume reached CNY 11.76 trillion, ranking the first in the world for eight consecutive years. (3) Emerging models and formats. Digital technologies are promoting the online transformation of traditional industries, creating a large number of new formats, new models, and new occupations (25 new occupations such as delivery personnel for online orders and internet marketers). (4) Innovative development of regional digital economy. The new economic circles, represented by Beijing-Tianjin-Hebei region, the Yangtze River Delta, Guangdong-Hong Kong-Macao Greater Bay Area, and Chengdu-Chongqing economic circle, focus on the development of core industries such as big data, artificial intelligence, advanced computing, and high-end chips of digital economy. At present, these economic circles have become China's digital economy innovation highlands and led the development of the national digital economy. (5) Integration of government information systems. On the basis of the national unified e-government network, China has established a national data sharing platform, which has basically achieved network communication, data communication, and business communication. Governments at all levels have created many new convenience services (such as "one visit at most") for business environment and in-process and post-event supervision, which has greatly improved the efficiency of governance. (6) Improvement of people's livelihood by digital services. The wide application of digital technology has accelerated the digital transformation of life services. The emergence of online education, online office, online shopping, and contactless distribution has profoundly changed the basic necessities of life and diversified the lifestyle.

In recent years, China has attained great achievements in industrial digitization, especially in the application of digital technology in sensitive industries such as finance and insurance. For example, the CAS Research Center on Fictitious Economy & Data Science assisted the People's Bank of China to establish China Score (the national personal credit scoring system of China), the accuracy of which is 10% higher than that of FICO (a United States credit scoring system), far higher than the international level, and has become a global leader of the industry ⑥. Since the online implementation, the system has been widely used in loan issuance, credit card approval and other work of commercial banks, effectively serving people's daily financial activities. It is the basic project of China's financial informatization and effectively supports the rapid development of digital economy.

3.2 Advantages of developing a digital economy in China

The rapid development of China's digital economy in recent years is mainly attributed to the advantages accumulated for a long time, which can be summarized as the following three aspects.

(1) The socialist system. China's socialist system has the obvious advantage of concentrating on major events. Since the 18th National Congress, the CPC Central Committee has formulated a systematic, scientific, and forward-looking top-level design for the construction of digital economy. Relevant departments have successively promulgated a series of policies, such as the Guiding Opinions of the State Council on Vigorously Advancing the "Internet Plus" Action, Action Outline for Promoting the Development of Big Data, and Outline of National IT Development Strategy, which has pointed out the way forward for China's digital economy. Relevant departments have also successively issued a series of policies to support the industry to open up new markets, which has accelerated the growth of the digital economy.

(2) Super-large scale market. On the one hand, China has more than 1 billion Internet users, generating huge consumer demand, which is the original momentum for the development of the digital economy. On the other hand, China has a complete range and complete chains of industries and is capable of providing all-round digital economy products and services.

(3) Research and development of digital technologies. China has a large basic research team and the ability to tackle key problems in the development of digital technologies. According to the Report of Development of Chinese Science and Technology Talents (2020) [5] issued by the Ministry of Science and Technology, the full-time equivalent of Chinese scientific researchers increased rapidly from 3.878 million person years in 2016 to 5.092 million person years in 2020, ranking the first in the world. The education background of scientific and technological talents has been improved, and young people have become the main force of scientific research. Increasing attention has been paid to basic research

⑥ The personal general credit scoring system is expected to be applied within this year. (2010-02-25)[2021-12-17]. http://www.gov.cn/govweb/fwxx//sh/2010-02/25/content_1541057.htm.

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and education. At present, China has formed a good advantage of local leadership in many technical fields such as 5G communication.

3.3 Challenges of developing a digital economy in China

Despite the great achievements of China's digital economy, there are still shortcomings in many fields. The major challenges in key technologies can be summarized as three points.

(1) The digital economy is big but not strong. Although China's digital economy grows rapidly and leads the world with a growth rate of 9.6% in 2020, more new models and new formats need to be cultivated. The scale of China's digital economy reached 5.36 trillion US dollars in 2020, ranking the second in the world, whereas it was only 40% of that (13.6 trillion US dollars) in the United States. Digital economy dominates the national economy in the United States, Germany and other countries, with a proportion of more than 60%, whereas that proportion in China, 2020 is only 38.6%. Overall, the development of China's digital economy mainly depends on the demographic dividend and market dividend of the Internet, with mature consumer side and immature technology side and innovation side. In the construction of computing platforms, for example, the number of supercomputers in China is 188, ranking the first in the world, accounting for 37.6% of the total number of supercomputers in the world. However, the total computing power of China's supercomputers is 541.3 Pflop/s, ranking the third in the world, second to 854.4 Pflop/s in the United States and 631.0 Pflop/s in Japan. According to the 58th annual edition of the TOP500 ⑦, Japan's Fugaku tops the list, the two systems of the United States rank the second and third, and China's Sunway TaihuLight and Tianhe-2 rank the fourth and seventh, respectively. Although China leads the world in the number of supercomputers, the total computing power remains to be improved. Compared with other countries, China has had some innovative applications in the use of supercomputing. For example, the Chinese Academy of Sciences, Tsinghua University, the National Supercomputing Center in Wuxi, and the China Financial Futures Exchange cooperated to use unstructured data mining technology on the supercomputing platform for the first time to explore the behavioral characteristics and correlations of different types of investors in financial futures trading, so as to facilitate the innovative development of China's financial market. The above case indicates that supercomputing can not only be used for large-scale engineering computing but also develop more innovative applications to serve the development of national economy.

(2) Breakthroughs in key technologies are urgently needed. Key technologies are the bottleneck hindering China's digital economy to move towards high quality, especially in the construction of computing platforms. Personal computers, supercomputers, cloud computers, and other computing platforms are all composed of four main parts: complete machine, chip, operating system, and application software. Among them, China's chip and operating system are most restricted by other countries. The operating system (OS) can be divided into server, desktop, and mobile terminal. In the international market, Google Android, Apple iOS and Microsoft Windows have long been in a monopoly position in all kinds of OSs. Although the overall OS market of China has a scale of CNY 100 billion, it has been dominated by products of the United States. For example, the desktop terminal is dominated by Windows, and the mobile terminal by Android and iOS. Compared with chips and application software, OS is the field with the lowest degree of localization. Fortunately, innovative attempts of domestic OSs have emerged and are narrowing the gap with other advanced economies. Examples include the desktop OSs Kirin and UOS and mobile OSs HarmonyOS and JingOS. From the perspective of comprehensive national strength and market demand, we must realize that except the United States, China is the only country in the world that has the ability and possibility to breed its own OS, and we must not lose the good opportunity.

(3) The position of China's digital economy in the world still needs to be improved. According to the *Report of Global Big Data Development* (*2020*) [6] released by Tianfu Institute of International Big Data Strategy and Technology, data openness has a positive correlation with economic development, and the government's data openness policy can promote economic growth. Among the countries participating in the Open Government Partnership (OGP) and making open data commitments, European countries and developed countries account for 36.5% and 26.9%, respectively. China still has a gap in data opening compared with developed countries, which cannot meet the needs of rapid social and economic development. At the same time, facing the growing unilateralism, the international influence of China's digital economy has also been weakened. For example, digital technology enterprises such as Huawei and ByteDance have frequently suffered setbacks in the process of internationalization. China still has a weak voice in digital economy-related international organizations and has not yet been in a position matching the comprehensive national strength.

3.4 Development goals of China's digital economy

The 14th Five-Year Plan and the Long-Range Objectives through the Year 2035 has specified the important position of digitization in the overall situation of China's modernization for the first time, put forward 13 overall goals of accelerating the construction of digital economy, digital society, and

⑦ Top 500 The List. The 58th annual edition of the TOP500. (2021-12-15)[2021-12-17]. https://www.top500.org/lists/top500/2021/11/.

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digital government, and depicted the grand blueprint of Digital China. Digital economy is becoming a new driving force for China to achieve the long-range objectives through the year 2035 and the goal of the second century. Therefore, China needs to use "digital" to open more fields and industry application scenarios, create new advantages of digital economy, and embark on a digital road with Chinese characteristics.

The 14th Five-Year Plan and the Long-Range Objectives through the Year 2035 plans to achieve the goal of constructing the computing hub of the national integrated big data center collaborative innovation system, i.e., considering the initial layout in the economic circles (Beijing-Tianjin-Hebei region, the Yangtze River Delta, Guangdong-Hong Kong-Macao Greater Bay Area, and Chengdu-Chongqing economic circle) and 4 provincial-level administrative regions (Inner Mongolia, Ningxia, Gansu, and Guizhou). At the same time, according to the national major regional development strategy, energy structure, industrial layout, market development, and climate environment, the national hub nodes of big data centers are deployed in the areas with rich energy and suitable climate, and a high-speed data transmission network is established between the nodes to support the scheduling of national computing resources and form a national computing hub system. In the process of layout, efforts should be made to vigorously promote the construction of green data centers, accelerate the energy-saving transformation of data centers, and support the joint construction and coordinated operation of power grids and data networks, thus reducing the power consumption cost of data centers. The goals by the end of the 14th Five-Year Plan period include forming an integrated infrastructure pattern of the data centers with reasonable layout and green intensity across the country; achieving structural balance between the east and the west and reducing the power utilization efficiency of large and super-large data centers to below 1.3; improving the intensification, scale, greening level, and utilization rate of the data centers; initially forming a public cloud service system and reducing the cost of computing power acquisition in the whole society; breaking the data barriers between government departments and between government and enterprises to enhance the vitality of data resource circulation; forming a number of industrial data brains and urban data brains nationwide to transform computing resources and data resources of the whole society into intellectual resources.

4 Suggestions to promote, optimize, and strengthen China's digital economy

General Secretary Xi Jinping has emphasized in the 34th collective study of the Political Bureau of the CPC Central Committee in October 2021 that digital economy has unprecedented rapid development, wide radiating range, and influence, and it is becoming a key force to restructure global factor resources, reshape the global economic structure, and change the global competitive landscape. Based on the challenges and shortcomings in the development of China's digital economy, and the author's personal work experience, six suggestions were put forward to promote, optimize, and strengthen China's digital economy.

(1) Data openness and protection. The Party Central Committee attaches great importance to data openness and data protection. To this end, China has successively implemented the Data Security Law of the People's Republic of China and the Personal Information Protection Law of the People's Republic of China in 2021 to coordinate the development and utilization of data, privacy protection and public security, which helps to clarify specifications such as data confirmation right, transaction circulation, and security assurance. In the future, we should pursue the basic policy of grasping two links at the same time. That is, we should actively open the data and at the same time strengthen the governance and supervision of the data to accelerate the market-oriented construction of data elements and build a new "trinity" data circulation ecology composed of government, enterprises, and society under the guidance of the market. Since a considerable part of the data is controlled by private enterprises, it is necessary to correctly handle the relationship between the government and private enterprises on the ownership confirmation and use of data. Specifically, the private enterprises should be guided to correctly use data guided by social value, make data from people and for the people, and develop a safe, healthy, and responsible digital economy [7].

(2) Training programs for big data talents. The talents in the construction of digital economy, especially the construction of computing platforms, are in serious shortage. According to the prediction of China Center for Information Industry Development (CCID), China's big data talent gap will reach 2.3 million persons by 2025. The talents cultivated by ordinary colleges and universities are insufficient to fill in the gap. The professional talents with big data processing and governance skills trained by secondary and higher vocational colleges will become the main force to meet this demand. In this regard, the Yangtze River Delta has taken the lead in vocational skills training in China, and has issued a series of cultivation policies, such as the establishment of an integrated teacher training center and the integration of vocational education with high-level universities. In the future, we should keep encouraging and supporting vocational skills training in big data and establish an effective incentive mechanism to lay a solid talent foundation for the high-quality development of the digital economy.

(3) Issues of key technologies. The key technologies cannot be required, bought, or begged. In view of the key technical problems faced by China, relevant departments are actively deploying and issuing a series of supporting policies. For example, the Action Plan for the Development of Basic Electronic Components Industry (2021–2023) released by the Ministry of Industry and Information Technology helps to

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achieve a breakthrough in the electronic components industry by strengthening basic research. In the future, China still needs to strengthen the ability of independent innovation, formulate deliberate plans, and develop target key technologies. Compared with hard technologies such as chips, China's innovation in soft fields such as OS has more advantages and better foundation, which can be used to break foreign constraints in the short term. At the same time, the government should assist enterprises related to key technologies to explore the market, encourage leading enterprises to invest in the development of key technologies in a market-oriented way, and foster small enterprises led by large ones, creating a more reasonable and competitive business environment.

(4) Livelihood services for citizens. Since the outbreak of COVID-19, China has implemented regional health codes in many places, which has promoted the management of epidemic prevention and control. However, the diverse health codes have caused the problem of information incompatibility, which has led to inconvenience to people's travel. To make people enjoy the convenience and happiness brought by the digital economy, we should break the barriers of data between government departments as soon as possible and integrate and collect citizens' personal education, social security, taxation, medical treatment, and other relevant information according to the laws, so as to establish a unified citizen information service organization and citizen service platform with "one card" (ID card) and "one code" (travel code) as the basis. Handling of the livelihood services including the epidemic prevention and control should be achieved nationwide with "one card, one code", so that China can catch up with advanced countries in livelihood service quality and social governance level.

(5) Social credit system. Any scenarios with transactions need to be supported by credit. The continuous improvement of the social credit system will ensure the maturity and high-quality development of the digital economy. The construction of credit reporting system in advanced countries mainly has two forms: (1) credit scoring system for individuals, such as FICO in the United States; (2) credit rating systems for enterprises and sovereign countries, such as Standard & Poor's, Moody's, and FitchRatings. China's credit reporting system starts from credit, and gradually forms a pattern dominated by the central bank's basic database of financial credit information and supplemented by market-oriented credit reporting institutions. In the future, we need to speed up the building of Credit China to Digital China, establish a credit reporting system covering the whole society through credit reporting legislation. It is suggested to make personal credit score as a label of individuals in the society, take enterprise credit rating as a credit symbol of enterprises, and establish a social ecology of third-party credit reporting evaluation to maximize the social value of credit of the government, enterprises, and individuals.

(6) International collaborations. The development of digital economy in China as the second largest economy in the world is inseparable from the support and cooperation of the international community. In this regard, China has the necessity and ability to join various international organizations of digital economy and participate in the formulation of rules of the international digital economy. We should exert greater influence in international organizations such as OGP, Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), and Group of 20 (G20). In the international cooperation of the Belt and Road, we should stress the green and digital coordinated development and further consolidate China's leading position.

At present, China is witnessing the great changes unseen in a century, which is closer to the great rejuvenation of the Chinese nation than ever. In the future, we should cherish and make timely use of this once-in-a-lifetime opportunity, adapt to the situation, and use technology to innovate, develop, and change life. "Digital" should be injected into the extensive and profound Chinese culture to cultivate the big data culture with Chinese characteristics. We should devote to building a world leading digital economy and building a Digital China as soon as possible to benefit the future generations.

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